NEVF

New England Vegetable & Fruit

2017

New England Vegetable & Fruit Conference and Trade Show

December 12, 13, and 14, 2017

Radisson Hotel
Manchester, New Hampshire

Proceedings 2017

2017
New England
Vegetable & Fruit Conference
and Trade Show

December 12, 13, and 14, 2017

Radisson Hotel Manchester
Manchester, NH

Sponsored by the Cooperative Extension Systems of:
University of Connecticut
University of Massachusetts
University of New Hampshire
University of Rhode Island
University of Vermont
Cornell University
Connecticut Agricultural Experiment Station
and
Maine Organic Farmers & Gardeners' Association
and
New England Vegetable & Berry Growers' Association
and
Massachusetts Fruit Growers' Association

U.S. Department of Agriculture Cooperating

General Chair
Becky Sideman

Proceedings
George Hamilton

Program Chair
Sonia Schloemann

CCA/CEU Recertification
Mark Hutchinson

Publicity
Tori Lee Jackson

Secretary
Andy Radin

Registration
Mark Hutton

Farmer-to-Farmer
Sandy Arnold

Treasurer
Christopher Grant

Media Specialist
Jon Clements

Trade Show Manager
Brian Aldrich

Evaluations
Vern Grubinger

Local Arrangements
Olivia Saunders

Travel
Hilary Sandler

Pesticide Recertification
Heather Bryant

Local Foods Coordinator
Stacia Monahan

Members at Large and Moderators

Chuck Bornt
Katie Campbell-Nelson
Andre Cantelmo
Mary Concklin
Glenn Cook
Heather Faubert
Ken Foppema
Jim Garman
Duane Greene
David Handley
Trevor Hardy
Ann Hazelrigg
Rob Johanson
Laura McDermott
Matt Pellerin
Sue Scheufele
Eric Sideman
Kim Stoner
Laura Tanferini
Tim Taylor

Table of Contents

Root Crops

Wildlife Management

Strawberry II

Tree Fruit II

Cover Crops

Specialty Vegetable Crops

Sweet Corn

Soil Health

Stone Fruit

Brassicas/ Leafy Greens

Mechanical Weed Control

Wine Grapes

Eggplant & Peppers

Brambles

Organic Production

Post-Harvest Tools & Tips

Hard Cider & Cider Apples

Table Grapes

Blueberry I

Farm Business Metrics

High Tunnels

Nutrient Management

Potatoes

Blueberry II

Farm Decisions

Water Management/ Irrigation

Infrastructure Decisions

Tomatoes

Appendix

Getting Started in Strawberries - Matted Row

David T. Handley

Vegetable and Small Fruits Specialist, University of Maine Cooperative Extension
Highmoor Farm, P.O. Box 179, Monmouth, Maine 04259, (207) 933-2100

The matted row has been a successful and profitable strawberry production system for many years in the colder regions of the country, and remains widely planted in New England because of this. Advantages of the matted of other, higher input systems include its relatively low initial investment costs, its adaptation to cold climates, and the ability to maintain the planting for several years. The system works well because it exploits the natural growing habit of the strawberry plant, optimizing both its vegetative characteristics and its fruiting potential to produce a profitable crop with a relatively low level of inputs.

Yields from matted row strawberries vary widely, ranging from 3000 pounds per acre to nearly 20,000 pounds per acre. The differences in production tend to be the result of management. Following good management practices, especially in regards to variety selection, plant stands, nutrient management, water management and pest management will maximize crop yield and prolong the profitable life of the planting.

Selecting A Planting Site

Selecting an appropriate planting site is the first critical decision that must be made. Planting strawberries in a poor or marginal site will result in poor plant stand, poor plant vigor and poor yields. While strawberries can tolerate a variety of soil types, they grow best in a deep sandy loam, rich in organic matter. The soil must be well-drained. Avoid areas that remain wet late into the spring. Strawberries produce best if they receive full sunlight and are planted on a gradual slope. This helps to prevent frost injury by allowing cold air to drain away from the plants. Do not plant strawberries in an area where tomatoes, potatoes, peppers, or eggplant have been grown in the past four years. These crops carry a root rot (*Verticillium*) which also attacks strawberries. Do not plant strawberries into recently plowed grass or sod areas. This can lead to devastating weed problems and damage by white grubs, a common turf pest, which will feed upon strawberry roots. Finally, choose a site where there is ready access to a water supply. Irrigation is important for good plant establishment, to maintain growth during dry periods, and is also used to prevent frost injury to strawberry flowers in the spring.

Preparing the Soil

Getting ready for strawberry planting may take two years, depending upon the condition of the site. Have the soil tested for pH and fertility. Strawberries prefer a soil pH of 5.8 to 6.2; this may require applications of ground limestone. Soil testing information is available at your Cooperative Extension office. If the organic matter level of the soil is low (less than 2%) and/or perennial weeds are a problem, a cover crop such as buckwheat, Sudan grass or oats can be sown and later plowed into the soil before it goes to seed. Applications of compost or barnyard manure and regular tilling for a full season can be used as an alternative to cover crops.

Fertilizer can be applied and worked into the soil prior to planting, or banded into the soil after planting. Rates should be determined through soil tests taken the previous fall. In general, a rate of approximately 30 lbs. of nitrogen, 60 lbs. of phosphorus (P_20_5) and 60 lbs. of potassium (K_2O) should be incorporated into the soil prior to planting (e.g. 300 pounds/acre of 10-20-20 or its equivalent). An additional 30 pounds of nitrogen per acre (e.g. 65 lbs. urea) should be applied over the plants in July to promote runner development. Another, lighter application of nitrogen may be applied in August to aid in flower bud development (e.g. 40 lbs. urea). Do not apply heavy applications of nitrogen in the fall. This will increase the likelihood of winter injury to the plants.

Planting and First Season Care

Plant strawberries in the spring as soon as the soil can be prepared. Purchase only certified disease-free plants from a reputable nursery. Plants should have large crowns and lots of healthy, light-colored roots.

Strawberries should be planted deep enough to bring the soil half way up the compressed stem or crown. Pack the soil firmly around the plants, and irrigate immediately after planting. Mechanical transplanters are available that work very well and greatly speed up planting.

The strawberry crowns should be initially planted 18 inches apart within rows, with 48 to 52 inches between rows. This will require about 7300 crowns per acre. These plants will produce runners during the summer that will root and fill out the rows. The width of the plant row should be limited to 24 inches to maintain easy access in the planting. Runner plants that grow outside the 24-inch row width should be pinned back into the row or removed if the plants become too crowded (less than 6 inches between plants). Varieties known to produce few runners can be initially spaced closer together (12 to 16 inches) within the row to compensate. This will require that a higher number of plants be ordered and therefore will increase planting costs.

Matted rows may be established on raised beds. This improves drainage and air circulation, reducing disease problems, and it makes harvesting the fruit easier. Raised beds should be six to ten inches high, and one to two feet across. The disadvantages of raised beds include added labor and equipment costs, and an increased potential for drought and winter injury to the plants.

All flower blossoms that emerge during the planting year should be pinched off. This encourages runner growth and plant vigor and leads to better yields next year. Because of the initial wide spacing of the crowns the planting year crop would be very small, difficult to harvest and thus of little value.

The new planting should be irrigated after planting and regularly thereafter to insure optimum growth. One to two inches of water per week is ideal. Increasingly, growers are using trickle irrigation in matted row strawberry plantings. One or two lines of trickle tube is either buried 3-4 inches under the bed prior to planting or laid on top of the bed just after planting. Trickle irrigation is a more efficient method of getting water to the plants and, unlike overhead irrigation, doesn’t soak the foliage, which can encourage disease problems. Trickle lines can also be used to deliver soluble fertilizers to the plants. However, trickle irrigation will not provide frost protection as overhead irrigation can, and care must be taken to avoid damaging the trickle lines during the renovation process.

Mulching

Mulch should be applied over strawberries in the late fall to protect the plants from extreme winter cold and from damage to the roots caused by rapid freezing and thawing of the soil. Straw is the most commonly used mulch, but any loose material that will provide cover without matting can be used, such as sawdust or wood shavings. Do not use hay, because it contains weed seeds, which will start to grow among the strawberries next spring.

Strawberry plants provide a good indication of when mulch should be applied. After a few hard frosts the leaves turn reddish and collapse down around the crowns. This is a sign that the plants are dormant (usually late November). Mulch should be applied anytime after that, but before the ground freezes. Two to five tons of straw per acre is recommended (approximately one ton of straw provides one inch of coverage per acre). Use the higher rates if your fields are exposed and do not get consistent snow cover. The mulch layer should be approximately 6 inches deep over the plants. Be discriminating about your source of straw. Straw from weedy fields will result in weed infestations in your strawberries.

In the early spring (late March-early April) the mulch should be pulled off the plants and placed into the aisles between rows. This creates a clean walkway and keeps the fruit dry and clean.

A light application of fertilizer may be applied after mulch removal to stimulate spring growth. Only 10 to 15 lbs of actual nitrogen is recommended to prevent excessive vegetative growth at this time, which can lead to fruit rot problems (e.g. 85 lbs./acre of calcium nitrate). Light applications (1 to 2 lbs./acre) of boron are also often applied in the spring to help fruit development.

Frost Protection

If a frost is predicted after the mulch has been removed irrigation should be set up to protect the flower buds. Set up sprinklers to provide complete coverage of the planting, and turn the water on when the temperature drops to 33° F. Continue to run the water until all the ice formed on the plants has completely melted. Frost nozzles are available for sprinklers that will provide protection using less water than regular nozzles, saving energy and preventing flooding.

Fabric, "floating' row covers may also be placed over the plants to provide some winter and frost protection. These lightweight fabrics create a greenhouse effect that will make the plants bloom and fruit earlier in the spring and produce larger yields. Rowcovers should be placed over the plants in the early fall. The plants and rowcovers may be covered with straw in late fall for additional winter protection. Remove the straw in early spring, or as soon as the snow melts. Leave the rowcovers on until the plants begin to bloom. This may occur 2 to 3 weeks earlier than plants without rowcovers, so you must be prepared to protect the flower buds from frost. Although the rowcovers will provide some frost protection, it is best to use irrigation over the rowcovers if the temperature drops below 30°F. Row covers may also be applied only in the early spring and removed when flowers first appear. This avoids the problems of trying to maintain the rowcovers over the winter, but the increased yield effects tend to be reduced.

Renewing the Planting

Strawberry beds can usually be carried over for three to five years. Annual bed renovation is a critical part of successful strawberry production with the matted row system. Renovation is primarily a plant thinning process carried out after harvest to stimulate healthy new vegetative growth. This in turn will promote a good crop for the following year. A strawberry bed that has had a productive season and that has vigorous plants, which are free from serious insect, disease, and weed problems should be carried over for another year. The renovation process will insure that such beds will have another good crop. All beds to be carried over should undergo the following steps beginning soon after harvest is complete.

1. Broadleaf Weed Control: If perennial broadleaf weeds (dandelion, daisy, etc.), and/or a high population of emerged annual broadleaf weeds (lambsquarter, pigweed) are present 2,4-D amine (Amine 4®) can be applied for control. 2,4-D is a post-emergent herbicide, which is effective on broadleaf perennial weeds. It will not control grasses, nor does it offer any pre-emergent control. If 2,4-D is not applied all broadleaf perennial weeds should be removed by hand.

2. Mowing: If 2,4-D was applied to the planting, wait four to five days following the application then mow off the leaves of the strawberries about 1 1/2 inches above the crowns. This allows time for the material to be taken in by the weeds. The leaves can be mowed immediately after harvest if 2,4-D is not applied. Mowing stimulates new leaf growth and may provide control of leave diseases. Removal of the leaf canopy also improves the distribution of fertilizers and herbicides. However, if the planting is stressed from drought or appears weak and will be carried over to next year in spite of this, mowing should be eliminated from the renovation process. Mowing weak plants may inhibit recovery.

3. Fertilization: Apply fertilizer according to soil test recommendations. Soil testing kits and information are available from your county Cooperative Extension office. Typically, about 40 pounds of actual nitrogen per acre is applied at this time (e.g. 87 lbs. of urea), with another 20 pounds of actual nitrogen applied four to six weeks later. Balanced fertilizers, such as 10-10-10, containing phosphorus and potassium may be used if soil tests indicate a need for these nutrients. Avoid over-fertilization with nitrogen. The resulting excessive growth on plants can lead to problems with winter injury, spider mite infestations and fruit rots, in addition to potential water contamination problems from soil leaching. Tissue nutrient analysis of leaves after renovation can offer more precise guidance to appropriate fertilizer rates for each field. Contact your state

Extension specialist for information on tissue analysis. A very light application of nitrogen is often applied the following spring after removal of the mulch. Ten to 15 pounds of actual nitrogen at this time can help to stimulate early plant growth. Heavier applications should be avoided because this could cause excessive vegetative growth and increase the likelihood of fruit rot. Light applications of boron (1 to 2 lbs. per acre) and calcium may also provide some benefit to fruit development in the spring.

4. Plant Thinning: Strawberry rows should not be allowed to get more than 24 inches wide. Till the sides of the rows to narrow the beds back to a width of ten to twelve inches. Set the tiller so it incorporates the mowed leaves and fertilizer, and spreads about one inch of soil over the remaining crowns. During the summer, new daughter plants should be allowed to root to fill out the row to the desired 24-inch width.

5. Pre-emergent Weed Control: To control annual weeds, terbacil (Sinbar 80WP) may be applied according to label directions. Terbacil is an effective pre-emergent herbicide with some post-emergent activity. It should be applied after mowing and tilling the beds, but before new growth begins. No more than 6 oz. of Sinbar may be applied in a single application, and no more than 8 oz. may be applied in one season. Sinbar can cause injury to strawberry plants. It is important to determine appropriate rates for each location. Certain strawberry varieties are especially sensitive to Sinbar, including Kent and Annapolis. Be sure to read and follow all precautions on the label.

6. Irrigation: Encourage optimal plant growth and get the most out of your fertilizers and herbicides by regular irrigation. Strawberries will grow best if they receive 1 1/2 inches of water per week during the growing season.

Do not delay the renovation process. Late renovation will delay the rooting of new runners needed to reestablish the bed. This will result in smaller plants and lower yields next year. Be vigilant! Be on the lookout for weeds, insects, spider mites and diseases throughout the year. Cultivation and/or sprays are likely to be necessary as the summer wears on.

Beds that will not be renovated and carried over should be plowed down and seeded to a suitable cover crop to reduce weed, insect and disease problems that have developed and to increase soil organic matter content. Ideally, beds that are plowed down should be rotated out of strawberries for at least three years. If properly managed, crop rotation will greatly reduce pest problems and improve the vigor and longevity of strawberry beds.

Growers who want to produce strawberries organically often forego the renovation process and simply plow the bed down after the first fruiting year, and have another bed planted that spring to harvest the following year. This prevents the build up of weeds in a field that will usually occur without the use of herbicides. While planting beds every year and not carrying over them beyond one harvest may cost the grower a bit more, the profit margin of a well-run organic strawberry bed can still be good.

For more detailed information on strawberry production, see the ***Strawberry Production Guide for the Northeast, Midwest and Eastern Canada***, published by the Natural Resource, Agriculture and Engineering Service (NRAES-88), and available through your University Cooperative Extension.

Where brand names are used it is for the reader's information. No endorsement is implied nor is any discrimination intended against products with similar ingredients. Always consult product label for rates, application instructions and safety precautions. Users of these products assume all associated risks.

Strawberry Variety Update – June-Bearers

Kathleen Demchak[1] & Timothy Elkner[2]

[1]Penn State University, 107A Tyson Bldg., University Park, PA 16802

[2]Penn State Cooperative Extension – Lancaster County
1383 Arcadia Road, Room 140, Lancaster, PA 17601

The comments below are partially based on results and observations from trials conducted in both matted-row and plasticulture trials conducted in central and southeastern Pennsylvania (USDA hardiness zones 6a and 6b), but also include information provided by the breeders or programs from which the varieties originated.

Information is mainly about strawberry varieties released within the last 10-12 years or so, assuming that most growers are already familiar with performance of older varieties, and especially “mainstay” varieties that have been fairly consistent performers, such as ‘Earliglow’’, ‘Jewel’, ‘Honeoye’, ‘Cavendish’, and others.

Variety characteristics, in particular fruit quality, vary with factors such as temperature and moisture. Fruit of many varieties tends to be softer when (and where) conditions are warmer and when moisture is plentiful, whereas berries are often firmer when it is cool, and sweeter when nights are cool and the weather is sunny. Growers know the conditions at their farm locations best, and thus should view this information as an indication of the potential that varieties have if grown under conditions suited to them, and also as an indication of potential weaknesses.

Often disease and insect susceptibilities may not become apparent until a cultivar is grown under conditions where disease or insect pressure is fairly high. If breeding and initial testing is done under conditions where pressure from a particular disease or insect is low, selection will be based on other factors, and some susceptibilities won’t be apparent until the variety is grown where pressure is higher.

Temperatures also affect fruiting season. While the earliness of one cultivar relative to others is generally the same, some cultivars appear to respond to warm temperatures differently. This means that sometimes there may be less difference between the first ripening date of early and late cultivars in one year than in others. Varieties are grouped within harvest season below:

<u>Galletta</u> (NC State Univ., 2008). Early season. In PA, ‘Galletta’ ripened about 3 days after ‘Earliglow’. ‘Galletta’ was better suited to plasticulture production in our trials, where it produced more than double the total yields (averaging 16,000 lb/a) compared to matted-row (4,000-7,000 lb/a). In both systems, color and flavor were good. Berry size was medium in matted row (11 g/berry) and large in plasticulture (16 g/berry). Plants were very vigorous in plasticulture, and it came back from renovation nicely in matted-row. The vigorous vegetative

growth resulted in the occurrence of some gray mold. It developed some powdery mildew under warm humid conditions, and was moderately susceptible to leaf scorch.

AC Wendy (AAFC – Nova Scotia, 2006). Early season. ‘Wendy’ fruit had large size combined with nice color, and very high yields in plasticulture, but sugars were low and flavor was poor under warmer conditions. Yield was average, and flavor was better in cooler matted-row conditions. Size did not drop off as quickly as with ‘Earliglow’. Produced a relatively low number of runners for filling in rows in matted-row production, though this would be a plus for plasticulture. Susceptible to angular leaf spot (bacterial) and somewhat susceptible to leaf scorch.

Archer (NYSAES – Geneva, 2016). Early season. Ripened a few days after AC Wendy. Trialed in both plasticulture and matted row. Was very productive with above average fruit size in matted row production, to which it was better suited than plasticulture. Bright red fruit was susceptible to fruit anthracnose, and fruit softened markedly in the plasticulture system under warm conditions.

AAC – Laurel (AAFC-Nova Scotia, 2014). Early season. Produced average yields, and pretty berries with excellent color and shape. Flavor was good, but not excellent. Its outstanding characteristic was excellent resistance to foliar diseases. Only available from Canadian nurseries at this time.

L’Amour (NYSAES – Geneva, 2003). Early-mid season. Nicely shaped fruit with good size, medium-red color and above-average flavor. Perfect degree of firmness. Yields were a bit on the low side in PA trials. Good resistance to leaf diseases.

Yambu (Fresh Forward, The Netherlands, year of introduction not listed). Early-mid season. Orange-red fruit with good flavor. Plant patent application indicates resistance to Botrytis and Phytophthora crown rot. Limited testing in U.S.

Purple Wonder™ (NYSAES – Geneva, 2011). Early-mid season. For matted-row production in a niche market or for home gardens. Dark color throughout, very good flavor, medium-sized fruit. Plants produce few runners. Not included in PA trials.

Darselect (Darbonne, France, introduced in 1998, but not available in U.S. until later). Mid-season. Grown in both plasticulture and matted-row production in PA. Flavor, color, and size were good, but very susceptible to fruit anthracnose and leaf scorch, and very attractive to tarnished plant bug. Moderate yields.

Flavorfest (USDA-Beltsville, 2012). Mid-season. Variable plant establishment in PA – only tested in plasticulture system, though intended for both plasticulture and matted-row production. Relatively low runner production. Yields increased greatly in second year once plants were established, producing the highest yields of all cultivars in the trial in year 2 (~19,000 lb/a) compared to producing only 6,000 lb/a in year 1. Good flavor, size, and color. Some plants tested positive for Phytophthora by PSU Plant Disease Clinic.

Herriott (NYSAES – Geneva, 2011). Mid-season. Intended for northern matted-row production. Large fruit with average flavor. Vigorous plants that produce many runners. According to release information, is tolerant of root-rotting diseases when replanted in former strawberry fields. Yields were moderate in PA.

AAC Lila (AAFC – Nova Scotia, 2014). Mid-season. Vigorous plants. Available only from Canadian nurseries at this time. Not included in PA trials.

Rubicon (CT, 2011). Mid-season. This variety was released because of its resistance to black root rot and black vine weevils. The plant is extremely vigorous, but yields are on the low side. Large amount of foliage results in susceptibility to Botrytis. Berries were fairly tart in PA.

Sonata (Plant Research Intl, The Netherlands, 2006). Mid-season. Extremely vigorous and productive plants. Fruit is on the small to average size because of the high number of branch crowns, resulting in a fairly high incidence of Botrytis fruit rot. Fruit tends to be soft and somewhat light-colored, and mild in flavor. According to breeders, it is susceptible to Verticillium wilt, Phytophthora crown rot, and Rhizoctonia. In PA, produced high yields in both plasticulture (over 32,000 lb/a in one plasticulture trial) and matted-row (18,800 lb/a), primarily due to a full 3-week harvest season, compared to only 2 weeks for most varieties.

Clancy (NYSAES – Geneva, 2003). Mid-late season. Trialed only in matted row in PA. Berries were dark red and had good flavor, but yields were on the low side, perhaps because plants did not runner enough to fill in the rows.

Mayflower (East Malling, U.K., Year of introduction not listed). Mid-late season. Firm dark red berries with yields that tended to be on the low side, but had a high percentage of marketable fruit even when grown without fungicide or insecticide applications. Susceptible to fruit anthracnose, and tarnished plant bugs, perhaps because the lateness of its season coincided with high tarnished plant bug populations. Somewhat susceptible to leaf scorch, which affected the otherwise pretty and large caps. Flavor was sometimes a bit spicey.

Rutgers Scarlet (Rutgers Univ., 2015). Mid-late season. Intended for both plasticulture and matted-row production. Characteristic of note is intense flavor. Untested in PA, though other numbered selections from same program were, which had excellent flavor, moderate vigor, and some unusually-shaped berries (long, bulb-shaped). Varieties from this breeding program were sought after by most harvesters of the trials because of their flavor.

AC Valley Sunset (AAFC – Nova Scotia, 2009). Mid-late season. Large fruit, orange-red color, can be a bit soft. Vigorous plants resulted in gray mold. According to release information, susceptible to phytophthora root rot and powdery mildew.

Record (C.R.P.V., Italy, Year introduced - ?). Late season. Large dark berry with a somewhat flattened shape and medium firmness. Moderate yields. Susceptible to botrytis and fruit anthracnose. Has a hint of cinnamon in its flavor.

Malwina (Germany – M. Stoppel). Late season. Very late variety that brings new meaning to the term, with fruit ripening about 2 weeks later than the next latest variety. Dark red fruit. Trialed in the matted-row system only, but didn't produce enough runners to fill the bed the first year. Renovated well, however, so yields increased markedly in the second year, but were still below average.

Understanding and Preventing Winter Injury

David T. Handley

Vegetable and Small Fruits Specialist
University of Maine Cooperative Extension
Highmoor Farm, P.O. Box 179, Monmouth, Maine 04259
(207) 933-2100

Although strawberries have been grown successfully in New England for well over 100 years, it is interesting to note that they are not particularly hardy plants. In early winter, before they have reached full dormancy, significant injury can occur at temperatures of 10° to 16° F, while in midwinter they can tolerate 0° to -8° F. Temperatures are often significantly colder than this during New England winters, and therefore strawberries could and likely would suffer significant injury if left exposed. However, because of the low growth habit of the plants, and their tendency to grow in protected areas near wood lines in the wild, they are often covered with leaves and snow during the coldest parts of the winter, which insulates and protects the plants from extreme temperatures. In cultivated beds, plants must also be protected, both directly, with insulating cover, and indirectly, through managing vigor throughout the season, in order to prevent winter injury from becoming a significant problem.

How do cold temperatures injure plants? It's all about water. If water within the plant tissues freezes, expanding ice crystals destroy plant cells and tissues. Additionally, if the plant loses too much water during the winter when its dry and windy, cells and tissue dehydrate, because plants cannot take up water when they are dormant and ground is frozen.

Options for winter survival are limited from a plant perspective. Many species avoid the problem by producing cold tolerant seeds in a single season then dying off as winter approaches, but others have adapted to tolerate the cold by preparing for it each year through a process called acclimation. A plant's ability to acclimate will determine its degree of hardiness. Successful acclimation is closely tied to the ability of a plant to reduce the amount of free water in its tissue, and to survive that lack of water for an extended duration. Examples of the means plants use to reduce their water content includes dropping leaves in the fall, and reducing water uptake from the roots. Within the plants, water may be compartmentalized in between cells where it is less likely to freeze and/or cause injury. Solutes, such as sugars and salts can be concentrated in the cells to lower their freezing point. Likewise, water can be isolated and purified such that it can "supercool", and be exposed to sub-freezing temperatures without crystallizing.

But timing is everything, and plants must be able to both initiate these processes and recover from them at the appropriate moment each season. The start of the process of acclimation is determined by environmental cues, which occur in stages as the season progresses. The first stage is usually initiated by shortened day length (actually lengthening dark periods) as fall approaches. This is "sensed" by the leaves via a chemical known as phytochrome, which changes how it reacts with chemicals within the plant when its exposed to different lengths of light and dark periods. Based on this change, the plants will begin the process of going dormant. The second stage is brought on by decreasing temperatures, and will stimulate further processes in the plant to reduce water uptake and content, leading to dormancy.

But once dormant, plants must have a mechanism to re-initiate growth once the winter is past. This is determined through a combination of exposure to time and temperature known as a chilling requirement. A dormant plant must be exposed to a certain range of temperatures for a particular length of time in order to once again begin growing. For most hardy plants, the range of temperature that counts toward a chilling requirement is 32° to 45° F. Temperatures higher or lower than this range don’t count; they simply extend the dormant period. The period of exposure necessary within the required range can vary from about 400 hours to over 1800 hours, depending on the plant species and variety. Chilling requirements for cultivated strawberries range from 400 hours to 600 hours, depending on variety. However, even with this mechanism in place, plants may break dormancy too early and become sensitive to freezing temperatures before winter is truly over. For example, a low chilling requirement may be met well before the end of a long winter, and if a warm spell should occur in late winter, the plant could break dormancy, only to suffer when extreme cold temperatures suddenly return. Often it is the winters that have late warm spells or widely fluctuating temperatures that result in high levels of winter damage, rather than those that are just very cold throughout.

The severity of cold temperature injury can vary considerably, dependent upon several factors. If an extreme cold event occurs in early winter, before full dormancy is reached, damage is much more probable. Alternatively, should the extreme cold occur very late in the winter, after dormancy has begun to break, damage is also more likely. The speed at which the temperature drops can also impact the likelihood of injury. A gradual decline over days or weeks is less likely to cause injury than a sudden drop of many degrees in just a few hours. The duration of the cold period can also effect a plants ability to survive it. Exposure to extremes for a few hours or days is probably tolerable, but as it extends to weeks or months injury becomes more likely.

As an herbaceous, or non-woody plant, strawberries don’t achieve what is considered a true state of dormancy. Rather, they go into a quiescent state, or pseudo-dormancy which offers some protection against extreme temperatures, but not to the degree that true dormancy provides. Should the plant tissues freeze during the winter, the effects will be apparent early in the spring. The beds will show weak, unthrifty growth, often most obvious anywhere the protective mulch has blown off or was applied too thin. Plants may be dead, or have small, short leaves and little new growth. To verify winter injury, as opposed to some other issue, pull up a few plants from the afflicted area that are still alive and cut through the crowns lengthwise, from top to bottom. If there is brown or rusty discoloration within the fleshy white center tissue of the crown, winter injury is the correct diagnosis. The larger the discolored area, the more severe the injury, and the less likely the plant will be able to recover. If the tissue shows no discoloration, another factor may be the cause, such as red stele root rot or root weevils.

Much can be done to prevent winter injury in strawberry beds, and growers should make every effort to see that their plantings face the lowest possible risk. Begin with site selection. Plant beds in well–drained soils that are protected from extreme winds. Snow cover during the winter is provides good insulation, and sites that tend to collect snow may be better protected. Plant varieties that are known to be hardy, and avoid those with a reputation for winter injury. Avoid applications of nitrogen fertilizer to the beds late in the season, e.g. after mid-August, as this can stimulate late, lush growth and delay quiescence. Finally, protect the plants each winter with a thick cover of mulch.

Apply mulch over the beds in the late fall after the plants are quiescent. A good indication of this occurs after a few hard frosts when the leaves turn reddish and collapse down around the crowns (usually late November). Straw, from oats, rye, barley or wheat is the most commonly used mulch. Do not use hay, because it contains weed seeds that will grow among the strawberries next spring. Be discriminating about your source of straw. Straw from weedy fields will result in weed infestations in your strawberries. Two to five tons of straw per acre is recommended (approximately one ton of straw provides one inch of coverage per acre). Use the higher rates if your fields are exposed and do not get consistent snow cover. The mulch layer should be approximately 6 inches deep over the plants. Several types of machines are available to break up straw bales and help distribute it over the beds. For plasticulture beds, fabric rowcovers are applied for protection over the beds rather than straw. While these sometimes do not offer consistent winter protection, they are much easier to work with in a plasticulture system. Covers should be applied soon after quiescence, and be at least 1.25 oz. thick to provide adequate insulation. Some manufacturers offer thicker covers specifically for winter protection. Be sure the edges of the cover are adequately weighted down with sand bags, or bury the edges to prevent the wind from dislodging them.

Should winter injury be evident in the spring, in spite of your best efforts, some practices may help reduce the impacts of the damage, if the severity is not too great. Make sure the plants get plenty of water, especially if the conditions are dry, to compensate for the damage to the roots and vascular system. Light applications of fertilizer, including nitrogen, soluble phosphorus, and the micronutrients zinc and boron may stimulate new growth in injured plants. Finally, if the damage is severe, and the profitability of the bed is in question, it may be best to plow it down and put the field into rotation for planting in the future. Badly damaged plants will yield poorly, and will not produce healthy runners to bring the bed back into production next year.

Understanding how cold temperatures can injure your strawberry plants and how they adapt to avoid that injury, provides you with management tools to encourage plant survival through New England winters and thus improve the odds of having a thriving bed each spring.

Improving Pesticide Spray Effectiveness

Laura McDermott

Cornell University Cooperative Extension
Eastern NY Commercial Horticulture regional program
415 Lower Main Street, Hudson Falls, NY 12839
lgm4@cornell.edu

Growers understand that to optimize a pesticide application there are three objectives that have to be met: you must 1) hit the target 2) cover the target and 3) put the correct amount of pesticide on the target. The second two objectives are difficult for strawberry growers to achieve, especially when using conventional boom sprayers. Poor pesticide coverage on the undersides of leaves, on lower leaves, and on the fruit when the strawberry plant is in full canopy can result in poor pest control.

Strawberries are high value crops with a low, 3-dimensional canopy. Drift is often targeted as being the biggest source of problems with spray deposition. In fact there are other, inter-related factors that, combined with drift, make designing the perfect crop protectant delivery system a challenge. These include the sprayer design, the droplet size and the size of the spray fan. The air volume, direction and velocity also affect the amount of material that is deposited vs. the amount that is lost to drift.

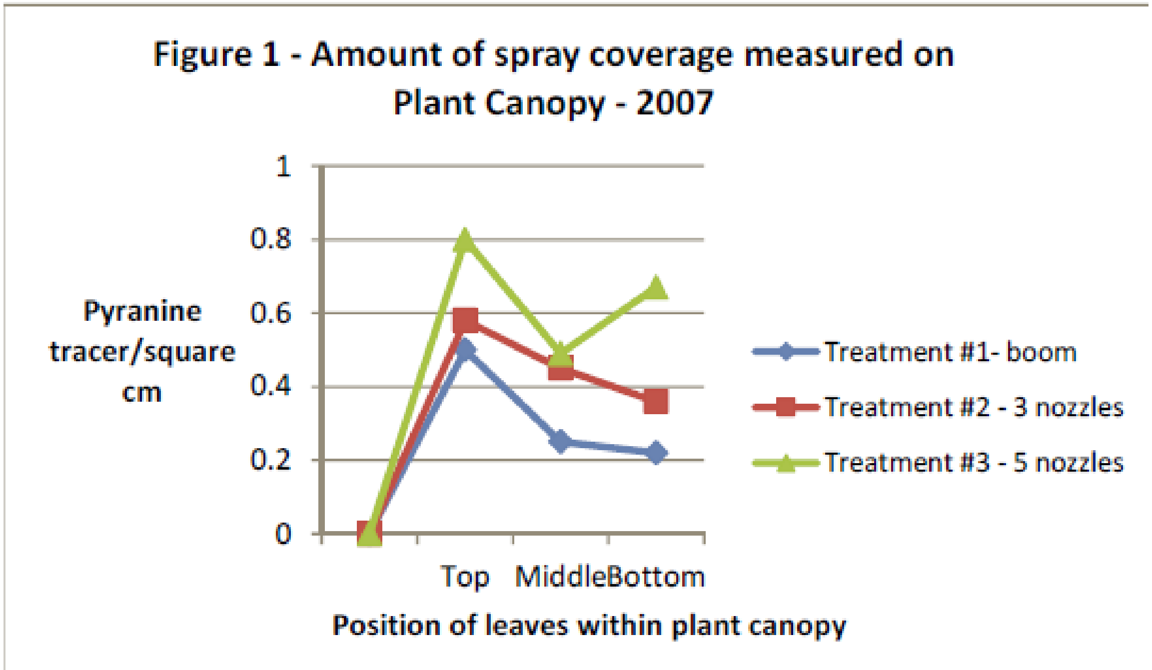
Consistent sprayer calibration plus the skill and attitude of the tractor operator are also factors. Like many crops, the plant canopy increases considerably during the growing season, so the volume rate has to adapt as well.

A prototype 'modified boom' was built at Cornell University and in 2007 the first field work was conducted to determine appropriate volume rates, proper nozzle selection and the best pressure and nozzle positioning. There were 3 treatments, one from a traditional boom, a hoop with 3 nozzles and a hoop with 5 nozzles. Deposition onto the crop was measured by adding Pyranine fluorescent tracer into the sprayer tank. Leaves were picked from the top, middle and bottom part of the canopy. Three leaves from each area were placed into plastic bags and sealed. 10 plants per treatment were selected, there were five replicates.

It was found that adjusting the volume rates from 6 liters/100 meter of row length to 9.5 liters then finally to 12.5 liters per 100 meters row length as the season progressed and as the crop canopy grew resulted in the best spray deposition over the season.

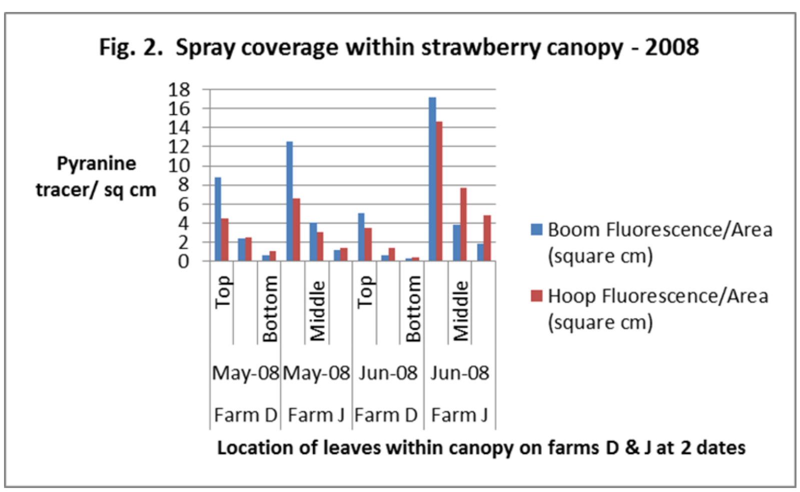
The most appropriate nozzles were found to be 02 and 03 nozzles because 015 nozzles were too small and the resulting small droplet size increased the risk of drift and lowered the capacity (rows per hour). Best coverage results were at 75 psi with the nozzles 4-8 inches above the target. See Figure 1.

In 2008, 2 more "hoops" were constructed and fitted to the sprayers belonging to berry growers John Hand of Hand Melon Farm in Greenwich, NY and Dale Ila Riggs of The Berry Patch in Stephentown, NY. The modified booms or hoops were connected to the existing plumbing system. The hoop was designed with 5 nozzles and the grower could target the canopy with the appropriate number of nozzles, most likely increasing from 3-5 targeted nozzles as the strawberry canopy developed.



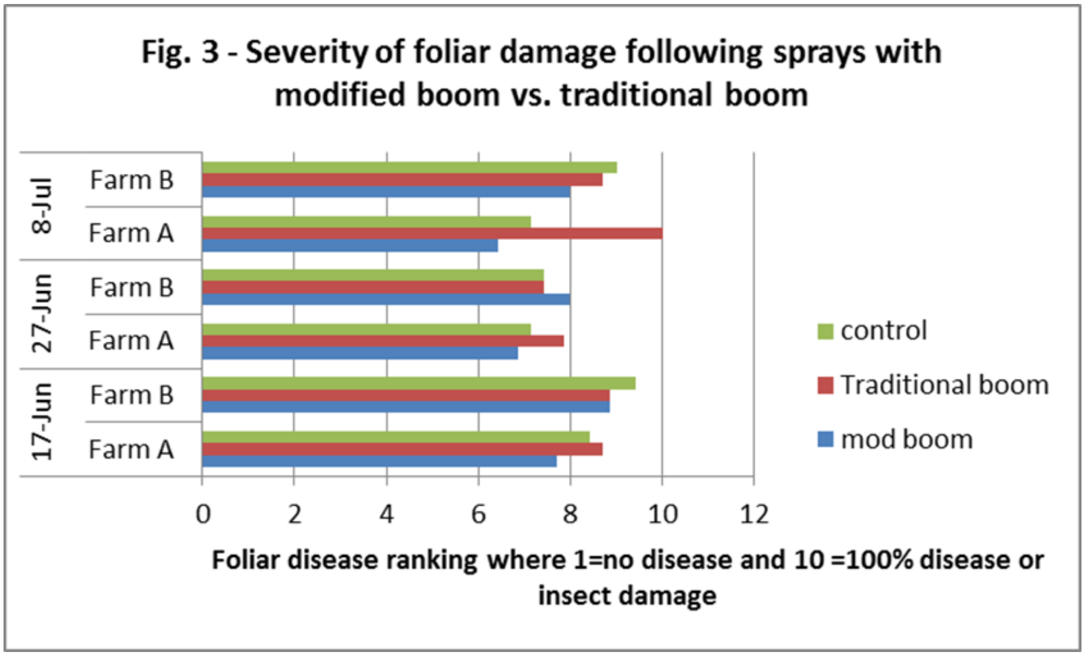
Florescent pyranine tracer was used to reveal the coverage of spray distributed throughout plant canopy at two different dates. The traditional boom sprayer delivered the best coverage to the outer leaves at both farms on both dates, but this was not the case for the mid and lower canopy leaves as the season progressed. The farm with the smaller boom sprayer and lower pressure application got better coverage from the modified hoop sprayer in the mid and lower canopy leaves and the improved coverage continued throughout the season. The larger boom that uses higher pressure during spray application did not see an advantage to the hoop until later in the season. Then, the inner and lower leaves were covered more thoroughly by the modified boom than they were with the traditional boom. See Figure 2.

Biological effectiveness was rated by noting the presence or absence of infection or insect damage on leaf and fruit tissue. These observations were made for 3 different canopy stages on 2 farms.



The degree of infection on leaf and fruit tissue was also rated.

The biological data did not support significant statistical differences between treatments, however, clear and consistent trends are apparent. See Figure 3. For 4 of the 6 comparisons, the use of the modified boom (hoop) appears to have an advantage over the traditional boom in the control of foliar disease. For all 6 comparisons, the use of the modified boom (hoop) appears to result in a lower incidence of disease infection and/or insect damage on the fruit than does the use of the traditional boom.



Summary: Applying crop protectants to strawberries can be improved with attention to variables like drift reduction, appropriate nozzle selection, increasing spray volume as the canopy grows and applicator skill and attention. The use of a modified boom may help growers perfect spray application, but more work on this prototype is necessary to better understand the importance of factors like row alignment in the field. The two farmer participants observed that straight rows and level fields would positively affect the spray application from a modified boom even more than those field attributes affect the performance of a traditional boom. Conversely, sloping fields and crooked rows will make it very challenging to use the more exacting modified boom successfully.

Source: New York Fruit Quarterly. Vol 19, No. 4.

Strawberry Weed Management Update

David T. Handley,

Vegetable and Small Fruits Specialist
University of Maine Cooperative Extension
Highmoor Farm, P.O. Box 179, Monmouth, Maine 04259
(207) 933-2100

One of the most common reasons for plowing down a strawberry bed is weeds. The first step in managing this problem is to select a planting site where the weed pressure, especially from perennial weeds, is low. This means a site that has previously had well managed cover crops and/or cash crops that either smothered weeds or allowed effective cultivation.

In a new bed, late planting can be used to manage early emerging weeds. The ground should be prepared in the fall or in the early spring, and the first flush of spring weeds allowed to germinate prior to planting. These are then killed by light cultivation, contact herbicide or flaming. Eliminating the first flush of weeds and planting into a warmer, drier soil, reduces the need for early cultivation and hand weeding. However, delaying planting by the four to six weeks this strategy requires may reduce the quality and performance of your stored strawberry plants, so work with your nursery to make sure the plants stored and shipped appropriately.

For weed management in harvest years, growers have developed renovation schemes that can reduce the typical flush of weeds that follows renovation by eliminating tillage from the scheme. Much of the weed pressure following renovation is due to tillage bringing buried weed seed up to the soil surface. Rather than tilling to narrow plant rows after harvest, contact herbicides or flaming are used. The sprayer or flamer must be adequately shielded to prevent burning the plants in the center of the rows (they should be narrowed to about 8 to 12 inches). Repeated burning will be necessary to manage weeds between the rows through the summer, and regular hand weeding within the rows will also be necessary, but by not tilling the soil, some growers have found that weed pressure in the second year is significantly reduced. Yields tend to be lower and fruit size smaller in the second harvest year with this practice.

The one harvest year rotation is probably still the best option for most organic growers (plant year one, harvest year two, plow down and plant to rotation crops) to manage weed problems in strawberry beds. However, some of the new strategies being developed may allow growers to extend the productive life of strawberry beds and thus improve their profitability.

Herbicides can offer good control of many weeds in strawberries if applied under the appropriate conditions. However, the use of herbicides alone rarely gives complete weed control. Other strategies should always be in combination with herbicides to get the best control of all weed problems. Herbicides registered for strawberries and their applications are listed below.

1. DCPA (Dacthal®): A pre-emergent herbicide used in the early spring, late fall or after renovation. It offers good, short-term control of some annual broadleaf weeds and grasses. It is weak on ragweed, galinsoga, smartweed, shepherd's purse and mustard. Its action will be improved if worked into the soil by irrigation or light cultivation, and it tends to work best in lighter, warmer soils. This may be used as an alternative to terbacil or napropamide when there is a high risk of plant injury from those products.

2. Napropamide (Devrinol®): A pre-emergent herbicide that provides good control of annual grasses, volunteer grains and some broadleaf weeds. It is typically applied just before mulching in the fall. Split applications have become popular due to the loss of other pre-emergent herbicides, e.g. half maximum rate application after renovation or in late summer after desired daughter plants have rooted, and a second half rate application once the strawberry plants are dormant. Napropamide should be worked in by irrigation, rainfall or light cultivation within 24 hours of application.

3. Terbacil (Sinbar®): A pre-emergent herbicide with some post-emergent activity, which should be applied at renovation time – after mowing and tilling the beds, but before new growth begins. A second application can be made in late fall, after the plants are dormant. No more than 6 oz. may be applied in a single application, and no more than 8 oz. may be applied in one season. An example of one season's use could be 5 oz. applied at renovation and 3 oz. applied in the late fall, the latter in addition to napropamide or DCPA. Terbacil can cause plant injury. It is important to determine appropriate rates for each location.

4. Clopyralid (Spur®): One application is permitted per crop per year following harvest to emerged weeds. Apply uniformly in a minimum of 10 gallons of water per acre. Do not tank mix with other herbicides. Clopyralid offers control of clover, dandelion and thistle.

5. Sethoxydim (Poast®): A post-emergent herbicide for control of actively growing grasses. It will not control broadleaf weeds. It should not be applied when grasses are under stress, e.g. drought, or on unusually hot, humid days. Do not use sethoxydim within 6 weeks of terbacil (Sinbar®) applications, to avoid leaf injury. Sethoxydim should be used in combination with a crop oil concentrate. Do not tank mix with 2, 4-D.

6. Clethodim (Arrow®, Prism®, Select®): A post-emergent herbicide, similar in activity to Poast®, for control of actively growing grasses. It will not control broadleaf weeds. It should not be applied when grasses are under stress, e.g. drought, or on unusually hot, humid days. Clethodim should be used in combination with a crop oil concentrate.

7. Paraquat (Gramoxone Inteon®): A contact herbicide for post-emergent control of most annual weeds and suppression of many perennial weeds. Paraquat will injure or kill strawberries, so applications are made between rows only, with a sprayer shielded to protect the strawberries. It should be used in combination with a nonionic surfactant. Paraquat should not be applied within 21 days of harvest or more than three times in one season.

8. Pelargonic Acid (Scythe®): A contact herbicide for post-emergent control of most annual weeds and suppression of many perennial weeds. Scythe® will injure or kill strawberries, so applications are made between rows only, with a sprayer shielded to protect the strawberries. This product has a relatively low toxicity and no residual soil activity. It has a strong, unpleasant odor.

9. 2,4-D Amine (Formula 40®, Amine 4): A post-emergent herbicide effective on most broadleaf perennial weeds. It will not control grasses, nor offer any pre-emergent control. 2,4-D should be applied immediately after harvest is complete if emerged broadleaf weeds are a problem. After application, the bed should be left undisturbed for three to five days, before mowing the leaves off the plants. This allows time for the material to be taken in by the weeds. This material can also be used when the plants are dormant (late fall or early spring) to control winter annuals and biennials. Fall applications may result in injury to the strawberries if the plants are not completely dormant. Do not tank mix 2,4-D with sethoxydim (Poast®).

10. Flumloxazin (Chateau®): A pre-emergent herbicide for control of broadleaf weeds, including dandelion and shepherd's purse. For use in the fall when plants are dormant for control of weeds the following spring. If small boadleaf weeds are emerged, also apply a crop oil concentrate at 1% or a non-ionic surfactant at ¼% by volume. Chateau will control emerged chickweed, field pansy, and oxalis if sufficient contact is made with the weeds. Chateau can also be applied with a hood or shield to row middles of non-dormant strawberries prior to fruit set.

11. Pendimethalin (Prowl H20®, Satellite Hydrocap®): A pre-emergent herbicide that may be applied to the soil surface prior to planting. It may also be applied as a band with a shielded sprayer between the rows of strawberries up to 35 days before harvest. No weed control will be provided within the plant rows, and contact of this product on the strawberry plants will cause injury. Prowl provides excellent control of many annual grasses and several broadleaf species. Satellite Hydrocap® can be applied during the dormant season or at renovation prior to new growth emergence.

12. Sulfentrazone (Spartan 4F®): A pre-emergent herbicide that may be applied to the soil surface prior to planting or just after planting, but before new growth appears. May cause damage to new growth; varieties differ in sensitivity. Offers good control field pansy and nutsedge.

Always read and follow all product label information and precautions. Where brand names are used it is for the reader's information. No endorsement is implied nor is any discrimination intended against products with similar ingredients. Users of these products assume all associated risks.

Managing Fire Blight Under Humid Climate Conditions in Eastern United States

Quan Zeng[1], Neil Schultes[1] and Daniel Cooley[2]

[1]The Connecticut Agricultural Experiment Station
[2]University of Massachusetts, Amherst

1. Fire blight disease cycle and control strategies

Fire blight is a devastating disease of Rosaceous plants such as apple and pear. Fire blight is caused by a bacterium *Erwinia amylovora* (van der Zwet et al., 2012).

Disease cycle:

- **Winter**: The fire blight bacterium overwinters in cankers formed during the previous growing season.
- **Spring**: When temperatures frequently reach 65°F, the bacteria become active and exude from the canker surface as bacterial ooze. Bacteria cells from ooze could be spread to open flowers through rain, wind, and insects. Under favorable conditions, fire blight bacteria can fast multiply on stigmas of the apple flower, and migrate from there down to the natural openings at the hypanthium tissue. This causes the blossom blight. Bacteria from the infected flowers will spread to other nearby shoots, leaves, and immature fruits through plant vascular system.
- **Summer**: Bacteria cells from the infected tissue may also exude to the plant surface as bacterial ooze, which will serve as the secondary inoculum of shoot blight stage of infection (Slack *et al.*, 2017). Ooze drops can be spread to nearby uninfected trees by insects, wind and rain. They enter plant through micro-injuries caused by wind, hailstorm, or insects.
- **Late season:** The infected tissue forms canker on branches and trunks.

Management practices:

- **Winter**: Remove fire blight cankers by pruning.
- **Early Spring**: Spray copper to reduce inoculum at silver tip and green tip.
- **Spring**: Protect the open flowers by spraying antibiotics at full bloom. Apply apogee to reduce the vegetative growth at petal fall.
- **Summer**: Scout for fire blight shoots and remove them by pruning.

2. Humid climate adds on additional challenges in fire blight disease management.

1. Apple growing regions in the U.S. differ by their precipitation patterns (Figure 1). Over 60% of the apples and 80% of organic apples were produced in the Pacific Northwest regions under the semi-arid conditions (NASS 2014). The humid climate conditions in Eastern United States added on additional challenges in controlling various diseases of apples.

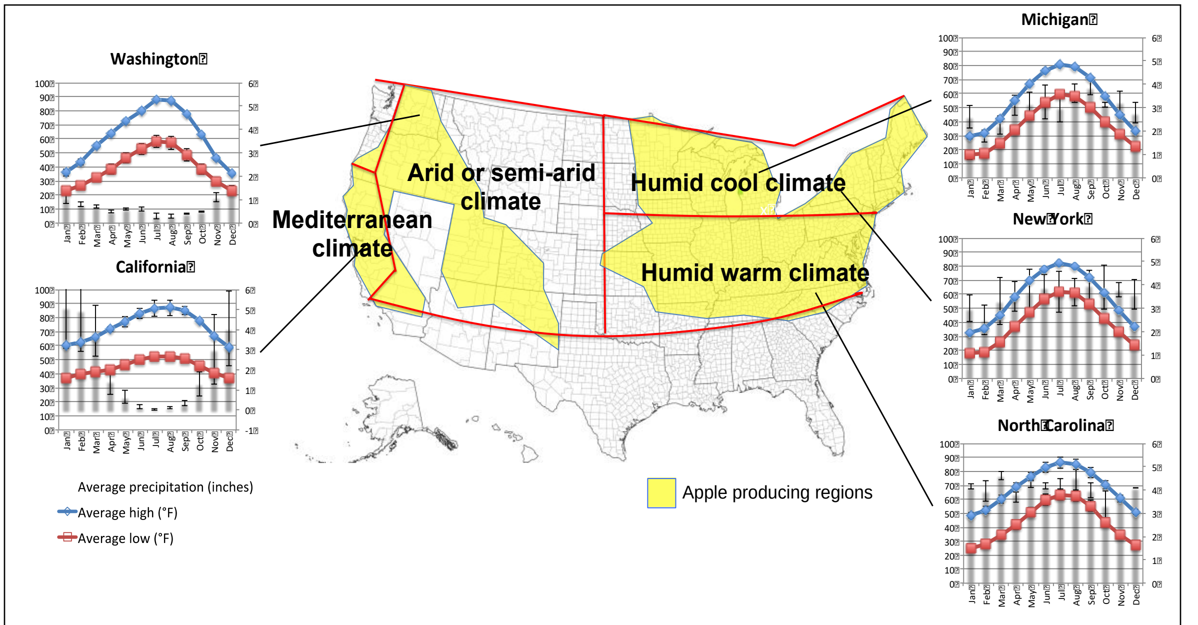


Figure 1. Dominant U.S. climate zones mapped against apple growing regions.

2. Precipitation and humidity is important in fire blight disease management. In the blossom blight stage of infection, water is essential for the fire blight bacteria to migrate from the stigma down to the hypanthium tissue where it causes infection. In the spring of 2016, temperature during bloom is highly inductive to fire blight in New England region (>70°C), however, relative humidity was really low. No major fire blight outbreak occurred that year.
3. Biological controls that suppress blossom blight stage of infection do not work as efficient under humid conditions as they do under arid or semi-arid conditions (Sundin *et al.*, 2009).
4. During shoot blight infection state, ooze drops can stay wet for a longer period of time under humid conditions than under dry conditions.
5. After bacteria from ooze droplets are spread to a nearby susceptible shoots, they can survive better under the humid condition than under dry condition with direct sun light.
6. Certain insects may be more active during humid condition which may facilitate the spread of fire blight pathogens.

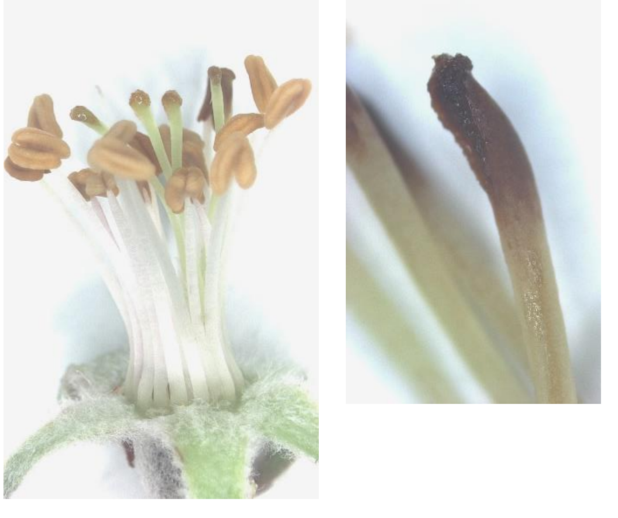


Figure 2. Fire blight infected stigmas showing moist associated with necrosis (browning).

3. **Take home messages for growers.**

   1. During bloom time, high temperature combined with high humidity/rainfalls is highly conducive to fire blight. Under these conditions, all open flowers need to be covered with streptomycin. Using one of the disease prediction models is recommended.
   - Flowers may not open the same time. Several applications on different days may be needed to cover all open flowers.
   - Wetting events are not restricted to only precipitations. Morning dews, or high humidity are also equally efficient in facilitating the migration of bacteria to cause infection.
   - Be careful with artificial wetting events, such as fungicide spay. Consider tank-mixing streptomycin with the fungicide. If they are not compatible, make sure the sequence of application is correct: apply the fungicide spray first, then apply strep immediately after.

   2. Planting and winter pruning need to be done in a way to ensure full sun penetration and airflow, especially for the high-density orchard setting.

   3. Scout the orchard often during the summer, and prune off the infected tissues especially EARLY in the season. The fire blight bacteria tend to form ooze droplets early in the season, mostly in May, June, and early July (Slack et al., 2017).

4. Research at CAES.

Goal: Develop effective biological controls for fire blight management in humid climate.

Objective 1: Evaluate the efficiency of current biological controls. Determine if combination with organic chemicals will enhance the disease control efficacy of the biological control materials.

Objective 2: Identify and test new biocontrol agents that are more adaptive to the humid conditions.

Methods:

Orchard testing in 2017 was performed at Lockwood farm of the Connecticut Agricultural Experiment Station on April 28th-May 1st. Red delicious apple trees were inoculated with E. a. ($5X10^6$ CFU/ml) at 100% bloom. Biological controls were applied at 40% and 70% bloom. Streptomycin was used as a positive control applied at 70% bloom and at 100% bloom after the inoculation. Organic materials Cueva and Oxidate 2.0 were applied at 100% bloom (after inoculation) and again at 24 hours after inoculation.

Results:

1. Bilogical control agents CT1 and Blossom Protect were able to reduce the fire blight disease incidence, to a level similar or better than copper (Cueva), when applied alone. CT1 exhibited a slightly better disease control efficacy than BP. Bloomtime biological did not show any level of protection against fire blight.
2. When used alone, organic antimicrobials/sanitizers cannot provide full protect against fire blight. However, these materials are useful in that they were able to further decrease the incidence of fire blight infection when used in combination with the biological

controls. When combined with biological controls, Oxidate 2.0 displayed a stronger fire blight inhibition than Cueva.

3. CT1+Oxidate2.0 is by far the combination with strongest fire blight inhibition effect. Trees treated with CT1+Oxidate2.0 displayed the same level of infection as the traditional material streptomycin.

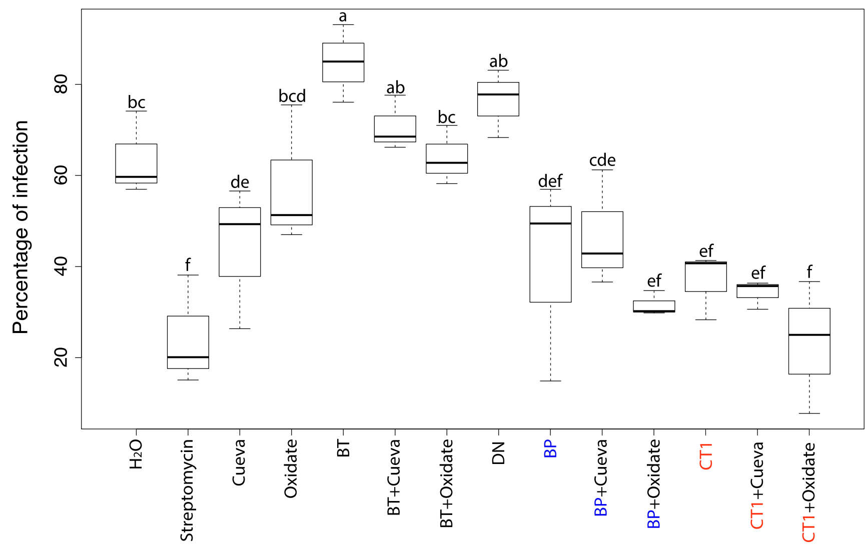


Figure 3. Fire blight control efficacy of the organic treatments in the 2017 trial. BT: Bloomtime Biologicals; DN: Double Nickle; BP: Blossom Protect; CT1: a new biological control strain from apple flower in CT.

References:

Slack, S. M., Zeng, Q., Outwater, C. A. and Sundin, G. W. (2017) Microbiological Examination of Erwinia amylovora Exopolysaccharide Ooze. *Phytopathology*, **107,** 403-411.

Sundin, G. W., Werner, N. A., Yoder, K. S. and Aldwinckle, H. S. (2009) Field evaluation of biological control of fire blight in the eastern united states. *Plant Disease,* **93,** 386-394.

van der Zwet, T., Orolaza-Halbrendt, N. and Zeller, W. (2012) *Fire blight history, biology, and management.* . American Phytopathological Society Press.

Development of a Multi-Life Stage Management System for Plum Curculio in Apple Orchards

Tracy C. Leskey[1]*, Torri J. Hancock*[1]*, Kathleen Leahy*[2]*, Daniel Cooley*[3]*, Arthur Tuttle*[3]*, Alan Eaton*[4]*, Aijun Zhang*[5], *David Shapiro-Ilan*[6] *and Patrick Drohan*[7]

[1] USDA-ARS, Appalachian Fruit Research Station,
2217 Wiltshire Road, Kearneysville, WV 25430-2771 USA

[2]Polaris Orchard Management, Colrain, MA 01340

[3]University of Massachusetts at Amherst, Amherst, MA 01002

[4]University of New Hampshire, Durham, NH 03824

[5]USDA-ARS, Invasive Insect Behavior and Biocontrol Laboratory,
BARC-W, 10300 Baltimore Ave, Beltsville, MD 20705

[6]USDA-ARS, SEE Fruit and Tree Nut Research Unit, 21 Dunbar Road, Byron, GA 31008

[7] Department of Ecosystem Science and Management, The Pennsylvania State University, 452 ASI Building , University Park, PA 16802-3504

A novel ‘attract and kill’ approach aimed at reducing insecticide inputs against was developed as a management tactic for plum curculio (PC). In this case, border row apple trees are baited with attractive olfactory stimuli including the male-produced aggregation pheromone, grandisoic acid, and the host fruit volatile, benzaldehyde. This approach results in PC attraction and aggregation in a few select border row trees. These select baited trees are subsequently treated with insecticides aimed at targeting multiple PC adults and eggs, while the remainder of the orchard are untreated. In addition, the identification of efficacious entomopathogenic nematode (EPNs) strains for PC have been identified. These EPNs are applied to the soil beneath ‘attract and kill’ trees to control larvae emerging from fallen fruit and pupating in soil, further reducing pest populations. In particular, *Steinernema riobrave,* has performed well against PC larvae in New England, killing greater than 95% of larvae in field trials. Future studies include replacing insecticide sprays targeting PC in ‘attract and kill’ trees with long-lasting insecticide treated nets as well as identification of persistent nematode strains that could replace strains that must be reapplied annually.

Nitrogen Management in Apple Orchards

Lailiang Cheng

Section of Horticulture, School of Integrative Plant Science, Cornell University
Ithaca, NY 14853 USA
Tel 607-255-1779; Email: LC89@Cornell.edu

Role of nitrogen in tree growth and fruiting

Nitrogen plays a very important role in determining apple tree growth and development, fruit yield and quality. This has been demonstrated in many sand culture experiments and field trials. In commercial orchards, however, some orchard soils with high organic matter provide a substantial amount of N during the summer, heavy N fertilization late in the spring with natural release of N from the soil during the summer can elevate tree N status to excess levels, leading to vigorous vegetative growth, poor fruit color development, and storage quality problems. At the other extreme, lack of N supply on soils with low organic matter can result in poor young tree growth, small fruit size, low yield, and alternate bearing. Because the effect of nitrogen on fruit set and size is just opposite to that of fruit color, flesh firmness, and storage quality, orchard nitrogen management has to be optimized to balance these opposite effects with the ultimate goal of producing high yield of quality fruit.

Nitrogen demand-supply relationship of apple trees

When developing a nitrogen fertilization program, the N demand-supply relationship of apple trees must be taken into consideration. Early season canopy development and fruit growth require high N supply whereas fruit quality development only requires baseline N supply. Our work with 6-year-old ‘Gala’/M.26 trees grown in sand culture showed that total tree N increased very rapidly from bloom to the end of shoot growth, and then continued to increase but at a much slower rate till fruit harvest. The net gain of total N from budbreak to fruit harvest is 20g per tree, which is equivalent to 50 lbs actual nitrogen per acre (Cheng and Raba, 2009). The total N accumulation in new growth (shoots and leaves and fruit) accounted for all the net N accumulation in the entire tree. Shoots and leaves and fruit have differential N requirements. Total N in shoots and leaves increased very rapidly from bloom to the end of shoot growth, and then remained unchanged till fruit harvest. In contrast, total N in fruit increased gradually from bloom to the end of shoot growth, and then increased rapidly till fruit harvest.

There are three sources of nitrogen supply. The first source is the reserve nitrogen that has accumulated in the tree from the previous growing seasons. This pool of nitrogen is readily available for the initial growth during spring. ^{15}N-labelling studies clearly indicated that the majority of the N required for spur leaf growth of apple trees is supported by tree reserve N. Better N supply to spur leaves and young fruits may improve spur leaf development and early fruit growth by promoting cell division. The second source is the natural N supply from soil mineralization process. The supply capacity of this process depends on soil organic matter content, soil temperature, moisture, and aeration of the soil. This process provides substantial amount of nitrogen for trees growing on soils with high organic matter (Stiles and Reid, 1991). The third source is nitrogen supply from fertilizers, either applied into the soil or to foliage.

The nitrogen demand-supply relationship is reflected in tree N status. Throughout the growing season, an ideal pattern of tree nitrogen status is that trees have relatively high nitrogen status early in the season to promote rapid leaf area development and early fruit growth. As the season progresses, nitrogen status declines gradually to guarantee fruit quality development and wood maturity. This provides a basic framework for guiding N management in apple orchards. Nitrogen management in apple orchards is all about matching tree N demand with the three supply sources in an environmentally sound way.

Tree and fruit nitrogen status

Determining tree N status is important for making decisions about whether and how much nitrogen fertilizer should be applied. Leaf analysis is highly recommended for this purpose as it indicates nitrogen and other mineral nutrients present in the foliage. If leaf samples are taken correctly and the results are interpreted properly, it provides a good tool for developing an effective fertilization program. Apple leaf analysis standards for nitrogen are listed in Table 1.

Tree growth is directly related to its nitrogen status. Rapid growth of young trees is highly desirable for developing the canopy to capture sunlight for promoting early cropping. The optimum leaf N for the growth of young apple trees is approximately 2.4 to 2.6%. As trees mature, less vegetative growth is desired and the optimum leaf N level should decrease to improve fruit color, firmness, and storage quality.

Table 1. Apple leaf analysis standards for nitrogen (from Stiles and Reid, 1991)

Tree type	Desired levels of leaf N (%)
Young non-bearing apples	2.4 – 2.6
Young bearing apples	2.2 – 2.4
Mature soft apples	1.8 – 2.2
Mature hard apples and processing	2.0 – 2.4

Varietal difference in fruit coloring and/or flesh firmness and storage quality is another important consideration. Apple varieties can be categorized into two groups, soft varieties and hard varieties, based on their optimum N status required for fruit quality.

Soft varieties include Cortland, Empress, Golden Delicious, Honeycrisp, Jerseymac, Jonagold, Jonamac, Jonathan, Macoun, McIntosh, Mutsu, Paulared, Spartan, Tydeman Red, and other early ripening varieties.

Hard varieties include Delicious, Empire, Gala, Idared, Liberty, Melrose, R.I. Greening, Rome, Stayman, York Imperial, and any other varieties if the fruit is for processing market.

Care must be taken when interpreting leaf analysis results, as many factors influence leaf composition, especially, cropload and tree vigor. Leaf N tends to be higher on trees with a heavy crop than those with a light crop. Off-year trees are generally lower in leaf N than on-year trees. This is because more vegetative growth of the light cropping trees dilutes the nitrogen in leaves. In contrast, trees that are spur-bound with very limited new growth tend to have higher than desired levels of nitrogen in their foliage, a result of N accumulation caused by the limited growth. To properly diagnose tree N status, one needs to combine leaf analysis with careful examination of tree growth.

Timing and Rates

Timing and rate of application of fertilizers must match the tree nutrient demand. For tall spindle trees, high N supply is needed in the first and second leaf to promote tree growth to reach the desired height. As trees are transitioned into fruit production in the third leaf, N supply should be lowered accordingly. Starting from the fifth leaf, N supply and tree N status should be strictly controlled to enhance fruit production and quality. For these trees, an ideal pattern of tree N status is that they have relatively high N status early in the season to promote rapid leaf area development and early fruit growth, and then the N status declines gradually to guarantee fruit quality development and wood maturity. This provides a basic framework for guiding orchard N management. N application via fertigation is preferred, which should match the high tree N demand period from bloom to end of shoot growth. If regular ground application of nitrogen is used, the best timing is between budbreak and petalfall for most soils except on sandy soils with low organic matter where multiple split applications during spring-summer period may be desirable. The rate of N application depends on soil organic matter content and tree N status. Because each orchard soil is unique and all the fertilizer field trials are site specific, the best way to fine-tune the amount of N fertilizer you should apply is to have your own N rate trial on your farm.

For orchard blocks that have good yield and fruit quality and satisfactory nutrient levels and balances, maintenance application of nutrients is needed for sustaining the productivity and fruit quality as all the mineral nutrients contained in the fruit are permanently removed from the orchard blocks by fruit harvest and they need to be replaced. This approach is applicable to all the nutrients, but particularly useful for those that have high concentrations in fruit, but a low reservoir in soil (Cheng et al., 2014). Potassium is a good example and its maintenance application rate is yield-dependent.

References

Cheng, L. and R. Raba. 2009. Nutrient Requirements of ‘Gala’/M.26 Trees for High Yield and Quality. New York Fruit Quarterly 17(4), 5-10.

Cheng, L. 2010. When and how much nitrogen should be applied in apple Orchards. New York Fruit Quarterly 18(4), 25-28.

Cheng, L., Hoying, S. and M. Miranda Sazo. 2014. Nutrient removal by fruit harvest and maintenance applications of nutrients in New York apple orchards. **New York Fruit Quarterly 22(2): 15-19.**

Stiles W. C. and W. S. Reid 1991. Orchard nutrition management. *Cornell Cooperative Extension Bulletin 219*.

Tips for Managing Young High Density Apple Plantings

Tyler Hardy

Brookdale Fruit Farm, Inc.
PO Box 389, 38 Broad St. Hollis, NH 03049
603.465.2241 ext.3 hardy.ty@gmail.com

With so many orchards across the country switching to larger and larger densities there is room for a lot of mistakes. At Brookdale Fruit Farm, we too are switching many of our older semi dwarf orchards to higher density orchards. Along the way we have made our fair share of mistakes, as is expected when trying something new. Here a few tips and suggestions to make when planting and training high density apples.

The biggest mistake we have made when planting high density orchards is having a consistent planting depth. By the book the correct way to plant a 3’x12’ orchard is to have the graft union about 4-6 inches above the soil line. Planting trees with a root shank of 18 inches is preferably, it is much easier to get a consistent planting depth with a consistent root shank. We use a Phil Brown planter to plant apple trees. At first we would plant and set the graft unions at about 4 inches above the ground. Over time, however, many of these graft unions sunk so that the graft unions were even or worse slightly under the ground. Talking with Phil Brown himself he gave us a couple different suggestions to fix this problem. By adjust the top-link from the tractor to the planter to apply more pressure on the back planting wheels, and by lowering the planting wheels themselves, we were able to get more consistent depth of the bud unions from the planter. The planter should be riding on the back wheels in order to properly get the right depth and for the trees to be packed in correctly. This correction seemed to correct most issues but we took it a step further.

One of the disadvantages of using a tree planter is the ridge that is left from the planter being pulled through the soil. This can lead to uneven ground which can cause an array of different issues. An uneven orchard floor can cause herbicides to be distributed unevenly; can also cause pooling of water around the trees in heavy rain events, and also drainage issues within the orchard itself. When we have planted trees in the past usually we are racing ourselves to get them in the ground and move onto the next task. When planting over 1200 trees to an acre you may as well through extra time and labor into it to make sure it is done properly. To eliminate the disadvantages of an uneven orchard floor and to also keep the bud union at a consistent height after planting we have changed our planting practices with extra steps. First plant the trees with a tree planter. Next rather than set the bud union height, rake the ditch and furrow smooth that the tree planter leaves behind. This follows with a worker setting the bud union height. Trees sometimes no matter what will sink a bit into the ground, so if your target bud union height is 4 inches set it to 6 inches. Always go slightly higher than what you would like it to be, or a good rule of thumb is the “fist” rule. If you can fit your clenched fist between the ground and the bottom of the bud union, the height will be ok. After someone goes through and sets the bud union height then come through again and rake the area smooth around the tree and into the row. By taking these extra steps it will help maintain a stable bud union height as well as eliminate draining problems.

After planting it's time to prune your trees right away! In the past many of us would never prune a newly planted tree very hard, cause the idea was to give the tree leaf surface to help the tree grow. In our experience it is imperative to prune young trees as if they were mature even after planting. First never, repeat never, head a tree that is planted in a high density system, it is important to let the height of the orchard fill as quickly as possible. Next remove any limbs that fall below knee height. An important step is to prune off limbs that fall with in the 50% rule, limbs that are half the size of the leader. Continue this up the leader of the tree, while trying to leave as many feathers as possible without too much competition to the main leader. The goal after planting is to have a well balanced tree that will allow even growth. When pruning limbs off of newly planted trees, it is in our experience to leave a beveled cut or renewal cut. Many may not want to do this on newly planted trees, but by leaving a renewal cut it will produce a weaker, flatter, and more favorable branch. Later in the summer single out the growth shoots by the leader. By pruning out any competitive shoots within 6 inches or more to the leader, it will allow the main leader to grow more dominantly. Be careful not prune far down the when singling out the shoots around the leader.

After planting it is very important to establish an irrigation system right away. Use 24 inch spacing ram tubing with flow rates ranging from 0.61 gallons per hour to 0.53 gallons per hour. Header line is what you punch the drip tubing into. Most orchardists like to have a more permanent header line that is buried on one end of the orchard while feeding the lines for each row of trees. This can be a timely process of digging and back filling, and can often lead to trees not receiving irrigation fast enough. At Brookdale one of the things we do to our newly planted orchards is use a non-permanent header pipe to establish irrigation right away. Using a 2 inch or 1 ½ inch header hose as a header line is a quick, cheap and easy way to get water to your new orchard right away. Pull out the ram tube down the rows, this will never have to be moved, and then lay down your header pipe. Using a starter with valve t-tape fitting you can connect your ram tube to your header pipe which will allow you the ability to water right away. This will help get water out right away rather than having to wait to dig and bury the header line. A 450 foot roll of removable 2' header usually runs around $145, so it's a relatively cheap expense to get water out right away. This also allows water to get out right away so you can worry about setting up your more permanent header pipe at a later time.

If planting high density makes you nervous and 1200+ trees an acre isn't something you're interested in doing, there are other options out there. At Brookdale we have a few plantings of more vigorous rootstocks planted closer together but applying some of the principles of tall spindle plantings to them. An option that we have had great success with is planting trees of M26 rootstock at 4'x'14' spacing. At 777 trees an acre at this planting it is 40% less trees planted per acre than at 3'x12' plantings which is a help to lower the startup cost. I double wire trellis with a conduit is a good trellis system for this style. Highly vigorous varieties, such as gingergold, may be tough to manage in a system like this. Like the tall spindle though you follow very similar rules. You still want a high bud union at planting, do not head the trees, prune heavy at planting and eliminate competition in the leader. In this system trees should reach their optimal height within the second or third year, pending on site and variety. When the trees reach height you want and vigor is still relatively high a good way to slow them down is to crop them heavily. The same principles of tall spindle should apply, "small limbs make small trees," any limbs half the size of the diameter should be pruned out. Limbs that are pruned out should be pruned with a renewal cut. To assure the development of a replacement branch, the large branch should be removed with an angled or beveled cut so that a small stub of the lower portion of the branch remains. From this stub a flat, weak replacement branch often grows. If you leave the stub longer, up to 4 inches, a very flat desirable replacement limb is more likely to regrow. Leaving a long stub is especially useful in varieties like gala, fuji, and macoun where those varieties tend to be very upright, but this practice can be applied to most any apple varieties. This system can produce large yields early and will easily exceed 1,000 bushel per acre at maturity.

Another system to consider if high density is not your thing is planting with Bud118 rootstock. Bud118 rootstock if left to grow to full size is similar in size to 111. This is a good rootstock to plant if there is not much water available, for instance on an away block or rented block, and is compatible with most soil types. Trees can be planted from 5’-7’ apart depending on variety with a row width of 14’-16’. This is a range of 622-384 trees per acre depending on spacing. Bud118 trees typically come with a good amount of feathers and a sturdy root shank. A single wire trellis with conduit is a good form of structure for this system. Renewal pruning still applies to this system and stick with the motto “small limbs make small trees” to help control vigor. One of the differences is that the bottom scaffold of the tree is more semi-permanent and will not be rotated out as frequently if ever like the tall spindle. In the first and second year it is encouraged with this system to weigh or tie down the bottom scaffold of limbs. This will help invigorate new limbs to be produced while keeping the vigor in check. If all goes according to plan you could pick as much as 600 bushel to the acre by the third leaf, with potential of around 1,000 bushel per acre at full maturity.

Growing high density trees can be an overwhelming feat. But with some of the tips as reported anyone can make it work. Find a system that works best for your needs including equipment, labor, and management. The key to successful orchards is finding a system that works best for the grower and the time they are willing to put into it.

Training Tall Spindle Orchards

Peter Rogers

Vice President, Rogers Orchards
336 Long Bottom Rd, Southington, CT 06489
peter@rogersorchards.com

Vertical extension of young trees is critical to the success and return on investment of a tall spindle system. Every pruning cut, bud removal, tying down limb or not, CLM call, and other decisions at the early stage of a high density planting will put that planting on a trajectory for higher and earlier yields. A tall spindle planting takes years of planning, its initially capital and labor intensive, and it will alter operation flow and conventional CLM decisions. The traditional benchmark for high density plantings suggested by Cornell is a production target at 3,300 bushels accumulated over the first five years. If this target is met, it is believed the entire investment is paid off in 5 years. Case studies done on our farm is slightly behind this benchmark with a breakeven into years 6-7. Here is our approach to a tall spindle system.

1.) Site prep: trees ordered years in advance, soil samples taken and planned course of action to remedy if needed, deer fenced, irrigation available.
2.) Install trellis immediately after planting: A new planting under support will help good vertical extension and will prevent breakage (especially with Geneva rootstock)
3.) Tree size and quality can vary from year to year / nursery to nursery, so pruning/training varies.

    <u>If trees have feathers:</u>

    A.) Remove limbs below 22” with a flush cut
    B.) Limbs larger than ½ diameter of leader, cut back to 1” stub (can be dutch cut but doesn’t have to be)
    C.) Any remaining limb, cut to 6”. Alternatively, tie limb tip down below horizontal. Either step will concentrate top growth.
    D.) On leader, remove buds 2-5
    E.) Leave small darts
    F.) Chemically remove flowers providing more energy for growth and reducing chance of fireblight. NAA at 5-10ppm
    G.) Do not head leader

    <u>If trees do not have feather</u>:

    A.) Bud removal of 2-10” on top of leader
    B.) Strip buds 22” and below
    C.) At bud break, spray bottle Promalin or MaxCel at 400ppm in branching zone. Notching is another option to promote branch development
4.) Applying white paint to trunks (22” & down) will help protect against SW injury, DWB and herbicide injury.
5.) Weed control applications after trunk painting: Our 1st application: Gallery & Prowl. 2nd application of Prowl & Gramoxone. 2nd application may vary based on scouting.
6.) Waiting 4-5 weeks after planting allowing soil to settle before applying Calcium nitrate. This will prevent fertilizer burn of roots.

7.) 1st dormant pruning, follow pruning steps previously mentioned with the idea of limb renewal.
8.) Defruit trees in 2nd leaf unless trees are at top wire.
9.) 2nd dormant pruning: follow pruning steps previously mentioned with the idea of limb renewal.

Profitable Winter Production of Microgreens in Michigan

Brian Bates

Bear Creek Organic Farm, Petoskey, MI 49770
bearcreekorganicfarm@gmail.com
www.bearcreekorganicfarm.com

We hear it all the time - microgreens must be one of the most profitable crops to grow, right?? And like so many things, it depends. And especially in the winter. Nothing matters unless you have a market. We started with 2 trays a week in the early spring to test the waters. We now seed over 200 flats per week year round, but that has been steady growth, not an overnight success. Do not be tempted by microgreens' fast growth time as an indicator of rapid riches. The learning curve takes time and is specific to you greenhouse, grow-room, latitude, market, etc. Here's what we've found to be the most important tips for success, especially in the winter.

Learn to grow microgreens sometime OTHER than winter. Winter is slow growth, long wait times, and expensive. Sure, it's great to have 'extra' income in the 'slow' times, but that can set you up for disappointment and frustration. Most of perfecting microgreens is the initial learning curve in your situation - your customers, climate, and lifestyle. So we think of it like this - if one flat of pea shoots takes 10 days to maturity from April - September, but up to 30-40 days in December - January, your rate of learning could be 3-4 times faster in the warmer months. Not only that, your heating/lighting expense will be next to nothing for most of those warmer months - making your learning curve take less time and only cost your time plus materials, no heating or lighting bills to pay.

Grow what you know. What you like. What customers enjoy. Learn the nuances of the micros you like and focus on those. In the winter, we find it necessary to reduce our variety offerings to accommodate longer growth times and less than ideal conditions for tender crops like basil. You should know your top sellers and focus on those. Even in a greenhouse, with heat and lights, not every microgreens crop enjoys knowing that it's 20-below outside! We like pea shoots, sunflower shoots, wheatgrass, red Russian kale, mizuna, cabbage, and daikon radish as reliable winter performers. Micro herbs, arugula, amaranth, sorrel, etc. tend to be more temperamental, take longer than they're worth, or both.

Plan for a backlog. If you grow microgreens April-September, you get into a consistent rhythm of timing and pacing, seeding and harvesting, and rate of sale. In the winter, you need to think of the same limitations as with any leafy crop, the time to harvest slows way down. Hence the backlog. Let's say you have space in your greenhouse for 100 flats. This means that in the summer, if your average production time is 14 days - you can have 50 flats getting ready to harvest each week, with the other 50 growing for the next week. And so on. So you have two plantings in the queue. In the winter, we find it common to have 4-5 plantings in the queue. This means that the 100-flat area you have can only provide 20-25 flats per week ready to harvest. So you can expand your area, decrease your market channels, reduce your variety selection, or some combination of all of those. Even with a germination chamber and supplemental lighting, we experience a backlog.

Know thyself. Know your lifestyle. This is last but certainly not least. We run a farm on fast-growing, high-rotation crops. We are seeding non-microgreens crops more weeks than not, for most of the year, in the greenhouse. We chose this life. We know many growers who think our approach is madness. They enjoy seeding long-season crops in the field a few times a year with less frequent but much larger harvests and doing ‘farm’ stuff, like cultivating with tractors, hauling trailer-loads of crops at a time, and enjoying some time off in the winter. If this sounds like you, microgreens are not your friend. Rain or shine, 100 degrees or 10-below, microgreens need daily attention. At least. They need water frequently. They can’t get too hot, but also not too cold. If you miss one watering in the summer, you can kill the entire crop. Microgreens are dependent on your care. In the winter, this means heating the greenhouse 100% of the time. It also means you need a warm place to seed, to store your soil, and water that won’t freeze. It means a wash/pack area that is heated, enclosed, and functional four seasons. Don’t underestimate the lifestyle shift microgreens can bring to your life - it’s more similar to a dairy farm than a vegetable farm. Our home is 40 feet away from our greenhouse - we can check on them all the time. But if you’re not used to crops being this dependent on your care, it can be a rude awakening.

So what makes microgreens a profitable crop at all? Especially in the winter? Well, the most important element - as with so many crops - is to make sure you can sell what you produce. Production is not always the problem, but with a rapid-growing, highly perishable crop - the margin for error is thin. The risk of overproduction is real. Secondly, you must carefully track your inputs in the winter - keep track of your propane or gas usage, your electric bill, your actual revenue. This assumes you know your cost of production in the summer. Your time, seed, and soil costs should be the same as in the summer. But your new costs are heat, electricity for lights/fans, snow removal (if applicable), rodent control, and potential crop failures for varieties that may not perform. We find microgreens to be very profitable in the April-September time frame and while still profitable in the winter, we plan for the realized net profit margin to be roughly half of the summer. Mind your costs, know your market, and know your lifestyle - growing microgreens can be a blast if you can do those three things. Happy growing!

Amazing Winter Tunnel Weed Control

Andre Cantelmo

Heron Pond Farm
299 Main Ave

If you have been growing in the winter for more then a few years then you have begun to see the challenge of winter weed control. Chickweed can wipe out entire crops of winter greens. Mechanical weed control can be time consuming to the point of making it not profitable to grow in the winter. Two methods of weed control rise to the top as choices for winter tunnel production; solarization and bed steaming.

Bed Prep

For weed control under either these methods to work bed prep, up to the point of seeding or transplanting must be complete prior to sterilization. If the soil is disturbed after treatment weed seeds that have not been treated will be brought into the germination zone and effect crop production. 25% soil moister content is a good level to aid in weed elimination. Greater soil moister creates a large BTU load to overcome to get to adequate soil temps for weed control. Less then 25% will reduce heat conductivity and result in cold spots that hinder weed control. I recommend those of you using a power harrow for bed prep to incorporate post watering. This will not only mix in the water to the soil but create air pockets for heat transfer.

Solarization

This will be more of the book report part of the talk. We mainly use bed steaming at Heron Pond Farm. We solarize one house out of seven used for winter production. Our goal for next year will be two. From an energy use perspective, it is the hands down winner. Solarization makes use of the sun to remove the threat of weeds from the top two inches of soil in the green house. The first steps of the process are the same for both solarization and steaming. After bed prep, a large sheet of plastic or tarp is laid out in the greenhouse. A nice tight fit and good soil contact improves success. After beds are prepped and plastic laid the house is shut up tight and the sun is left to cook the soil. The length of time needed for this process is the drawback. The Power Point will have a graph with time versus weed control axis. Nevertheless, If you have the time this is the way to go. Most of us have extra plastic around. If not a weed tarp can be had for a few hundred dollars and used for many years. This brings the cost of weed control down to below a penny a square foot if factoring in the multiple years of use of materials.

Solarization has two modes of action. Weed smothering and seed sterilization. I am convinced with this technique you are doing more of the former then the latter. For this reason, control will be less complete then with steam. Weed control will increase with every week you can leave the tarps on. One month seems to be a good rule of thumb depending on time of year. It is because of my greed to stretch the yield from summer crops in the greenhouses that led me to steaming. Solarization required me to pull out my summer crops to soon to in order for it to work correctly.

Bed Steaming

A steam sock is placed down the center of the area to be steamed. We had used a sock with grommet holes to distribute steam, now we use a woven sock. A tarp is placed on top of the area but a clear piece of plastic can be used in a pinch. The most important part of this set up is that the tarp is smoothed out and weighted down on the edges well. We use chains. 3/8th chain has more weight per foot then a two-inch piece of lay flat filled with water. The big benefit of using chain is that it follows the contour of the ground making sure there is a good seal. To aid in that we lay out the chain, then walk on it to make for good soil contact and a nice seal.

The steamer is started up and brought up to temp. We start the timer when we get up to full steam production. For our unit with the area of four foot by one hundred it takes four hours of steaming. If we move and restart the steaming just as the last bed is done we do not have to wait for full steam production. The unit is hot enough to produce steam from the get go and the clock can start running as soon as we turn it on.

A temp of 160 degrees needs to be held for 30 minutes to achieve desired weed control. When monitoring for temperature we need to be sure to take the temp from the coldest spot in the bed. Scouting will help with this. I would have thought that the coldest spot would be the furthest from the steam. In our case that is not true. The end of the run tends to be the hottest for us. We take our samples from the middle of the bed. Also, be sure not to take the temp from the very edge of the bed where the tarp meets the chain. Steam condense there and that spot gets hotter than four inches in from the edge, which will be colder. Stay away from the sock for measurement as that will be the hottest part of the bed.

When moving tarps remember that steam is hot! Chains will be hot. When cover come off a blast of steam will rise up and can burn you. Caution is required.

BTU Requirements

The power point will have a graph that has unit size, soil type, water contact, and total area that relates directly to BTU's. This is then translated into time needed to achieve desired temps. If you can afford a bigger unit then the economics of the steaming gets better. The more BTU's the better the efficiency of the process.

Results & Economic Benefits

Weed control is near complete with this process. Side benefit is that if you are going after weeds then most soil born disease will be wiped out as well. Our cost for this treatment works out to about eight cents a square foot. There is no way we could hand weed or hoe all winter for this kind of cost. The power point slide will have a breakdown of different cost and benefits under different crop conditions. This should give you an idea of how profitable this can be in your operation. In our case the winter weeds would make cropping in the winter impossible. The sterilization process makes winter production profitable.

Managing Spinach Downy Mildew & Other Diseases in Winter Greens

Margaret Tuttle McGrath

Plant Pathology and Plant-Microbe Biology Section, SIPS, Cornell University
Long Island Horticultural Research and Extension Center,
3059 Sound Avenue, Riverhead, NY 11901. mtm3@cornell.edu

Conditions during production of winter greens have proven favorable for some foliar diseases caused by pathogens that also tolerate cool temperatures, in particular downy mildews, and root rots. Occurrence is sporadic reflecting where the pathogen is present and conditions are favorable. Early morning is the best time to look for symptoms because foliar pathogens produce spores during nighttime; seeing spores confirms a diagnosis. Long periods of leaf wetness or high humidity promote development of most foliar diseases; powdery mildew being a notable exception. Common management practices for these diseases include selecting resistant varieties when available. Use drip irrigation or overhead irrigate when leaves are dry and afterwards promote rapid drying with fans. It is especially important to make sure leaves are dry after watering before placing row cover over plants. Vent high tunnels as often as temperature permits; but realize when open while field-grown crops are present, spores can move outside from an infected crop inside and vice versa. Foliar diseases are difficult to control with fungicides in leafy vegetables because of low tolerance for diseased tissue, especially when applications are started after symptoms are seen. Fungicides do not have the capability to cure diseased tissue. Thorough coverage is particularly important with organic fungicides as most have contact activity and cannot move through leaves as conventional fungicides can. Destroy diseased leaf tissue promptly after the crop is finished. Physically remove this tissue from tunnels when feasible to minimize potential for the pathogen to remain.

Spinach: Downy Mildew. ***There can be a long delay between infection and symptom appearance when conditions are unfavorable following infection. Downy mildew can seem to explode overnight when conditions become favorable again.*** The initial sources of the pathogen for recent occurrences of downy mildew in the region are not known.

<u>Symptoms</u>. **Purplish-gray, fuzzy growth of the** pathogen, which is usually on the underside of leaves, is diagnostic**. Early morning is the best time** to see as the growth (which is spores and the structures holding them) is produced overnight, and during the day spores are dispersed by air currents. On the top side of leaves, opposite where the growth develops, the leaf tissue will be yellow, initially dull becoming brighter and larger with time. Subsequently affected tissue will become dry and tan. If only leaf yellowing is seen, which could occur when humidity is low, put suspect leaves upside down on wet paper towel in a closed ziplock bag for a day. Keep the bag in the dark, such as inside a box, to further promote the pathogen if present to develop.

Management.

1. Select varieties with resistance to at least races 12 and 14. These races were identified associated with recent cases in the northeast that were tested. This is the most important management practice. There are varieties with resistance to all 16 races described so far, but seed is limited, in high demand, and thus more expensive than seed of other varieties.

2. Use production practices that minimize leaf wetness and reduce humidity. When using row covers, do not place over wet plants. Some occurrences of downy mildew in high tunnels have been associated with covering spinach when leaves were wet from watering.

3. Locate spring spinach transplants and crops as far away as possible from high tunnel spinach crops.

4. Rotate out of land where spinach was grown for at least 2-3 years. The pathogen can survive a few years in soil as oospores. Oospores can be produced when both mating types (equivalent of gender) of the pathogen are present together infecting a leaf. This spore type is the result of sexual reproduction. Oospores also could be left behind in soil after planting contaminated seed. Oospores are not dispersed by wind as occurs with sporangia, which are the asexually-produced spores on the underside of leaves.

5. Check plants carefully for symptoms at least once a week. Conditions during spring become more favorable as temperature and humidity increase.

6. For crops not managed organically, apply fungicides preventively or at first symptom. Conventional fungicides permitted used in greenhouses include Actigard, Aliette, ProPhyt and other phosphorous acid fungicides, Ranman, Revus, and Tanos). Organic products tested in university experiments have been ineffective or not adequately effective for commercial production. See report at
http://vegetablemdonline.ppath.cornell.edu/NewsArticles/SpinachDownyMildew.html

Labeled products include copper, Actinovate, Double Nickel, Regalia, Oxidate, Trilogy, and Zonix. Copper is considered most effective based on limited evaluations conducted. Check REI and PHI when selecting conventional or organic fungicides to make sure fits production schedule.

7. Report suspect occurrences promptly to your state extension specialist so that we can keep everyone generally aware of occurrence in the region, samples can be submitted for race identification to guide variety recommendations, and we can improve our knowledge about this disease.

8. Destroy spinach crop if symptoms continue to develop despite management practices or right after final harvest even if no downy mildew seen. It is important to control the amount of inoculum in the region to minimize opportunities for spread and keep downy mildew impact low.

Hot water seed treatment is unfortunately not expected to work for this downy mildew pathogen because it contaminates the seed as oospores, which are pretty tough structures. They are likely imbedded in the seed coat making them difficult to physically remove. Additionally, there is not solid evidence that oospores on seed serve as a source of inoculum.

Note that while leaves are held in plastic bag after harvest, affected leaves may rot and new symptoms may develop, especially if there is residual moisture from washing.

<u>Other Susceptible Plants</u>. The pathogen, *Peronospora farinosa* f. sp. *spinaciae,* is only known to infect spinach. It is possible some related (Chenopodium) weed species are susceptible to some races. However, cross infection experiments conducted to date have not been successful: pathogen taken from spinach did not infect any weeds and pathogen from weeds did not infect spinach.

<u>Pathogen Sources</u>. Possible initial sources of the pathogen for the northeast region are wind-dispersed spores (sporangia) from affected crops outside the region, infected spinach produce

from outside the region, or oospores on contaminated seed. Spinach with downy mildew has been observed for retail sale.

Favorable Conditions. Cool with long periods of leaf wetness or high humidity. Wet foliage is especially favorable. Optimal temperature range for this pathogen is 59 – 70 F. However, spores of the downy mildew pathogen have been observed on plants over a very wide temperature range, from freezing (frozen plants) to 118 F!

Based on observations from growers, conditions in high tunnels are not very favorable for downy mildew (likely too cold) except during long periods of leaf wetness (such as when row cover put over wet plants). Varieties bred to be resistance to downy mildew can be very effective when resistance includes the pathogen race present. Past spring occurrences were promptly destroyed, thus the pathogen did not have much opportunity to spread. Some downy mildew pathogens have demonstrated ability to spread well via wind-dispersed spores. The cucurbit downy mildew pathogen in the eastern U.S. starts in southern Florida and spreads at least as far north as Long Island every year (occurrences in upstate New York and New England may result from spores dispersed from the mid-west). The basil downy mildew pathogen has been found on single, isolated plant in a landscape planting. Sources of the pathogen for the recent occurrences have not been identified.

Spinach: Cladosporium leaf spot.

Symptoms. Spots caused by this fungal pathogen are round, small (up to 1 cm in diameter) and tan with green fungal growth (mostly spores) eventually developing in the center. This growth distinguishes this disease from anthracnose and Stemphylium leaf spot.

Disease cycle. This pathogen can be seedborne. Its spores are dispersed by wind and splashing water. Cool, moist conditions are favorable.

Management. Treat seed with hot-water or bleach. Use drip irrigation. There are no conventional or organic fungicides labeled specifically for this disease that are permitted used in a greenhouse.

Lettuce: Downy Mildew.

Symptoms. Initial symptom on upper leaf surface is typically light green to yellow areas, often angular in shape being bounded by major veins. Diagnostic white fluffy growth of the pathogen develops typically on the lower surface under these lesions, but can occur on the upper surface (especially when affected leaves are bagged and refrigerated) and can be present more generally on the lower surface similar to powdery mildew. Early in infection only spores may be present. Affected tissue eventually turns brown. Older leaves often are affected first.

Disease cycle. Potential initial sources of the pathogen include spores dispersed by wind from other lettuce plantings, plant debris when previous lettuce crop was affected, and contaminated seed; however, the risk of infection from contaminated seed is not know. Downy mildew pathogens have narrow host ranges (the one affecting lettuce is not the same as the one on spinach) and they are obligate pathogens, meaning they need living host tissue to survive unless they are able to produce a specialized spore (oospore), which requires presence of two strains of the pathogen of opposite mating types because oospores are the result of sexual reproduction.

Management. Select resistant varieties. Conventional fungicides labeled for this disease that can be applied in greenhouses include: Actigard, Aliette, ProPhyt and other phosphorous acid fungicides, Ranman, Revus, and Tanos. Organic fungicides include copper (check label as some products are not permitted used in greenhouses), Actinovate, Cease, Double Nickel, LifeGard, Oxidate, Regalia, Serenade, Sonata, Timorex Gold, Trilogy, and Zonix.

Kale and Lettuce Powdery Mildews.

Symptoms. Characteristic superficial white growth of the pathogen develops on both leaf surfaces. It develops a powdery appearance when the pathogen produces spores. Leaves can quickly become covered with the powdery growth.

Disease cycle. Powdery mildew pathogens have narrow host ranges, thus different pathogens cause powdery mildew in kale and lettuce. Also similar to the downy mildew pathogens, they are obligate pathogens. But in contrast, they do not need long periods of leaf wetness or high humidity to develop, and in fact develop best under dry conditions. Kale is more commonly affected than other brassica crops as a result of variation in susceptibility and/or physiological specialization in the pathogen.

Management. Organic fungicides listed above for lettuce downy mildew are also labeled ofr powdery mildews with the exception of Zonix. Other fungicides include sulfur, JMS Stylet-oil and other mineral oils, and MilStop and other potassium bicarbonates.

Root Rot. Several pathogens able to survive in soil can infect roots. These pathogens do not need living plant tissue to survive, and have much wider host ranges than the mildew pathogens. *Pythium* is likely the most common affecting winter greens because cold, wet soils are favorable for its development. Typical symptom of root rot caused by *Pythium* is the outer cortex sloughed off revealing the white center.

Management. Manage irrigation to avoid soils becoming saturated and remaining wet for long periods. Biopesticides labeled for root rotting pathogens include Actinovate, Bio-Tam, Double Nickel, Promax, RootShield, Serenade, Taegro and SoilGard.

Please Note: The specific directions on pesticide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Note that some products mentioned are not yet registered for use on cucurbits. Check labels for use restrictions. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.

A Farmer's Winter Production Story in Vermont

Paul Horton

Foggy Meadow Produce
2494 Lake Rd. Benson, Vt. 05743
phorton@shoreham.net

Vegetable farming can be a reasonably pleasant and orderly profession, especially when managed as a production system. That is, if the farm business has, and employs the necessary and effective components of a production system. Seeding and planting schedules, labor management practices, production quotas, and the management and continuous reduction of variables all help to make outcomes more predictable. We all spend much time and money reducing the variables in our systems. That is why we have irrigation systems – to mitigate the inevitable variability of rainfall. We use drainage systems such as ditches and drain tiles to give us better control of the moisture in the ground. Many of us have heated benches in our propagation houses to deliver consistent heat to our plug trays and we use shade cloth for cooling. We do anything we can to flatten out the curves nature gives us.

It didn't take many years of winter greens production to realize my biggest constraint to greens harvest every week of the winter was the inability to control the temperature of the soil in my winter greenhouses. I would have great looking greens until early January or so, then would come a week or two of very cold weather. Yields would plummet. Plants would freeze and thaw and melt to the ground. Some would die while others survived. I could usually recover pretty well in late winter and spring, but the fact remained that I could not control the soil temperature, my plants were either dying or losing quality, and it was costing me money. In addition, I had customers who had counted on me, and I felt that I had let them down when I didn't have enough greens each week. I simply was not able to control the highly variable temperature at the root zone of the plants in my High Tunnel; the same plants I had already spent considerable time and money nurturing.

When I installed my first High Tunnel I decided to install radiant ground heat. It cost me about $8,000.00. I calculated that if I could have greens for sale every single week of the winter, the system would pay for itself during the first year.

A radiant ground heat system is not that complicated. My systems each have a tankless Rinnai propane fired hot water heater as the heat source. I installed nine loops of 100 psi. black poly pipe, buried 24" below the surface to distribute heat to the soil mass. There is a pipe every 18" across the width of the High Tunnels. I went 24" deep on the pipes so I can use my 70 hp tractor for primary tillage once per year. In addition, there is considerable mass in the soil volume and more thermal mass translates to greater temperature stability. The rest of the radiant system consists of a circulator pump, expansion tank, temperature and pressure gauges, and two manifolds to distribute the water to the soil and return it to the heater. I generally set the water temperature at 100 degrees and it returns to the cold water manifold at 60 or 65 degrees. The difference in temperature represents the heat given up to the soil.

During the years I had only the one 30’ x 144’ High Tunnel, we only planted greens that would allow us to harvest them right down to the ground and then they would begin to regrow immediately regardless of the day length, providing the soil temperature was kept in the high 40’s to the low 50’s. This allows growth for kales, chard, claytonia, spinach, and a wide variety of Asian greens and mustards. Spinach is not one of my favorites in terms of total yield. It produces very little regrowth when I need it the most – between mid December and early February and is susceptible to disease. Customers, however, demand it. Claytonia is my favorite winter green. We have not been able to harvest it before late January, but it is a vigorous grower that produces a pound per bed foot per cutting for five or six cuttings until it bolts in April. Claytonia goes in all of my greens mixes and customers also like buying bags of just claytonia.

My winter greens production system begins each year on August 1st. All the kales, swiss chard, and the first winter spinach seeding are done then.

September 15th brings soil preparation; chisel plowing and rototilling, to the High Tunnels. All the above kales, chard and spinach are transplanted at that time.

We have been doing three or four plug seedings, beginning about September 15 and ending October 10. I prefer transplanting into the winter High Tunnel because I am guaranteed to have the plant density I want. I seed several hundred extra plugs for backup in case there is any mortality after transplanting. The plugs go in the ground three to five weeks after seeding with the last transplanting near November 1. Three weeks after transplanting, just as the plants begin top growth is the time to hoe everything. This is the best defense I have found to prevent problems with chickweed.

Indoor harvesting begins some time in November depending on weather. Kales and chard are bunched until too small to bunch then they are bagged. We cut mizuna and arugula with knives and harvest everything else leaf by leaf. This allows for much faster regrowth and bagged greens without flat spots from a knife. Three of us can harvest 100 pounds of greens in just two or three hours this way.

We always clean the plants as we harvest. Any dead, low quality, or diseased greens are put in piles in the aisles. We pick them up and compost them at the end of the day. I think this is important because it maximizes the amount of energy and resources going into growth that will be saleable, increases airflow and helps to keep fungal disease at bay. I run the HAF fans each morning until all foliage is dry and all dripping from the purlins has stopped.

Regardless of how many methods I use to promote rapid regrowth, there is a limit to it. I have added another 30’ x 96’ High Tunnel because there has been more demand for winter greens than supply. I have discovered that if I can stockpile enough greens to get through late January, then the regrowth from the earliest harvestings back in late November and early December will be ready to harvest in early February. We will harvest for three weeks, or into mid February when the day length begins to exceed ten hours, then everything really takes off. Everything goes great until brassicas decide it is time to bolt so it is imperative to either have overwintered plants ready to come online or to re-transplant in very early February. We do staggered transplantings starting in early February and continuing into April. It takes some practice to figure out how many producing plants to pull out and replace with plugs. It works because the yields are increasing each week instead of decreasing each week as they do in the fall.

I have settled into using many of the same winter greens varieties each year, and have continued to experiment with different plug seeding dates and trial several new greens varieties each year. This has been a dynamic process with always much to learn. In general I have found winter greens production to be rewarding, profitable and enjoyable.

Baby Lettuce and Other Winter Greens Trials at Intervale Community Farm
Andy Jones

Intervale Community Farm, 282 Intervale Road, Burlington, VT 05401
andy@intervalecommunityfarm.com

Intervale Community Farm grows 25 acres of certified-organic produce and 30,000 ft^2 of tunnel crops. Crops are marketed through on-farm summer and winter CSAs. In business since 1990, but we didn't enter the winter growing game seriously until the winter of 2013-2014. The addition of a significant quantity of fresh greens to our winter CSA has been a huge crowd-pleaser for our CSA members and also a good marketing move.

Hardiness, consistency, and yield have been the key criteria for us in evaluating our winter tunnel crops, and after a few years, we have settled on a few staple crops, which we aim to have throughout the winter, and a few reliable secondary crops that we aim to have some of the time:

- Staples: Baby lettuce, spinach, arugula
- Reliable secondary crops: (Baby) kale, (Baby) Pac Choi

Our primary houses are four unheated 32' x 132' Harnois Ovaltech IIIs, with additional seasonal use of 14' x 96' & 14' x 144' Ledgewood tunnels. The baby lettuce, baby pac choi, and most of the spinach are grown in the larger houses, as they provide a warmer environment with less temperature fluctuation. The baby lettuce and pac choi would not survive in the narrow houses. We can harvest arugula in the 14' wide houses through early January and then again from late March onward. We also seed arugula as our fill-in crop for vacated beds. The baby Red Russian kale seems fine in the 14' tunnels, though it is a low yield per square foot no matter where we plant it, so we don't grow much.

We use 0-2 row covers suspended about 12" above the crop for additional protection of sensitive crops on cold nights. Covers are removed many daytimes for humidity control and solar capture. The Harnois tunnels are ventilated with rollup sides in the spring, summer, and fall, and a 3' peak vent fan during winter months. We typically aim to keep our winter daytime temperatures in tunnels 45 degrees F or below.

Our greens rely on substantial residual from summer tomatoes or cucumbers, though we've gradually increased our supplemental nitrogen to a nominal rate of 80lb. N/A. Relying on residual fertility alone wasn't keeping growth and re-growth rates up throughout the winter.

Our baby lettuce production revolves around the baby leaf lettuces from the Salanova (through Johnny's Selected Seeds) and Eazyleaf (Vitalis Seeds; various vendors) product lines. All of our lettuce is transplanted on a 5" x 7" spacing from 4 week old transplants, 8 rows to a bed, 4 drip lines per bed. This density seems to be close enough for reasonable yields per square foot, but far enough apart to allow for decent airflow. We typically harvest each plant 2-3 times for baby leaf. Regrowth takes from 3-6 weeks, depending on the time of year.

We began comparing the Salanova and Eazyleaf lines in 2016, and we have more trials of each this winter. Salanova lines feature red and green leaf, red and green oakleaf, and red and green butterhead. The Eazyleaf pantheon is not quite as broad, in that butterhead lettuces are not available, being limited to red and green of both oakleaf and leaf types. Neither lettuce is cheap, but Eazyleaf runs about ¼ of the cost per seed of the Salanova, despite Eazyleaf being certified organic seed in addition to an organic pellet.

Overall, the Salanovas are clearly more productive in the outdoor summer and fall crops by 35-40%. This varies by cultivar within the group. In the winter tunnels the Eazyleaf we grew were very comparable in yield, with the variance mostly related to the particular cultivar rather than the entire line.

Almost all of the ICF staff preferred the taste and texture of the Eazyleaf varieties, especially after the initial cutting. The Salanova leaf varieties have a tendency to get spiky and coarse in the mouth as the planting ages, which happens, but more slowly, with Eazyleaf. Likewise, most of the Salanova have an inoffensive neutral taste, where some of the Eazyleaf cultivars actually have a pleasing, lettucy taste. The butterhead Salanovas are the best tasting and have the nicest mouth feel of all, but are much less consistent and productive than the other Salanovas, and don't respond to multiple cuts as well.

All of the Salanova and Eazyleaf have very strong resistance to Lettuce Downy Mildew. Most of the leaf and oakleaf varieties of both Salanova and Eazyleaf are similarly strong vs. powdery mildew, thought the Salanova butterheads are susceptible, which has been a problem for us in the winter. However, leaf disease is not our chief winter problem: Botrytis Crown Rot (BCR) is the bane of our winter lettuce crop. We have been working to reduce humidity in the winter tunnels with increased ventilation, since moisture is the ostensible culprit. We are also planting our lettuce plugs shallower to keep soil away from the crown. It appears to us that there are also strong genetic factors at work. In prior years, we ran our tunnel soil very dry all winter long, and still had a lot of BCR.

Many of the Salanova cultivars collapse over 2-3 weeks in the event of an outbreak of BCR. When facing an infestation, we can usually get an initial harvest, but won't have a second or third cut. Last year, 'Buckley', a red oak Eazyleaf, stood tall and hardy while every other Eazyleaf and Salanova collapsed around it. Literally months later it was unaffected. We are running that trial again this winter to see, but it begs the question of genetic factors. 'Buckley' has a very dark red, shapely leaf, with relatively good eating texture and flavor.

Ultimately, we are growing both Salanova and Eazyleaf lettuce. We do this partly to spread our risk over different genetics, and partly because we want what our customers want: a baby lettuce mix with lots of different shape, textures, and colors, and growing both provide that.

Grafting Melons to Extend the Growing Season, Reduce Sudden Wilt & Increase Yield

Janel Martin M.S.

University of New Hampshire
Jlmart17@ncsu.edu

Melons [*Cucumis melo* L.], though potentially a high value crop for New England, production is often limited by traditionally cool growing season and sudden wilt. Sudden wilt is a syndrome characterized by rapid wilting of vines typically near the harvest period when plants have a heavy fruit-load. Plants do not typically recover from these symptoms, resulting in yield reductions, fruit quality, and ultimately revenue loss. The main cause is thought to be a soil-borne pathogen with possible secondary abiotic factors that increase the severity of the symptoms. Though the use of early melon varieties, rowcovers, and black plastic mulch have brought about earlier melon yields to address cool growing conditions, sudden wilt occurrence remains a problem for growers in the region. One promising solution that has been shown to reduce sudden wilt in melon production in other areas of the world is vegetative grafting (Fig. 1). Rootstocks of interspecific hybrid squash [*Cucurbita maxima* Duchesne x *Cucurbita moschata* Duchesne] have shown compatibility with melon scions and have shown increased tolerance to soil-borne diseases. In addition, melons grafted to interspecific rootstocks have exhibited tolerance to cold soils which is essential for earlier transplantation.

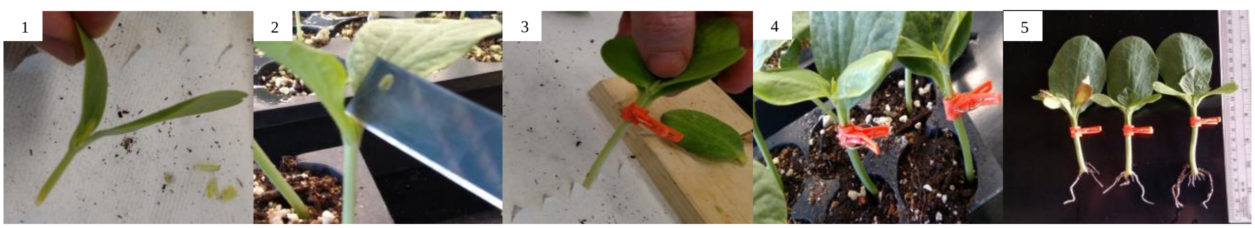


Figure 1. Grafting process: 1) Remove scion from roots cut at 45º. 2) Remove one cotyledon and growing point of rootstock using 45º cut, and remove from roots just above soil. 3) Clip scion and rootstock together using grafting clip. 4) Insert seedling into very moist growing medium and place in healing chamber. 5) Root emergence after 4 days. Plants remain in healing chamber for eight to ten day. In 2016, two studies were performed at the Kingman Research Farm to compare grafted and non-grafted melons for season extension, and to evaluate five popular New England varieties with a single rootstock selection. For the season extension study, the yield and quality of fruit from grafted and non-grafted 'Halona' melon plants using NH1320 rootstock were compared at two early transplantation dates on May 12 and 21, and a standard schedule on June 1. In addition to planting dates, two irrigation frequencies were used, each watering session was two hours and lengthened to three hours in periods of high water stress, one treatment received water every two days, and the other treatment received water every four days. For the cultivar-grafting study, 'Carnivor' rootstock was grafted melon varieties 'Sarah's Choice', 'Athena', 'Diplomat', 'Goddess', and 'Snow Leopard' and fruit yield and quality were evaluated. Plants were field grown in raised beds with black plastic mulch and irrigated with drip tape. Beds were eight feet on center, and plants were transplanted two feet apart within the row. Wide floating rowcovers were used for protection during cool periods.

Grafted melon plants maintained growth and continued to set fruit over a longer time-period compared to non-grafted melon plants, resulting in a longer market window. However, variations in the pattern of fruit development occurred among varieties in both grafted and non-grafted plants (Fig. 2). Harvests of non-grafted melon were typically a few days earlier than grafted melons, but total marketable yields of grafted plants were 131%, 123% and 148% higher than non-grafted plants from May 12, May 21, and June 1 planting dates, respectively (Table 1). Similar yield increases occurred in the five varieties grafted to the Carnivor rootstock compared to non-grafted plants, but the scale of increase varied among varieties. Total marketable yields of grafted varieties were 36% to 90% higher than that of non-grafted plants. The higher yields were due to the increased fruit number and size of grafted over non-grafted melons (Fig. 3). Average fruit size was significantly larger in most grafted plants (2.02-3.1 kg) as compared to non-grafted plants (1.35 – 2.01 kg), with exception for ‘Snow Leopard’ which had similar fruit size between grafted and non-grafted melons (1.2 kg).

The quality of melon fruits, determined by measuring soluble solids content (SSC), was not significantly different between grafted (10.7-11.4%) and non-grafted (10.7-11.8%) melons with exception for ‘Diplomat’, which had higher SSCs in grafted melons than non-grafted melons. For all experiments, grafted plants exhibited more vigorous and sustained vegetative growth than non-grafted plants, increased yields between 36% and 147% over non-grafted melon plants, and fruit quality was similar in grafted and non-grafted melons. Grafted melon plants certainly possess potential benefits for New England growers who have experienced yield losses due to sudden wilt, or are not able to justify planting this traditionally short season crop. These results demonstrate the potential of melon plants grafted to interspecific hybrid squash rootstocks to reduce the effects of sudden wilt in melon, increase yields dramatically, and maintain fruit quality.

Table 1. Marketable yield in cwt per acre of grafted and non-grafted melon plants at three different planting date, May 12 and 21, and June 1, 2016, and at two irrigation frequencies. NG=non-grafted, G=grafted, High=higher watering frequency, Low=lower watering frequency.

	Planting Dates		
	May 12	May 21	June 1
Treatment	Marketable Yield (cwt/acre)	Marketable Yield (cwt/acre)	Marketable Yield (cwt/acre)
NG/High	341		278
		283	
NG/Low	318	299	287
G/High	713	629	690
G/Low	690	595	515

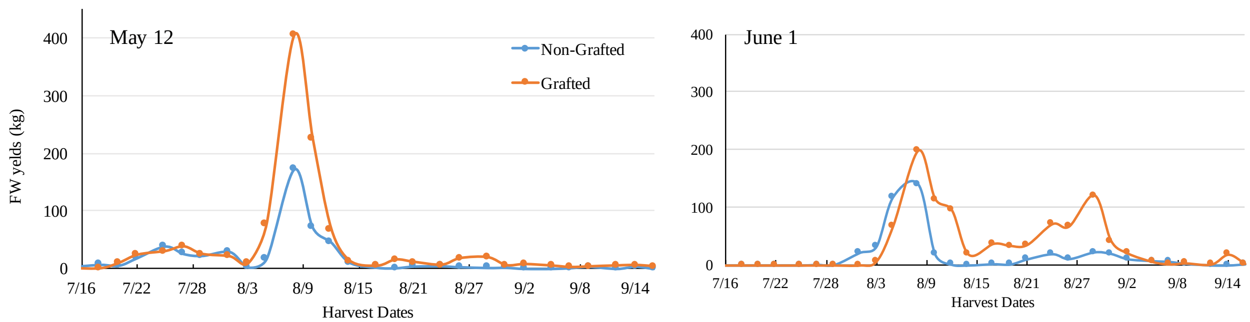


Figure 2. Comparison of seasonal harvest patterns between early and traditional planting dates of grafted and non-grafted melon plants.

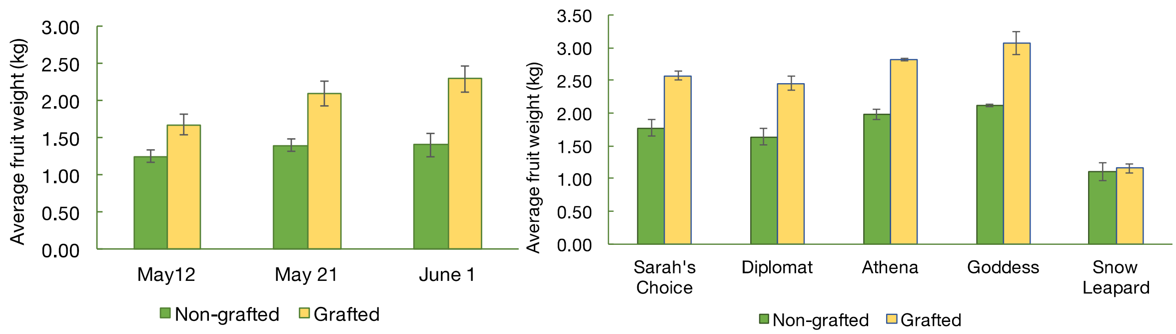


Figure 3. Comparison of average fruit weight between grafted and non-grafted melons of five different cultivars. Different letters within rows indicate significant difference according to Tukey's HSD ($p < 0.05$).

Figure 4. Peak harvest of 'Halona' melon variety on August 8, 2016. Each pile represents yield from single plot of eight plants. Largest fruit number of 53 fruit from plot of eight plants. The right side of photo in foreground is grafted plants with maintained vigor, and row above is non-grafted plants that show signs of sudden wilt.

Developing Innovative Cucurbit Varieties for Expanding Local Agricultural Markets

Brent Loy

Department of Agriculture, Nutrition, and Food Systems,
University of New Hampshire, Durham, NH;
james.loy@unh.edu

Current breeding efforts encompass research on several cucurbit crops, including melons, acorn squash, yellow summer squash, ornamental pumpkins, seed pumpkins, butternut squash, kabocha squash, processing squash, exotic squash, and use of wild species as a source of disease resistance. Most of these programs are long term, but many projects such as those dealing with ornamental pumpkins, melons, acorn squash, and seed pumpkins have resulted in recent releases of new varieties. In this report I will describe some of the most notable recent releases which appear to have promise in New England, and also some projects which may produce some unique varieties in the near future.

YELLOW SUMMER SQUASH. The quality of yellow summer squash being sold in most supermarkets is exceedingly poor. The squash are piled in bins, have inconsistent shape, and often display bruises from lack of care during harvesting and scratches from the extremely spiny foliage of most yellow summer squash varieties. As a result of my discovery of a glabrous (spineless) gene in yellow summer squash 25 years ago, I have sought to bring to market some productive varieties, which because of fewer spines (technically trichomes), are kind to harvesters and reduce postharvest damage to fruit. The first variety released, Slickpik® YS26, while quite productive, tends to produce excessively elongated fruit and lacks powdery mildew resistance (PMR). We have two new varieties available this fall, ‘Blonde Beauty’ (Rupp Seeds) and ‘Smooth Operator’ (High Mowing Organic Seeds). Another variety is in production by a seed company in the Northeast, and a fourth company plans to offer a glabrous variety in the near future. The advantages of the newer varieties over YS26 are intermediated PMR, increased productivity, and shorter, thicker fruit. Another feature of these varieties is that none carry the ‘B’ gene for precocious yellow fruit. Many current yellow squash varieties incorporate the ‘B’ gene because the early color masks some of the green streaks caused by some viruses. However, fruit of varieties carrying the ‘B’ gene are susceptible to chilling injury, thus appreciably reducing refrigerated storage life.

MELONS. Compared to when I came to UNH in 1967, there are now a plethora of early maturing varieties from which to choose. In spite of this and the high retail value of locally grown melons, melon acreage in New England is under 200 acres. Part of the problem is that melons are susceptible to a disease syndrome called ‘sudden wilt’ that lowers eating quality and reduces yields. We have had recent success in grafting melon to interspecific hybrid squash. In our grafting studies, grafted plants were resistant to sudden wilt, increased melon yields by over 50%, and also extended the harvest season. Fruit size is significantly increased in grafted plants, and this might be a negative aspect of using grafting on varieties with inherently large fruit size.

I have been ramping down my melon breeding program, but still have several breeding lines being used in the seed industry and a few additional ones being added to the list. One new variety developed by Seneca Vegetable Research (SVR) and containing a UNH breeding line is ‘Milan’, a Tuscan type melon similar to ‘Wrangler’, but earlier. In our trials, ‘Milan’ was very early and exhibited high yields of moderately sized fruit, averaging about 3 kg, and with consistently high soluble solids. Another new variety from my program, also produced by SVR, is Honey Sak, a relatively early golden Crenshaw. It is a large, oval melon with light orange flesh and the typical aromatic Crenshaw flavor which most people find especially appealing.

ACORN SQUASH. Breeding acorn squash is challenging. Good eating quality is correlated with high starch and sugar content, but on the other hand, fresh weigh yields are inversely correlated with high starch content. It is a conundrum because return on investment is tied to fresh weigh yields. This is especially true for wholesale markets; whereas, for local retail markets, growers can charge more per pound for a higher quality fruit and give customers a delightful vegetable which cannot be purchased in most supermarkets.

Two varieties of acorn squash have been released from our breeding program, both with PMR, but with fruit on the small side. ‘Honey Bear’ (Johnny’s Selected Seeds) varies from 1 to 1.4 pounds and ‘Sugar Bush’ (High Mowing Organic Seeds) usually ranges from 1.5 to 1.8 pounds. The fruit of both varieties accumulate high starch content, in the 8 to 10% range, are quite sweet at harvest, and can normally be consumed within about 50 days after fruit set. The smaller fruit size is ideal for a convenient serving in the half shell. These varieties reach high sugar content much earlier than either kabocha or butternut squash, but nonetheless, like most acorn varieties, have a propensity for setting too heavy a fruit load and exhibiting variability in fruit quality. Nonetheless, ‘Sugar Bush’ is exceptional in having relatively high proportion of fruit with very good eating quality.

We have been breeding larger acorn squash, similar in size to acorn squash retailed in supermarkets, but with high starch content, between 8 to 12% versus 2 to 3% starch common in the most popular varieties being marketed wholesale. These new breeding lines also incorporate the dominant ‘L-2’ gene which results in slightly darker green skin and higher carotenoid content. One of these hybrids is currently in pilot production, and may be introduced in seed catalogs in the near future.

BUTTERNUT AND RELATED VARIETIES. The beginning of our program on developing butternut varieties dates back to 2004, relatively recent in breeding terms. One of the challenges in butternuts is to develop strains which exhibit consistent stability for fruit shape and size in different environments. We have produced several new experimental hybrids with PMR, four of which have shown good stability over the past five years. One of these will become available in the commercial market in the coming year. In the pipeline we have some hybrids that have earlier maturity than ‘Waltham Butternut,’ the industry standard, and do not need to be stored as long to develop acceptable sugar content. Also, some of these new hybrids have smaller fruit size which many growers prefer for local markets. In addition to the above traits, we are also developing varieties with appreciably higher carotenoid content, and thus, greater nutritional benefits than many of the current varieties. The intense flesh color of some of the new hybrids should make them especially attractive for the pre-peeled squash market that is gaining in popularity.

Butternuts belong to the squash species *Cucurbita moschata*, as do the large, Dickinson Field-type, oval processing squash. There are also other groups of *C. moschata* such as the Calabaza squash popular in the Caribbean basin and central American countries and some other round-fruited sorts popular in SE Asia and Australia. We are concentrating on a subset of small, round-fruited squash that have a size and appearance similar to the Buttercup/Kabocha group (C. *maxima*). There are several advantages of a *C. moschata* kabocha type as compared to buttercup varieties: 1) resistance to squash vine borer, 2) non-preference of squash bug feeding as compared to buttercup, 3) higher resistance to powdery mildew, 4) improved resistance to soil-borne diseases, and 5) better shelf life. The non-preference for squash bugs is a particularly valuable trait because squash bugs can transmit a bacterial disease, cucurbit yellow vine decline (Serratia marcescens)**, that** is rapidly increasing in incidence in the Northeast. The challenge has been to improve eating quality in these new types, develop strains which retain green skin color in storage, and develop strains in which minimal storage time is needed to attain a suitable balance of starch and sugar content for good eating quality. Several experimental hybrids will be evaluated during the summer of 2018, and it is hoped that some varieties will be released in the near future.

ORNAMENTAL PUMPKIN. UNH germplasm is now in over 20 pumpkin hybrids currently available commercially through seed catalogs. All of the newer varieties have intermediate tolerance to PMR and most display consistently strong handles that do not shrivel post-harvest, a trait I regard at the top of the list for an ornamental pumpkin. Because pumpkin varieties are so numerous, there are many that I have not even evaluated in my experimental plots, and as a result, I am reluctant to recommend any particular variety. There are some varieties, however, with rather late maturity for much of New England that I would not recommend. Maturity was very late this past year and fruit of some varieties in our plots were still mostly green during the first week of October, revealing the risk of growing a later maturing variety in New England.

The current emphasis of my pumpkin program is on developing novel pumpkin types that give local growers unique varieties to offer customers. One of the first of these was 'Moonshine', a nice medium-sized white pumpkin, but one lacking PMR. My germplasm is in other recently introduced white pumpkins, Snowball and Blanco, but these varieties also lack PMR and have the thinner, but hard, acorn stem type. Within the next few years there will be several new white pumpkin hybrids released from my program in several size categories from about a 2 pound size up to 15 to 20 pounds, and all with PMR. One of my favorite releases is 'Sunlight', a bright yellow pumpkin with PMR, a stout handle, and quite productive. It is especially attractive to market this pumpkin with the white pumpkins because of the color contrast; both types are good for face painting. Also in the mill are pumpkins with brown and tan skin color which many people find appealing. Pumpkins with distinct stripes and expressing the bicolor gene are in the works, but it will be a few years before hybrid varieties will be available commercially.

Growing Melons at Crossroad Farm and Choosing Great Varieties

Tim Taylor

Crossroad Farm
671 West Fairlee Road, Fairlee, VT, 0504
tim@crossroadfarm.com

Melons are my favorite crop to grow. Given our unpredictable Vermont climate, I do not expect an excellent yield every year as I do with greens or sweet corn. Out of 5 years I expect one excellent year, 2 good years and 2 just barely “ok” years.

We seed 3 crops of melons in the greenhouse on 4/20, 5/4 and 5/18. The watermelons are seeded a week earlier for each planting. We grow a 3 week old transplant (4 weeks for watermelons). We grow 5-6 varieties of cantaloupe which constitutes about 60% of the plantings. Additionally, we grow smaller amounts of honeydew, canary, crenshaw, galia, pixel de sapo, ananas, French charentais, and watermelon. We seed 2 seeds per 2 inch cell into styrofoam “Speedlings”. We propagate the flats on mats at 85 degrees. After germination they are moved to a “warm” greenhouse and grown on at 75 degree daytime and 60 degree nighttime temperatures.

Our first planting is always on our lightest, best drained, sandy loam, Windsor soil. Our second and third plantings perform well on heavier Agawam soil. We prepare the soil by spreading 20 tons per acre of cow manure and supplementing with additional 50 lbs. of N. broadcast before laying the plastic. We use 4 ft. I.R.T. plastic. Ours rows are 6 feet apart. We lay the plastic 7-10 days before transplanting in order to increase soil temperature. Ideally, we lay the plastic after it has rained.

Choosing the right day to plant is perhaps the most challenging aspect of growing melons. Plants may be the perfect size but the weather may be cool and cloudy either previously or following the proposed planting date. If the soil temperature drops below 55 to 60 degrees, the plant roots are unable to absorb water. When the sun reappears, the plants transpire faster than they can absorb water and consequently wilt and often die. If the transplants have been placed in a cold frame to harden, we return them to the greenhouse. We reduce water and fertility but not temperature, and then wait for the weather to improve.

We plant using a water wheel. We plant at 3 foot spacing, 2 plants per cell. We cover the plants immediately (unless it is sunny and 80 degrees) with 6 foot Pro 19 Covertan Crop Cover, using hoops to keep the cover off the plants. We do not use clear plastic either as a cover or as a ground cover. We immediately place over head irrigation in the field so we are able to irrigate, keep them cool, or protect them from frost if necessary.

We control striped cucumber beetles with Sevin sprayed after the sun has set and only after thorough scouting and population thresholds have been met. Only the first crop is usually sprayed and only about every third year. We do not use any fungicides on the crop. Last year we lost 90% of the third cantaloupe crop to Downy Mildew.

Crows have become a significant pest problem. We use a net to keep them from pecking very small melons. If left uncovered, they will destroy the crop. We put the netting on after the largest melons are about the size of a baseball, sometimes sooner. The bees are able to continue pollinating. Weeds help lift the cover off the melons. I think the net holds moisture longer, encouraging foliar diseases.

Many of the melon varieties are picked when they “slip” from the vine. However, there are some varieties including Watermelons which you learn by experience when they are ripe. Many of these varieties have a longer harvest window than those which slip from the vine.

Our favorite Melon varieties along with the approximate percentage of each we grow, are the following:

Halona: 18 %, an early eastern cantaloupe, which year in year out, produces a consistent crop of excellent flavored melons. It has good size and sets fruit under adverse weather conditions.

Hannah’s Choice: 34%, a mid-season Tuscan cantaloupe developed at Cornell University. It is our favorite. It produces consistent, large crops of melons, almost of which all are marketable. The flavor is not mild but a deep, rich sweet muskmelon flavor.

Minerva: 4% is a late season melon 6-8 lbs., larger than “Athena” eastern-type.

Milan: We were quite happy with our trial. It is a 4-6 lb. early eastern type with “great hold ability” and very high 15% Brix. We will grow more.

Sunshine Watermelon: 12%, Always yields large number of sweet yellow flesh 8-10 lb. melons.

Sweet Favorite: 6%, 10-18 lb. oblong red flesh melons ripen quite early. Very consistent.

French Charentais: 2%, Escorial is our preferred variety. I’m never sure when this melon is ready or if it will taste good. When it’s good, it has a very interesting sweet flavor.

Honeydew: 6%, Honey Blonde is a vigorous, early sweet honeydew type with loads of 3 lb. fruit. Does not have a strong typical honeydew flavor.

Honeydew: 2%, Dream Dew is a large 6-8lb. traditional honeydew type that does ripen in VT.

Canary: 2%, Brilliant is a very sweet mild flavored melon weighing not more than 4 lbs.

Galia: 5%, Arava has fantastic “tropical” unique flavor. In a good year it produces loads of fruit. I have seen this variety and Diplomat get fusarium.

Crenshaw: 2%, Honey Sak is a bright yellow melon, quite large 5-7 lbs, mild flavor, very nice.

Growing Fall Cucumbers; Efficacy and Economics of Downy Mildew Resistant Varieties

Susan B. Scheufele

Extension Educator, UMass Extension
250 Natural Resources Rd.
University of MA, Amherst, MA 01003
sscheufele@umext.umass.edu

Growing cucumbers through the late-summer and early fall is increasingly difficult. This is due to several factors including increasing pressure from insects and diseases which build up all season, but the main culprit is the disease known as cucurbit downy mildew (*Pseudoperonospora cubensis*). Cucurbit downy mildew (CDM) affects all cucurbit crops and can cause sudden and complete death of foliage, effectively ending crop growth. The pathogen is an obligate parasite, meaning it needs a living host to survive. Thus, the disease overwinters in FL where cucumbers are grown throughout the winter, and works its way north as the growing season progresses. There are several strains that affect different crops, but all strains affect cucumber, making them the most susceptible to CDM. The disease was controlled for decades with host resistance but in 2004 the pathogen evolved and overcame that resistance and now there is a great effort to breed new varieties with alternative sources of resistance. This is why growing fall cucumbers seems to have gotten so much harder in recent years, because it has!

We conducted two studies looking at new sources of resistance (experiment 1) and the economics of spraying versus using resistant varieties (experiment 2) during the 2016 and 2017 field seasons. *We found that there are several new cucumber varieties with strong resistance to multiple diseases which would be good choices for fall production in the Northeast. Planting resistant varieties increased profitability dramatically in 2016 but less so in 2017. Under high disease pressure, conventional fungicides protected susceptible crops well. Use of resistant varieties reduces the need for fungicide applications, saving time and money!*

Experiment 1: Resistant cucumber variety trial

Methods. We seeded cucumbers in the GH during the first week of June and transplanted on 6/23 and 7/1 in 2016 and 2017, respectively. Plants were grown at 18” spacing on black plastic mulch with drip irrigation. We treated all plants with imidacloprid at transplant, irrigated at least 1/wk, and fertigated with synthetic fertilizers twice—once at planting and again at vining. No other pest control was used, and we had severe infestation with cuke beetles/wilt and anthracnose in both years. Downy mildew pressure was extremely high in both years due to all the untreated cucumbers in this study and the nearby CDM sentinel plot. We rated disease severity weekly and harvested twice a week.

Conclusions. Downy mildew was first observed on 8/17 in 2016 and on 8/1 in 2017, two weeks earlier. Disease pressure was very high in 2017 but not as high in 2016 due to the drier weather and later arrival of the pathogen. All varieties had significantly less powdery mildew and downy mildew than the control variety Straight 8. Many also had resistance to other diseases like watermelon mosaic virus and anthracnose which both caused significant losses in yield in our studies. Green Bowl, Bristol, DMR401 and NY264 had the highest DM resistance, as measured by area under the disease progress curve (AUDPC) where a higher number means more disease. NY264 has the strongest resistance and plant vigor, and it was the latest-producing variety in both study years.

Experiment 2: Cost-Effectiveness of Different Management Strategies

We also investigated the economics of different management strategies, and compared a resistant and susceptible cucumber under different fungicide spray programs. The goal of this study is to reduce farmers' reliance on fungicides to control disease, and improve farmers' "bottom line" when it comes to producing fall cucumbers.

Methods. We chose Straight 8 as the susceptible control because it is an old heirloom slicing variety that is susceptible to many diseases, and chose SV4719CS for the resistant variety because in research trials it had the strongest DM resistance available while still having good production qualities. These two varieties ended up being fairly different from each other in terms of production and yield, with Straight 8 being a very robust plant which was slow to start producing but then very prolific while SV4719CS produced smaller plants and fewer cucumbers over a shorter period of time. SV4719CS was also more susceptible to bacterial wilt than Straight 8. Some differences in yield are due to these differences and not just because of disease resistance. Fungicides were applied on a 5-7-day schedule once disease (PM or CDM) arrived, since disease pressure was extremely high and included a powdery mildew-specific and a downy mildew-specific fungicide plus Bravo Weatherstik for the conventional plots, and an organic copper formulation NuCopHB for the organic plots.

Conclusions. In 2016, treatments with the resistant variety had lower DM severity and the higher yields than the susceptible treatments. Conventional and organic sprays both improved disease control and yield. Marketable yields in the susceptible variety were low in part because of a virus (watermelon mosaic virus) which affected the susceptible but not the resistant variety. In this year, under relatively low disease pressure, it was most profitable to plant a resistant variety and also spray. In 2017, DM arrived early in the season and disease pressure was extremely high. The susceptible plants went down almost as soon as we planted them, except for those sprayed with conventional fungicides, which kept producing until 10/2 and therefore had the highest yield (Table 2). The resistant variety held up fairly well and had significantly less disease and higher yields than un-sprayed susceptible plots (Table 2). Spraying did increase profits by about $7,748 (organic) and $9,247 (conventional).

Table 2. Results from the resistant variety trials (experiment 1) in 2016 and 2017.

	DM AUDPC^{y}		Total Marketable Yield (lb)^{x}		Last Harvest Date	
Cultivar	2016	2017	2016	2017	2016	2017
Straight Eight (Susceptible)	16.4 a	2418.8 a	42.3 d	20.3 cd	2-Sep	1-Sep
SV4719CS	8.1 b	1345.0 b	66.3 c	35.7 abc	9-Sep	4-Sep
Green Bowl	3.7 d	134.2 c	52.2 cd	12.7 d	13-Sep	1-Sep

Bristol	7.1 bc	419.4 c	93.5 ab	39.9 ab	13-Sep	4-Sep
DMR401	5.7 c	1249.4 b	74.6 bc	45.8 a	9-Sep	4-Sep
NY264	0.6 e	175.9 c	122.4 a	37.5 ab	30-Sep	11-Sep
Diamondback	na	1426.3 b	na	28.1 bcd	na	1-Sep
Python	na	1391.3 b	na	34.4 abc	na	4-Sep
p-value	<0.0001	<0.0001	0.0005	0.0087	--	--

[z]Data were analyzed using the Kruskal-Wallis non-parametric test. Numbers within each column followed by the same letter are not significantly different from each other (Dunn's Test for Multiple Comparisons, alpha = 0.003, after adjusting for multiple comparisons).

[y] Data were analyzed using a general linear model. Numbers within each column followed by the same letter are not significantly different from each other (Fisher's LSD, alpha = 0.05).

[x]Total yield was recorded twice weekly and is here summed across the whole season.

Table 3. Results from the fungicides + resistant variety trials (experiment 2) in 2016 and 2017.

		DM AUDPC[y]		Total Marketable Yield (lb)[x]		Last Harvest Date	
Cultivar	Spray Program	2016	2017	2016	2017	2016	2017
Straight Eight (Susceptible)	None	21.7 a	132.3 a	67.6 b	0.96 c	2-Sep	25-Aug
Straight Eight (Susceptible)	Conventional	6.3 c	14.9 e	74.6 ab	38.2 a	9-Sep	2-Oct
Straight Eight (Susceptible)	Organic	17.5 b	84.6 b	70.6 b	4.7 c	9-Sep	4-Sep
SV4719 (Resistant)	None	14.3 b	49.4 c	99.2 ab	16.9 bc	16-Sep	15-Sep
SV4719 (Resistant)	Conventional	1.7 d	8.9 e	109.8 a	26.0 ab	20-Sep	25-Sep
SV4719 (Resistant)	Organic	4.6 cd	32.1 d	110.1 a	22.2 b	20-Sep	22-Sep
p-value		<0.0001	<0.0001	0.0575	0.0022	--	--

[z]Data were analyzed using the Kruskal-Wallis non-parametric test. Numbers within each column followed by the same letter are not significantly different from each other (Dunn's Test for Multiple Comparisons, alpha = 0.003, after adjusting for multiple comparisons).

[y] Data were analyzed using a general linear model. Numbers within each column followed by the same letter are not significantly different from each other (Fisher's LSD, alpha = 0.05).

[x]Total yield was recorded twice weekly and is here summed across the whole season.

Table 4. Potential increase in yield and profits per acre under different management systems, based on data from Experiment 2 in 2017.

Variety	Spray Program	# Sprays	Total Cost of Materials/ A	Potential Increase in Marketable Yield (lbs/A)	Potential Increase in Sales (at $1.50 / # Conventional; $2.00 / # Organic)	Potential Increase in Profit (Sales - Cost)***
Straight 8 (Susceptible)	Un-Sprayed	0	$0.00	0	0	$0.00
Straight 8 (Susceptible)	Conventional	9	$704.29	27,026	$40,539.00	$39,835
Straight 8 (Susceptible)	Organic	9	$40.04	2,707	$5,414.15	$5,374
SV4719CS **(Resistant)**	Un-Sprayed	0	$0.00	11,556	$17,344 ; $23,112	$17,344 ; $23,112
SV4719CS **(Resistant)**	Conventional	9	$704.29	18,187	$27,281	$26,577
SV4719CS **(Resistant)**	Organic	9	$40.04	15,448	$30,897	$30,857

***Does not include cost of labor or tractor hours to make pesticide applications!

** Pricing info is for NuCop 50 WP, not HB.

This research was funded by a Specialty Crops grant from the MA Dept of Agricultural Resources.

Update on Fungicides for Managing Diseases in Pumpkins

Margaret Tuttle McGrath

Plant Pathology and Plant-Microbe Biology Section, SIPS, Cornell University
Long Island Horticultural Research and Extension Center,
3059 Sound Avenue, Riverhead, NY 11901. mtm3@cornell.edu

Managing diseases is an important component of a successful production program for pumpkin, as well as other cucurbit crops. At a minimum powdery mildew will occur. Several other diseases can occur in the northeast. Powdery mildew always occurs due to the quantity of easily wind-dispersed spores that the pathogen produces and the breadth of conditions under which it can develop (no high moisture requirement). The downy mildew pathogen also can move long distance; its occurrence in the northeast varies yearly, especially on crops other than cucumber. Occurrence of other diseases varies among farms depending on whether the pathogen is in the soil (several including Phytophthora blight), surviving in alternative host plants including weeds (e.g. white mold, viruses), present in insect vectors (e.g. bacterial wilt) or present in/on crop seed (e.g. bacterial leaf spot). Infected crop at a near-by farm can also be a source of pathogens that move short distances such as during a rainstorm (e.g. Plectosporium blight). Most diseases are more severe during a rainy than dry season because wet leaves or soil are favorable conditions for most pathogens (exceptions include powdery mildew, bacterial wilt, and virus diseases).

Fungicides are an important tool for managing diseases. Cultural practices, which include resistant varieties, are valuable components of an integrated management program, but typically when used without fungicides will not achieve sufficient control to avoid a reduction in yield or fruit quality. Fungicides recommended routinely change as new products are registered and pathogens develop resistance to fungicides that have been in use for several years. Modern fungicides because of their targeted mode of action typically have medium to high risk for resistance to develop in the pathogen. These need to be used in alternation to delay development of resistance, avoid control failure when resistance develops, and comply with label use restrictions.

Powdery mildew. An integrated program with both management tools (resistant varieties and fungicides) is recommended to maximize likelihood of effective control. The pathogen has demonstrated ability to evolve and become less effectively controlled by these. Alternate among targeted, mobile fungicides in the 5 chemical groups below, and apply with protectant fungicide to manage resistance development. Begin very early in disease development (one older leaf out of 50 with symptoms).

<u>Vivando</u> (FRAC Code U8) is a new fungicide with a new mode of action. Cucurbits are on a supplemental label. It has exhibited excellent control in fungicide evaluations conducted recently. Activity is limited to powdery mildew. Do not mix with horticultural oils. It can be applied three times per year with no more than two consecutive applications. REI is 12 hr. PHI is 0 days.

Torino (Code U6) has exhibited excellent control in fungicide evaluations conducted recently. Activity is limited to powdery mildew. It can only be applied twice to a field in a 12-mo period. Consecutive applications are not recommended. REI is 4 hr. PHI is 0 days.

Carboxamide fungicides (FRAC Code 7) include Luna fungicides (Luna Experience and Luna Sensation), Fontelis, Endura, Pristine and Merivon. Powdery mildew pathogen strains resistant to boscalid, active ingredient in Endura and Pristine, have been detected since 2009 in NY and likely are the reason its efficacy has been poor in some fungicide evaluations. Boscalid-resistant strains exhibit sufficient cross resistance with Fontelis and Merivon that these are expected to be ineffective as well, but not with Luna fungicides. Luna Experience is the best choice. REI is 12 hr. PHI is 7. Maximum number of applications is 2-5, depending on rate used. Low rate is not recommended. Luna Experience also contains tebuconazole (Code 3), which needs to be considered when developing an alternation program. Luna Sensation is not recommended because it also contains trifloxystrobin (Code 11); resistance to this chemistry is very common.

Quintec (Code 13) has been consistently effective in fungicide evaluations. Activity is limited to powdery mildew. Label specifies no more than two consecutive applications plus a crop maximum of four applications, and no aerial applications. REI is 12 hr. PHI is 3 days.

DMI fungicides (Code 3) include Proline and Procure, which are considered most effective, plus Aprovia Top, Folicur, Inspire Super, Mettle, Rally, Rhyme, and Tebuzol. Resistance is quantitative. Highest label rate is recommended because the pathogen has become less sensitive to this chemistry. Efficacy has varied in fungicide evaluations. Procure applied at its highest label rate provides a higher dose of active ingredient than the other Code 3 fungicides. Five applications can be made at this rate. REI is 12 hr for these fungicides. PHI is 0 - 7 days. Powdery mildew is the only labeled cucurbit disease for these fungicides, except for Proline (labeled for Fusarium), Rhyme (gummy stem blight), and Aprovia Top and Inspire Super, which contain another active ingredient (Code 7 and 9, respectively) and are labeled for additional diseases (see last section).

Resistance continues to be very common to MBC fungicides (FRAC code 1; Topsin M) and QoI fungicides (Code 11; Quadris, Cabrio and Flint); therefore these are not recommended.

There are several protectants for powdery mildew, including chlorothalonil, sulfur, copper, botanical and mineral oils, and several biopesticides.

Phytophthora blight. This destructive disease has more been severe recently in areas where there were intensive rainfall events, which created unusually favorable conditions. A key to successfully managing this disease is managing soil moisture to avoid saturated conditions. Achieving this is difficult when rainfall amounts are large. Another key has been fungicides registered in recent years with targeted activity for pathogens in this biological group (Oomycetes). Information about these follows section on downy mildew. These are considered the reason many growers have been effectively managing Phytophthora blight. A preventive fungicide program is considered essential. Ineffective control with fungicides has been associated with poor application timing in some fields (application missed when rain began before expected) while in others favorability of environmental conditions seemed to have been too great. Development of fungicide resistance is a concern with all targeted fungicides due to single site mode of action; therefore, alternation amongst chemistry is recommended. Resistance to Ranman has been detected in the southeastern US. Protectant fungicides, such as coppers, are not sufficiently effective to be recommended alone for Phytophthora blight; however, they are useful tank-mixed with targeted fungicides to manage resistance.

<u>Biopesticides</u> There are several products (Actinovate, Double Nickel, Regalia, RootShield, Serenade, SoilGard, Bio-Tam, etc.) that can be applied to soil pre-transplant, at planting, and via drip to manage the blight pathogen, *Phytophthora capsici*, in the root and crown zone and to induce resistance (Regalia). Most of these biopesticides can also be applied to foliage. They are approved for organic production.

See http://vegetablemdonline.ppath.cornell.edu/NewsArticles/PhytoBlight_cucurbits-others.html for additional information about managing Phytophthora blight.

Downy mildew is primarily managed with fungicides. Cucumbers with a new source of resistance are becoming available. Some suppression, albeit variable, can be obtained with varieties bred to be resistant to pathogen strains present before 2004. An integrated program with fungicides applied to resistant varieties is recommend. As with powdery mildew, fungicide resistance is also a concern with the downy mildew pathogen and therefore the fungicide program recommended is also targeted, mobile fungicides applied in alternation based on FRAC Code (see list below) on a weekly schedule and tank mixed with a protectant fungicide (chlorothalonil or mancozeb) beginning very early in disease development. An important tool for determining when fungicide application is warranted is the forecast web site for this disease at http://cdm.ipmpipe.org. Cucurbit plants are susceptible to downy mildew from emergence; however, this disease usually does not start to develop in the northeast until later in crop development when the pathogen is dispersed by wind into the region. The forecast program monitors where the disease occurs and predicts where the pathogen likely will be successfully spread. The pathogen needs living cucurbit crops to survive, thus it cannot survive where it is cold during winter. The risk of downy mildew occurring throughout the eastern USA is forecast and posted three times a week. Forecasts enable timely fungicide applications. Label directions for some fungicides state to begin use before infection or disease development. The forecasting program helps ensure this is accomplished. Growers can subscribe to receive customizable alerts by e-mail or text message. Information is also maintained at the forecast web site of cucurbit crop types being affected by downy mildew. This is important because the pathogen exists as pathotypes that differ in their ability to infect the various crops. All pathotypes can infect cucumber; some also can infect melons and squashes are susceptible to others. Success of the forecast system depends on knowledge of where downy mildew is occurring; therefore prompt reporting of outbreaks by growers is critical.

Fungicides for Phytophthora blight (PB) and/or downy mildew (DM):

Presidio (FRAC Code 43). Recommended used early in the season for PB when DM not a concern. No longer effective for DM because of resistance. Apply no more than 4 times in a season with no more than 2 consecutive applications. Must be applied with another fungicide.

Orondis (49). The novel active ingredient, oxathiapiprolin, has exhibited excellent activity in fungicide evaluations. It is formulated with mandipropamid as Orondis Ultra (REI is 4 hr) and with chlorothalonil as Orondis Opti (REI is 12 hr). PHI is 0 day.

Ranman (21). Use organosilicone surfactant when water volumes are less than 60 gallons per acre. REI is 12 hr. PHI is 0 day. Apply no more than 6 times in a season with no more than 3 consecutive applications.

Zing! and Gavel (22). These are the only products that have a targeted fungicide and a protectant fungicide (chlorothalonil or mancozeb). Only Gavel is labeled for PB as well as DM. REI is 12 hr for Zing! and 48 hr for Gavel. PHI is 0 and 5 days, respectively. Apply no more than 8 times in a season with no more than 2 in succession. Limit total use with all products used to 1.6 lb zoxamide and 9.44 lb chlorothalonil per acre per season. The amount of chlorothalonil in an application of Zing! (1.18 lb/A) is less than the highest label rate of chlorothalonil fungicides for downy mildew (1.5 lb/A) and is below the range for other diseases including powdery mildew (1.5-2.25 lb/A). Increasing the amount of chlorothalonil applied is prudent for these diseases. To obtain an application rate of 1.5-2.25 lb/A chlorothalonil, tank mix Bravo WeatherStik at 0.43-1.43 pt/A with Zing!.

Omega (29). REI is 12 hr. PHI is 7 days for squash/cucumber subgroup, which includes pumpkin, and 30 days for melons. Apply no more than 7.5 pts/A to a crop or 4 applications applied at highest label rate of 1.5 pts/A. Omega is more expensive than other fungicides.

Zampro (40, 45) and Revus (40). While in the same fungicide chemical group (40), there is indication they may have slightly different mode of action, thus there may be benefit to using one for the first application of a product in this group in a fungicide program and then switching to the other product later in the program. REI is 12 hr. PHI is 0 day. Apply no more than 3 times (4 for Revus) in a season with no more than 2 consecutive applications (none with Revus). Revus must be applied with a spreading/penetrating type adjuvant. Revus is recommended used sparingly because of suspected resistance. Forum is no longer recommended; it has the same FRAC Code 40 ingredient as Zampro.

Ariston, Curzate or Tanos (27). These have some curative activity (up to 2 days under cool temperatures) but limited residual activity (about 3-5 days). They can be a good choice when it was not possible to apply fungicide at the start of a high risk period when temperature is below 80 F. Apply another targeted fungicide 3-5 days later. Curzate and Tanos must be tank-mixed with a protectant; Ariston also contains chlorothalonil. REI is 12 hr. PHI is 3 days. Apply no more than 4 times in a season (6-9 for Curzate depending on rate); no consecutive applications of Tanos are permitted. Ariston and Curzate are not labeled for PB.

Phosphorous acid fungicides (33). There are numerous products (e.g. Agri-Fos, Fosphite, K-Phite, Phostrol, ProPhyt, Rampart), all effective only for PB. They are recommended used at a low label rate tank mixed with the targeted fungicides listed above for PB.

Previcur Flex (28). Activity is limited to DM. Use sparingly (less than label limit of 5 times in a season) because of suspected resistance. REI is 12 hr. PHI is 2 days.

Recommended protectant fungicides. Chlorothalonil and mancozeb are the main protectant fungicides for DM and PB. Copper is also good for PB, but isn't as effective for DM.

No longer recommended for downy mildew. Resistance to mefenoxam and metalaxyl (Ridomil) and to strobilurins (e.g. Cabrio) are sufficiently common that fungicides with these ingredients, which use to be highly effective, have been ineffective since 2004.

It is suspected that some strains of the downy mildew pathogen, in particular those infecting cucumbers, have developed resistance to other fungicides based on the fact they have exhibited reduced efficacy, compared to prior efficacy, in fungicide evaluations and also based on fungicide seedling bioassays. Fungicides that have exhibited signs of being affected by resistance include Presidio, Previcur Flex, Revus, Forum, Curzate, Tanos, and Zampro. This research was done with cucumber because downy mildew occurs most commonly on this cucurbit crop type. Some variation in results among locations has been detected. For example, Zampro was effective in seedling bioassays conducted on Long Island in 2016 and 2017, but not in bioassays conducted in South Carolina. Additionally, a recent study revealed that the pathogen strains obtained from pumpkin are often genetically different from those from cucumber.

Other diseases that can affect pumpkins and labeled fungicides.

Alternaria leaf spot. Fontelis (7), Inspire Super (3,9), Aprovia Top (3,7), Pristine (7,11), QoI fungicides (11), Reason (11), Tanos (27), and Omega (29).

Anthracnose. Aprovia Top (3,7), Inspire Super (3,9), Pristine (7,11), QoI fungicides (11), Tanos (27), and Topsin M (1).

Bacterial leaf spot. Actigard (21) and copper (M1). Quintec applied for powdery mildew may apply some suppression of bacterial diseases.

Fusarium fruit and crown rot. Proline (3).

Gummy stem blight/Black rot. Fontelis (7)*, Aprovia Top (3,7), Inspire Super (3,9), Pristine (7,11)*, Proline (3), Switch (9,12), Omega (29), QoI fungicides (11)*, and Topsin M (1)*.

Plectosporium blight. Aprovia Top (3,7), Inspire Super (3,9), and QoI fungicides (11)*.

Septoria leaf spot. Aprovia Top (3,7) and Inspire Super (3,9).

* Resistance detected in the US.

See http://vegetablemdonline.ppath.cornell.edu for more information about diseases of cucurbit crops and their management.

Please Note: The specific directions on pesticide labels must be adhered to -- they supersede these recommendations, if there is a conflict. Note that some products mentioned are not yet registered for use on cucurbits. Check labels for use restrictions. Any reference to commercial products, trade or brand names is for information only; no endorsement is intended.

Weed Management in Root Crops

Laura Tangerini

tangerinifarm@verizon.net
508-667-7638

Tangerini's Farm is located in Millis, Ma. We raise about 40 acres of vegetables and fruits. Most all of our crops with the exception of sweet corn and apples are raised using organic methods.

Weed management in any crop starts with identifying what type of weeds are in your fields. When raising, root crops this is imperative. Our primary root crops are slow growers so it's important to provide them with a weed-free environment for as long as possible, early in the growth cycle.

Carrots and Beets

- Identify fields that have low weed pressure. Broadleaves we can handle easily, grasses and purslane we cannot during the main season. For our winter plantings, we stay away from fields that may have winter weeds such as chickweed.
- We chisel plow and then prepare the seed bed two weeks in advance.
- If it's dry, we will irrigate to get the weeds germinated.
- The day of planting, we flame just prior to planting to remove any broadleaves that have emerged. This also help to knock back any grasses that may have emerged.
- It is important to continue to irrigate if needed especially with carrots so that they emerge as quickly as possible. Erratic germination will cause a weeding nightmare.
- Just prior to emergence of the crop we flame for a last time.
- If grasses have emerged it important to identify where in the field they are and take care of them as soon as possible.
- When removing tough weeds, make sure you avoid disturbing the seedbed so make sure you either remove the grasses by hand or with shallow tillage.
- When the crop is high enough to cultivate, we use a Kress cultivator a few times during the growth cycle.

Winter Carrots (Seeded in Nov.)

- Identify fields with low winter weed pressure.
- Plant the carrots
- Cover with tunnel
- Early March we uncover the tunnel and weed underneath. This is usually only done once. All the other cultivation from this point forward is done mechanically until harvest.

Parsnips

- Since this is a slow crop to germinate we add an additional step to our "Carrot and Beet" technique. After preparing the soil we solarize the bed with greenhouse plastic a couple weeks prior to planting.
- In the future, we will decrease plant spacing because of poorer germination rates in parsnip seed.

Potatoes

- Identify fields that have low weed pressure. Broadleaves we can handle easily, grasses cannot.
- Prepare the seed bed for planting.
- Plant potatoes.
- When they are at the 4-leaf stage we go over the whole field with the flamer. It kills all the broadleaves and burns the antennas of the CPB. It doesn't affect the potatoes at all.
- All other cultivation is done with the hiller until the canopy is formed.

These are pretty simple yet effective methods of weed management in our root crops. Identifying what kind of weeds, you have in the field, proper irrigation to germinate weed and crop seed and the timing of flaming are key to our success. We do very little hand weeding unless one of these doesn't go according to plan.

Diseases of Root Crops

Robert L. Wick

Stockbridge School of Agriculture
University of Massachusetts, Amherst MA 01003
rlwick@umass.edu

Root Diseases of Root Crops

Root diseases of carrots, parsnips, beets, and turnips are caused by soil-borne fungi, bacteria, and nematodes that generally have a broad host range. Fungal plant parasites include *Pythium, Rhizoctonia, Fusarium, Sclerotinia,* and *Thielaviopsis*. The bacterium *Streptomyces scabies* causes scab. Nematodes include lesion (*Pratylenchus*), root-knot (*Meloidogyne hapla*), and sugar beet cyst nematode (*Heterodera schachtii*). The sugar beet cyst nematode is mostly restricted to the Amaranthaceae, Brassicaceae and Chenopodiaceae. Generally, the fungal root diseases are of minor importance except to seedlings which may be stunted or killed. When high populations of these fungi build up in the soil, or environmental conditions are particularly suitable for disease, considerable loss in yield can result. This is particularly true of *Sclerotinia*, which thrives under cool, wet conditions. Fungicides are generally not recommended for soil-borne fungi.

Root-knot and cyst nematodes are particularly damaging, and populations will increase under continuous cultivation of susceptible crops. Lesion nematodes are less important but hot spots in the field can result in some losses. Soil sampling for nematodes should be done while the crop is growing and it is possible to see where poor growth is occurring. Due to the uneven distribution of nematode populations in soil, composite sampling in a field of bare ground may produce unreliable information regarding the potential of nematode injury. Nematodes are difficult to control without fumigation.

Foliar Diseases of Root Crops

Foliar diseases of root crops cause spotting and blighting of the foliage and petioles. *Alternaria, Colletotrichum, Cercospora*, and downy mildew occur on most root crops. The bacterium *Xanthomonas* causes leaf spot and blight as well. Fungal and bacterial diseases can result in loss of foliage, reduced weight of root crops, and may make mechanical harvesting difficult. Pathogens of the foliage do not survive well in the soil and plowing plant debris under the soil after harvest is recommended. *Alternaria, Cercospora,* and *Xanthomonas* can be seed-borne. Fungicides can reduce the fungal diseases but *Xanthomonas* is difficult to control.

Managing Voles in Vegetable Crops and High Tunnels

Dr. Alan T. Eaton

Extension Specialist, Pest Management, University of New Hampshire, Durham
alan.eaton@unh.edu

Vole injury can be a tough problem to solve. Often the injury is hit-and-run, and you can't tell what really caused it. We have relatively few tools to combat the problems in vegetables and high tunnels, except prevention. I'll start with biology & behavior.

Voles are small rodents that sometimes attack our crops. People frequently confuse them with both mice and moles. Rodents have a distinctive arrangement of teeth in the jaw: chisel-shaped incisors at the front, and then a long gap, followed by flat, grinding teeth at the rear. Moles are not rodents. They are insectivores, and have numerous small, pointed teeth designed to feed on grubs, worms and insects. Mice are rodents that are closely related to voles, and have similar teeth. There are several differences in appearance between mice and voles. Mice have large, prominent ears, and large, prominent eyes. Voles have smaller ears and eyes, and the ears are somewhat buried in their fur. The mouse most commonly found in crops and high tunnels in New England is the white-footed mouse. It is largely a seed and grain eater, but will accept fruit, and (when food is really scarce) occasionally feeds on bark.

Voles tend to feed on grass, bark, and (especially pine vole) roots, bulbs and corms. They leave tooth marks that are easy to see on some things, like sweet potatoes. They are active both during the day and at night. We have four species of voles in New England (meadow, pine, southern redback and rock), but little or no agricultural damage is caused by the last two.

Meadow voles largely feed on grass, and make extensive networks of trails ("runs") that are about 1.5 inches wide. If given the opportunity, they will feed on fruit. When their favored foods are limited, they feed on bark. Most of the time they live above ground, though in winter, they are usually hidden under the snow. Meadow voles are extremely prolific, with 4 to 5 young per litter and 4 to 8 litters per year. This is why populations can build up quickly, when they have what they need. They favor thick vegetation (especially grass), because it hides them from their numerous predators, which attack day and night. When I see possible vole damage above-ground to plants in a field or greenhouse, usually I end up concluding that this species is the cause. This is the vole that we see most commonly in fields and gardens. In my yard, it attacks beans, sometimes tomato & asparagus, girdles grapes, peaches & apples and chews tubers of potato and sweet potato. The tail is about 1.5 times the length of the hind FOOT.

Pine voles largely live underground. They have short tails; about the same length as the hind foot (not leg). They have finer fur, less coarse than meadow vole. They construct a network of tunnels, many of which are only 1 to 3 inches below the surface. The feed in these tunnels, on roots, bulbs, and corms. Occasionally they appear above ground, and they will feed on fruit if given the opportunity. They are nowhere as prolific as meadow voles. They average 1 litter of 2 to 4 young per year. They do extensive root damage to apples, blueberries and other plants, and vegetable & flower roots as well: sweet potato, potato, carrot, crocus, tulip, hyacinth and more.

Usually we do not see them in soils that get regularly plowed, since deep tillage destroys their (usually shallow) feeding tunnels. In plowed fields, I sometimes see them in the edges. In my garden, they hit roots of blueberry, apple, raspberry, carrot, potato and sweet potato.

Redback and rock voles are not likely to be in agricultural settings. The first tends to be in cool, damp woods, and the second is around rocks, especially near streams or in woods. Sometimes redback voles nest in firewood piles.

Meadow voles sometimes turn up in some places we wouldn't expect them, and chew off a plant or two, then leave. That could be in a high tunnel, a mulched tomato garden, a field of beans (excellent cover unless the plants are very small), or elsewhere. Sometimes, if conditions are right, they'll do extensive damage. One thing they strongly prefer is <u>cover</u>, so if you can prevent weed growth in **and close to** your crops, and avoid using mulches, these reduce the likelihood that meadow voles will attack. Reducing cover exposes meadow voles to their enemies, which hunt them day and night… owls, hawks, weasels, mink, skunks, foxes, coyotes, cats, dogs, snakes and more. Planting vole-susceptible crops immediately adjacent to a hay field is great for the voles.

Repellents: although there are some materials reputed to be taste repellants (capsaicin and the fungicide Thiram), generally repellants are not very helpful for protecting vegetable plants from voles. Capsaicin might offer very short-term protection, and thiram might last a bit longer, but they rarely fit in vegetable crop production.

Rodenticides & legality issues: There are plenty of rodenticides available, but many of them are formulated to be attractive to mice or rats. Relatively few are formulated AND LABELED for voles. Many are labeled for "commensal" [in and around buildings] use. You'd have to read the label carefully to see if it fit your pest situation (site/crop/pest). Finding a product that indicates it can be used in greenhouses or high tunnels is difficult. Sometimes a label says for use in "agricultural buildings". Greenhouses might qualify, but does a high tunnel fit that designation? To me, it is a gray zone where I'd need the opinion of a regulator. We do have products licensed for nurseries, orchards and highbush blueberries, but they are allowed only after harvest is completed.

I found two products with limited use allowed in or close to vegetables: <u>Prozap ZnP</u> (by Hacco) is registered for vole control in a) cucurbits, but only at planting time, using equipment designed to place the bait in the furrows; b) in potatoes but not within 30 days of harvest. (Rain breaks down Zinc phosphide fairly quickly; so use in sunny weather)

<u>Rozol vole bait</u> (LiphaTech) can be applied in buffer strips adjacent to crops, but there are several restrictions, including not within 50 feet of surface water.

Some growers have GAP certification plans that call for rodenticide use in or around their buildings. Don't confuse that function with protecting your crop from voles. For either situation, I advise growers to be very cautious about using the second-generation anticoagulants (brodifacoum, difethialone, bromadiolone). These (esp. brodifacoum) have been found in an amazingly high percentage of dead, sick or injured predatory birds and predatory mammals in the northeast states. EPA responded to this by making brodifacoum products only for use by licensed pesticide applicators, in and around buildings. If pets or wildlife can reach the bait, they can be poisoned. Also, if a pet or wild animal eats a vole that has ingested the bait, it can also die. This is called secondary poisoning. I strongly suggest you not use these, especially brodifacoum.

Rodenticide labels are usually available to examine at the manufacturer's website. Common manufacturers that include some field-applied products registered in New England include 1) Bell labs http://www.belllabs.com/ 2) Bonide https://www.bonide.com/ 3) HACCO http://www.hacco.com/Rodenticides.htm 4) Liphatech http://www.liphatech.com/

There are additional manufacturers that provide materials for commensal rodent control. If you cannot tell if a rodenticide is registered for use in your state, check the registration list. Each New England state has a list of pesticides that are registered in that state for that year. Often the list is incomplete early in the year. In most states, that list is available through the state pesticide control division. ***So my overall message about using toxicants to solve vole problems in vegetable is: it is unlikely you'll find a product that is legal and can help.***

Trapping for monitoring & control: Trapping can help indicate what species is/are causing a problem (by producing bodies for identification). That can be very helpful, because chipmunks, mice, voles and rats all produce similar teeth marks. Trapping might also help control a small, localized problem. I like snap traps myself, and have found that Victor brand traps have strong springs that last a long time. I have experimented a bit with what I call vole or mouse tunnels. I make them from scrap wood, about 16 inches long, with inside dimension 2.5 inches wide and 3.5 inches tall. I make them large enough for a standard mouse trap to fit inside, and not have the spring bar or lock lever hit the ceiling when the trap is sprung. It provides a dark, protected (inviting to the vole) spot to place a trap. It also makes it difficult for the trap to hurt someone's toe, or your cat. I make a large door in the side, to make it easy to place and check on the trap. On mine, the door hangs on with good old duct tape, and once I set and place the trap, I swing the door back into position. Set the tube in a logical spot in your high tunnel. If done correctly, you may not need bait, but I often bait mine with peanut butter. If you wished, you could attach a wire flag to make the wooden tunnel more visible in, say, a greenhouse full of potted plants. Generally, tiny details greatly affect the success of trapping. Yes, it is somewhat labor intensive.

For More Information

1) Eaton, A. T. Wildlife Pest Problems in New England Vegetables. [in: New England Vegetable Management Guide. March 2017.
2) Eaton, A. T. Managing Voles in New Hampshire Orchards and Highbush Blueberries. 14pp. [reformatted 2017]

https://extension.unh.edu/resources/representation/Resource003424_Rep4893.pdf

3) Wildlife Services [USDA APHIS] for ME: 207-629-5181 for NH/VT: 603-223-6832 for MA/CT/RI: 413-253-2403

Use of Repellents for Averting Deer and Rabbit Damage

Scott C. Williams, PhD

The Connecticut Agricultural Experiment Station
123 Huntington Street, New Haven, CT 06511
Scott.Williams@ct.gov

Rabbits, particularly eastern cottontails (*Sylvilagus floridanus*), can be the cause of significant agricultural damage, not only in New England, but throughout the country. We tested the ability of eight different repellents to protect plants commonly damaged by rabbits. We used Johnny jump-ups *(Viola tricolor* 'Helen Mount'), "Gourmet Lettuce Mix" (*Lactuca sativa* 'Allstar'), and alfalfa (*Medicago sativa* 'Summer'). It should be noted that most repellents are not labeled for use on produce meant for human consumption. However, we estimated that if repellents were capable of protecting some of the most susceptible plants, they should perform similarly in protecting a broad spectrum of garden plants with varying degrees of susceptibility to rabbit damage. The repellents tested included:

- Bobbex-R Animal Repellent® from concentrate
- Bobbex Deer Repellent® Canadian formulation from concentrate
- Bobbex Deer Repellent® Canadian ready-to-use formulation
- Bonide Deer & Rabbit Repellent® from concentrate
- Bonide Repels All® from concentrate
- Liquid Fence® Deer & Rabbit Repellent from concentrate
- Plantskydd® soluble powder
- Rabbit Stopper® ready-to-use formulation

We constructed a rabbit enclosure measuring 24 by 48 feet. We trapped two juvenile and one adult eastern cottontail and relocated them into the enclosure. The addition of the three rabbits resulted in a rabbit density of 113 rabbits/acre. For comparison, biologists recommend a density of one rabbit/acre in the wild to maintain a healthy population. Feeding stations, water, and shelter were provided. The choice of using highly preferred vegetation and an unnaturally high rabbit density certainly put repellent performance to the test.

At both ends of the enclosure were three raised beds filled with leaf compost as a planting medium. Throughout the growing season, we germinated and grew flats of each of the three plants to be tested in a greenhouse. When plants were mature, flats were removed from the greenhouse, and were randomly assigned into blocks of four flats each. Each block of four was then randomly assigned one of seven treatments: four were assigned a repellent formulation, two were planted within the enclosure and received no treatment (negative controls), and one block was planted in a raised bed outside the enclosure that was protected from all mammal damage by a fence (positive control). After vegetation was treated with the assigned repellent, it was allowed to dry, then transported to the rabbit enclosure and planted in raised beds for a period of two weeks. We conducted six two-week trials over the growing season to test the effectiveness of the eight different repellent formulations on three different plant types.

At the end of two weeks, all uneaten vegetation from each flat was cut at soil level, bagged, and labeled. Cut vegetation was air-dried for one week in a greenhouse and then placed in a forced-air oven for five days to completely dry plant material. Dry weights from vegetation within repellent flats were standardized against unprotected control plants to determine the proportion of plant biomass that was protected by the repellent formulations. These values were analyzed across repellents and across the different plant types.

Because the entire trial occurred over 14 weeks, there were some other variables that had to be considered, including the growth of the rabbits over that time and the impact of the approaching winter on the rabbits' feeding behavior. Plants at the end of the growing season received more feeding pressure because rabbits were bigger and ate more in preparation for cooler temperatures. We used formulas from previous research to calculate daily caloric demand for the three rabbits based on body mass and average ambient temperature. To determine an overall effectiveness index for repellent formulations, uneaten biomass values were adjusted by estimated caloric demand and the adjusted scores were ranked. The results can be seen in the table below.

Treatment	Adj. Score	Rank	Dilution
Fenced Control	5728	1	-
Plantskydd	5342	2	8 cups/8 quarts
Bobbex-R	3872	3	1 : 8
Bobbex Deer Repellent Canada RTU	3409	4	N/A
Bobbex Deer Repellent Canada	3107	5	1 : 5
Bonide Repels All	1402	6	1 : 7
Rabbit Stopper RTU	1293	7	N/A
Liquid Fence Deer & Rabbit Repellent	1186	8	1 : 15
Bonide Deer & Rabbit Repellent	680	9	1 : 15
No Treatment (Control)	0	10	N/A

Plantskydd performed the best among repellents, however, purchasers should be aware that this product consists of dehydrated porcine/bovine blood that needs to be hydrated by mixing in a watering can. When applied to vegetation, Plantskydd looks like blood and coats and discolors vegetation, and may attract scavengers, butterflies, and house flies. The Bobbex and Liquid Fence products had slightly unpleasant odors that quickly dissipated after drying. Rabbit Stopper and the Bonide products had a pleasant odor which also dissipated after drying. In general, all repellent formulations were comparable in price.

White-tailed Deer Repellents

Browsing by overabundant herds of white-tailed deer can cause significant economic damage to nurseries, garden centers, and homeowner landscapes. Annual losses due to deer in Connecticut included $1 million in lost sales to homeowners discouraged by repeated deer damage and $1.5 to $2.0 million in direct damages to plants prior to sale at nurseries and garden centers. According to a survey of gardeners, more than 20% discontinued growing yews, hostas, and lilies because of extreme deer browse damage. A survey of Connecticut growers found that crop-damage permits for lethal control of deer and fencing were the only methods reported as generally effective ≥50% of the time. However, in developed areas with high housing density, use of lethal management of deer to reduce browse damage is often unfeasible. Fencing, alternative plant selection, or repellents may be the only practical options in such environments. Fencing is very effective but can be costly, unsightly, and restricted by local zoning ordinances. In many instances, commercially available repellents may be an appealing alternative to physical exclusion and lethal control of animals for both growers and homeowners.

Ten different commercially available repellents were tested (Chew-Nott® (no longer available), Deer Off®, Deer-Away Big Game Repellent®, Plantskydd®, Bobbex®, Liquid Fence®, Deer Solution®, Hinder®, Repellex® systemic tablets, and coyote urine) on yews (*Taxus cuspidate* 'Densiformis') at two different locations in Connecticut. The Windsor study area in northern Connecticut was an agricultural field adjacent to other fields that had been repeatedly damaged by browsing. The Dawson study area in Connecticut was a periodically-mowed, grassy field. There was no hunting permitted at either location.

We planted 12 groups of 6 yews in two blocks at each location. Each group within each block was randomly assigned one of the 12 treatments. The study included both positive (fence) and negative (no treatment) controls. We applied Deer Solution, Bobbex, Hinder, and Liquid Fence with 7.6-L tank sprayers. A plastic watering can was used to apply Plantskydd, Chew-Nott, and Deer-Away Big Game Repellent.We placed Repellex tablets directly in the root ball at planting. We applied coyote urine directly to cotton darts and placed them between planted yews. We purchased Deer Off in a hand-spray bottle and used it throughout the study. To avoid potential mixing of repellents, a labeled, dedicated sprayer, watering can, or spray bottle was used for each repellent. Reapplication intervals were as close as possible to label instructions, but did vary because of weather. Repellents were applied based on manufacturer's label recommendations over two growing seasons. Application costs were recorded, and a Protection Index was derived based on plant size and dry needle weights at the end of the study.

In general, repellents that required more frequent application performed better. Bobbex ranked highest, but was the most expensive repellent treatment (Table 1). Hinder performed nearly as well at a fraction of the cost (Table 1). Yews protected by Repellex, Deer Solution, coyote urine, and Plantskydd were not larger than unprotected controls at both sites and did not have significantly more needles.

While proper physical exclusion can prevent 100% of browse damage by white-tailed deer at a one-time cost and minimal long-term labor, fencing can be unsightly and expensive to install. Commercially available repellents provide an alternative to fencing, but are not as effective. The selection of which repellent to use is a trade-off between effectiveness, cost (material and time), ability or willingness to follow reapplication interval, and plant species to be protected. Our research has shown that generally, repellents that were applied more frequently ranked higher on our Protection Index.

	Protection Index	Total Cost	Per Yew
Control	49		
Repellex	50	$14.40	$0.60
Deer Solution	52	$111.97	$4.67
Coyote urine	53	$102.02	$4.25
Plantskydd	60	$111.70	$4.65
Deer-Off	65	$134.75	$5.61
Big Game	72	$141.10	$5.88
Chew-Not	74	$141.00	$5.88
Liquid Fence	78	$94.98	$3.96
Hinder	83	$62.99	$2.62
Bobbex	93	$331.19	$13.80
Physical fence	100		

Using a Sonic Net to Deter Wildlife: a Potential Long-Term Solution for Reducing Crop Losses

John P Swaddle

Institute for Integrative Bird Behavior Studies
Biology Department, College of William and Mary
Williamsburg, VA 23187-8795, USA
Tel. 757 221 2231, Email: jpswad@wm.edu

Many forms of wildlife, including birds, use acoustic information to coordinate their foraging, maintain social ties, find mates, recognize each other, and to listen out for predators. Noise in the environment degrades this information and masks the ways in which wildlife can hear each other and hear predators. We have developed technology, called “sonic nets”, that delivers carefully designed and highly targeted noise to a specific area, such as a field. In captive and field-based experiments we have shown that spatially-controlled noise that maximally interferes with acoustic communication for birds deters many species of bird from target areas, including those with food sources. In field-based trials, our sonic net technology has reduced the presence of birds by more than 80% with no indications of this effect diminishing over time. It appears that the technology increases the perception of predation risk for birds—they are permanently more vigilant in the area with the sonic net. This increased perception of predation risk is a real threat to the birds, hence any degree of habituation (a form of learning) is not predicted to decrease the effectiveness of the sonic net.

This technology has been commercialized and I will review the latest information related to real-world agricultural installations and effects on non-avian species. Preliminary reports from customers who have installed the Sonic Net appliances report a reduction in deer and, perhaps, skunk populations as well as marked effects on birds.

Laser Scarecrows: Gimmick or Solution?

Dr. Rebecca Nelson Brown[1] & David H. Brown[2]

[1]Dept. of Plant Sciences and Entomology, brownreb@uri.edu
[2]Dept. of Computer Science and Statistics, david_h_brown@uri.edu
University of Rhode Island, Kingston, RI 02881.

History of Anti-Avian Lasers

Lasers have been investigated as a tool for controlling birds since the 1970s. The first effective systems were developed for use at airports in Europe in the 1990s (Briot 2005). Studies of anti-avian laser systems in the US began in 1999. These early studies used hand-held laser units, and focused on disrupting night-time roosting of the target birds. Lasers deployed against wild birds at dusk permanently dispersed double-crested cormorants, and temporarily dispersed American crows, but were not effective against redwing blackbirds (Glahn et al. 2000, Gorenzel et al. 2002, Homan et al. 2010). Using captive birds, Blackwell et al. (2002) found that laser beams did not affect behavior of catbirds or starlings, and that rock doves and mallard ducks became habituated to the lasers. Captive Canada geese avoided areas protected by laser beams, even in daylight (Werner and Clark 2006).

The mixed results from scientific studies have not deterred development of lasers marketed for use in bird control, and both hand-held and automatic models are now available from multiple manufacturers. The automatic models, in particular, are advertised as an effective solution for protecting grapes, cherries, berries, and other crops from flocking birds. We became interested in anti-avian lasers in 2016 when a Rhode Island sweetcorn grower purchased a laser scarecrow developed for use in orchards. Initial grower feedback on the performance of the laser scarecrow was extremely positive, and generated considerable excitement in Rhode Island. However, there have been no reports of controlled studies using automated laser scarecrows on any crop, thus Cooperative Extension was unable to make recommendations. In addition, all of the previous studies had emphasized that lasers were only effective under low-light conditions, but to protect sweet corn the lasers would need to be effective in full sunlight. In 2017 we obtained funding from Northeast SARE to conduct controlled tests of laser scarecrows to prevent bird damage in sweet corn.

Bird Control in Sweet Corn

Fresh-market sweet corn is an important crop occupying many acres, particularly in peri-urban areas. It was the number one crop, by acreage, in the 2012 Census of Agriculture for all the New England States except Maine, where fresh market sweet corn ranked second behind potatoes. Blackbirds and starlings can be a severe problem in sweet corn; the birds shred the husks and peck the kernels, rendering the ears unmarketable. Even more frustrating for growers, losses occur just before harvest, after growers have already invested time and inputs into the crop. Large flocks of blackbirds and starlings can ruin a field of ripe sweet corn in less than a day. The preferred bird control method for many sweet corn growers is some combination of scare guns, pyrotechnics, and hunting. This can keep bird damage to a tolerable level, but in peri-urban areas ordinances often prohibit use of firearms, and the noise pollution from scare guns creates problems with non-farm neighbors. In Rhode Island the conflict over scare guns has resulted in legal threats to the Right-to-Farm Law, so farmers, politicians, and regulators are very interested in a practical alternative for protecting crops.

Study Methods

We developed an inexpensive laser scarecrow emitting a beam of green light at 535 nm as a research prototype, and deployed five units in commercial sweet corn fields at multiple sites in Rhode Island and southeastern Massachusetts. Scarecrows were placed in fields approximately 3 days before growers expected to begin harvesting and removed once harvest was complete. The scarecrow was adjusted such that the laser beam swept over the field at tassel height on the crop, protecting a circular area approximately 350 feet in diameter. In addition to horizontal rotation, the angle of the beam varied between horizontal and 20 degrees below horizontal. The scarecrows were controlled by light sensors and automatically turned on at dawn and off at dusk. Cooperating growers reported back to us the amount of bird damage in the protected fields, and also in any unprotected fields on their farms.

We also conducted a controlled test at the Gardiner Crops Research Center. We planted two one-acre plots of corn at the ends of a 3 acre field, with an acre of cover crops separating the two plots. The plots were seeded with the same mix of eight varieties of bicolor se corn, ranging in maturity from 72 days to 86 days. A laser scarecrow was equipped with a shield so that the rotating beam impacted a semi-circular area rather than a full circle. The unit was set up between the two sweetcorn plots, so that the laser beam passed over one plot at tassel height, but did not impact the other plot. After 3 to 5 days all bird-damaged ears in both plots were counted and removed, and the laser scarecrow was repositioned to protect the previously unprotected plot. The test was repeated for a total of six counting events.

Results

The maximum grower-reported bird damage in a protected field was 5%. Damage in unprotected fields ranged from 40% to 100%. One grower in Warwick, RI began the season with a commercial laser scarecrow in his field. Redwing blackbirds were present in the hedgerows around the field, and feeding on sweet corn in one corner where the laser beam did not reach. There was no damage on corn elsewhere in the field, until the motor on the laser scarecrow failed. The field was unprotected for five days; 80% of the ears on the two plantings that matured during this time were rendered unmarketable by bird damage. Once a new laser scarecrow was installed, blackbirds stopped feeding on the corn until the scarecrow was moved to protect a different field. Similar results were seen in Cranston, RI with starlings when the grower had sweet corn maturing at the same time in two different fields, and was only able to protect one field. The unprotected field was a complete loss, while there was no reported damage in the protected field.

The laser scarecrow significantly reduced bird damage in the controlled study at URI. Bird pressure was low at the Gardiner Crops Research Center, but the protected plots consistently had fewer damaged ears than the unprotected plots. Starlings were the primary bird species damaging sweet corn at URI. The birds did not appear to become habituated to the laser beam, and avoided the fields even in full sunlight when the beam was not visible to human eyes. No residual effect was observed – if the laser scarecrow was powered down or removed, birds resumed feeding in the field in less than a day. If field shape or rolling terrain blocked the laser beam from a portion of a field, the birds would congregate in the unprotected area. The height of the laser beam relative to the crop appears to be important – if the beam is too low it will be blocked by the crop, but if it is aimed too far above the crop the birds will not be dispersed

Conclusions

Laser scarecrows appear to be effective as a means of preventing starlings and blackbirds from feeding in sweet corn fields. Based on grower reports, they are more effective than scare guns at preventing damage. Commercial laser scarecrows are more expensive than scare guns, but cost less to operate, and avoid problems with noise pollution. Labor requirements are similar to scare guns. A preliminary single-site trial suggests that laser scarecrows are effective at preventing starlings, blackbirds, crows, and flickers from feeding on grapes, but are less effective against catbirds. The scarecrows also may be effective at protecting newly-seeded cover crops from Canada geese. Laser scarecrows are not effective against deer or other mammals (VerCauteren et al. 2006). We will be repeating the controlled studies on sweet corn in 2017, and will be initiating further tests of the laser scarecrows on additional crops and against additional bird species.

Laser Scarecrow Sources

Carpe Diem Technologies, Vancouver, BC http://www.carpediemtechnologies.com/ manufactures an automated laser scarecrow with a fixed beam angle. Units sell for ~$3,000. Several RI growers have purchased Carpe Diem units; there have been issues with product quality and customer service.

Bird Control Group, Lake Oswego, OR https://birdcontrolgroup.com/ sells the full configurable Agrilaser Autonomic, which is designed to cover very large areas but is not easily moved. Units start at ~$8,000. They also offer less expensive hand-held units. No Agrilaser Autonomic units are in use in New England.

URI Research Prototype http://digitalcommons.uri.edu/riaes_bulletin/ for growers who wish to construct laser scarecrow units to use on their farm. These units have been developed specifically for use in small fields. Beam angle and vertical motion are configurable to accommodate slopes. The laser can be easily programmed to turn on or off at specific points in the rotation to prevent the beam from interfering with roadways or annoying neighbors. Unit design prevents beam from aiming above horizontal to eliminate risk of interference with aircraft. Materials cost is ~$300 including stand and battery.

Acknowledgements

Jasper Romero and Gabrielle Torphy assisted with laser scarecrow construction and field data collection. Jim Lawson of the RI Division of Ag Wildlife Damage Prevention Program has tirelessly championed laser scarecrow development and recruited farmers for field testing. Vinny Confreda, Ken Elliot, Pat Usher, Jim Verde, and Bill Stamp allowed us to test laser scarecrows on their farms. This work was funded by NESARE project ONE17-291-31064 and by funds from the Rhode Island Division of Agriculture and the RI Agricultural Experiment Station.

References Cited

Blackwell, B.F., Bernhardt, G.E. and Dolbeer, R.A., 2002. Lasers as nonlethal avian repellents. *The Journal of Wildlife Management*, pp.250-258.

Briot, J.L., 1995. Last experiments with a laser equipment designed for avian dispersal in airport environment. IBSC27/WP V-1 pp 1-5.

Glahn, J.F., Ellis, G., Fioranelli, P., and Dorr, B.S., 2000. Evaluation of moderate and low-powered lasers for dispersing double-crested cormorants from their night roosts. Ninth Nat. Wildlife Damage Manag. Conf. Proceed. Oct. 5-8, State College, PA.

Gorenzel, W.P., Blackwell, B.F., Simmons, G.D., Salmon, T.P. and Dolbeer, R.A., 2002. Evaluation of lasers to disperse American crows, Corvus brachyrhynchos, from urban night roosts. *International Journal of Pest Management*, *48*(4), pp.327-331.

Homan, H.J., Slowik, A.A., Blackwell, B.F., and Linz, G.M., 2010. Field testing class IIIb handheld lasers to disperse roosting blackbirds. National Sunflower Association Sunflower Research Forum, Jan. 13-14, 2010, Fargo, ND.

VerCauteren, K.C., Gilsdorf, J.M., Hygnstrom, S.E., Fioranelli, P.B., Wilson, J.A., and Barras, S., 2006. Green and blue lasers are ineffective for dispersing deer at night. Wildlife Soc. Bull. 34(2):371-374.

Werner, S.J. and Clark, L., 2006. Effectiveness of a motion-activated laser hazing system for repelling captive Canada geese. *Wildlife Society Bulletin*, *34*(1), pp.2-7.

Getting Started in Strawberries-- Plasticulture

David T. Handley

Vegetable and Small Fruits Specialist
University of Maine Cooperative Extension
Highmoor Farm, P.O. Box 179, Monmouth, Maine 04259
(207) 933-2100

Although the matted row has been a successful and profitable strawberry production system for many years in the colder regions of the country, plasticulture systems, widely adopted in other climatic regions of the country may, with significant modifications, be adapted to New England growing conditions. Advantages of plasticulture may include earlier harvest, higher yields, improved fruit quality, better harvest efficiency, and better weed control. Disadvantages may include higher initial costs (plastic, plants, labor), increased winter injury, more frequent re-planting, difficulty in obtaining planting stock, and increased disease pressure. Plasticulture systems tend to offer significantly higher yields in their first harvest over matted row production, but the costs are significantly higher and thus profitability is often comparable. However, for growers who are accustomed to using plastic mulches in vegetable systems, or who are interested in alternatives to the matted row for extending the harvest season or altering pest management strategies, plasticulture may offer a viable alternative to the matted row.

Varieties

Any strawberry variety that performs well in the Northeast in a matted row system will probably do the same in a plasticulture system. Some of the June-bearing varieties that have worked well include Chandler, Galletta, Jewel, Flavorfest, and Valley Sunset. For day-neutral varieties, the best varieties include Seascape, Albion and San Andreas.

Selecting A Planting Site

Selecting the right planting site is a critical decision. Planting strawberries in a poor or marginal site will result in poor plant stand, poor plant vigor and poor yields. While strawberries can tolerate a variety of soil types, they grow best in a deep sandy loam, rich in organic matter. The soil must be well-drained. Avoid areas that remain wet late into the spring. Do not plant strawberries in an area where tomatoes, potatoes, peppers, or eggplant have been grown in the past four years. These crops carry a root rot (*Verticillium*) which also attacks strawberries. Do not plant strawberries into recently plowed grass or sod areas. This can lead to damage by white grubs, a common turf pest, which will feed upon strawberry roots. Finally, choose a site where there is ready access to a water supply. Irrigation is critical in a plasticulture system for good plant establishment, and to maintain high plant vigor throughout the growing season

Preparing the Beds

Have the soil tested for pH and fertility. Strawberries prefer a soil pH of 5.8 to 6.2. Soil testing information is available at your Cooperative Extension office. If the organic matter level of the soil is low (less than 2%) a cover crop such as buckwheat, Sudan grass or oats can be sown and plowed into the soil before it goes to seed. Applications of compost or manure and can also be used to increase organic matter.

Fertilizer should be applied and worked into the soil prior to planting, including about 100 lb. slow release nitrogen. Phosphorus and potassium rates should be determined through soil tests taken the previous fall. In addition to nitrogen, 60 lbs. of phosphorus (P_20_5) and 60 lbs. of potassium (K_2O) should be available prior to planting.

Plasticulture beds are generally raised four to eight inches high, and are 36 to 42 inches wide, spaced 60 to 72 inches apart on center. Having the bed smooth and firm before laying the plastic is critical to getting good mulch to soil contact. Working the soil with a rototiller just before shaping it with a press pan is often helpful. Having the middle of the bed "crowned", i.e. higher than the edges, will help to shed water, reducing the incidence of diseases. Most plasticulture beds have two rows of plants, although some have a single row or as many as four. For each row of plants, a line of drip irrigation tape should be laid as the beds are being formed, three to four inches below the surface and just inside of the plant row. Lay the plastic mulch snuggly over the raised beds, with the sides secure, and the ends tucked under soil. Feed the ends of the drip tape through slits in the plastic at each end of the row. Black plastic generally provides the best results in New England. Clear plastic allows too much weed growth on the beds, and white plastic, although it keeps the plants cooler during the summer months, tends to have lower yields.

Planting

In New England, dormant bare-root crowns are most commonly used for planting. Some growers have used plug plants (rooted runner tips), that are more commonly used in the southeast, but these can be difficult to obtain in late spring/early summer when planting here is recommended, are more expensive, and offer limited variety selection. For dormant crowns, late planting can reduce the number of runners that will need to be removed. Dormant crowns should be planted from late May to late June, depending on your location. Later planting can reduce the quality and vigor of the crowns from prolonged storage, and the warmer, drier soils of summer may additionally stress the plants. It is helpful to mark the plant spacing on the plastic prior to planting. This can be done with a measuring tape, marking plant spacing by dimpling the plastic with your finger. For large plantings, a marking wheel can be made from a bicycle wheel rim, with small cleats screwed on to it, placed to mark the plastic at the desired spacing. Plants are usually spaced 9 to 14 inches apart within rows, with 16 to 24 inches between rows on a bed, depending on the vigor of the variety being used. A simple planting tool made from a 16" long, 1/8" thick, 1 ½" wide piece of flat bar can great speed up planting. The bar should be bent at 90° about 4" down from the upper end to form a handle. The planting end should be filed to create a shallow notch across the width, with the edges smoothed. The crowns are placed on the plastic with the end of the roots over the planting mark. Placing the notch of the planter just in from the end of the roots, gently push the end of the planter straight down through the plastic mulch and into the soil, taking the roots and crown with it. When the top of the crown is just above the soil line, hold it in place and gently pull the planter straight back up, leaving the crown in place. Be sure not to place the planter higher up on the root system when pushing the crowns into the soil. This will result in folding the roots, or "J-rooting" which will stress the plants, and may kill them. Also, be careful to avoid hitting the irrigation lines with the tool. Once the plants are in place they should be watered in to reduce stress and stimulate new root growth. For plug plants, larger holes are needed and a hand trowel is used to cut the plastic and make planting holes for the plugs. For larger plantings, a water-wheel type transplanter can be adapted to properly space and plant the plugs. Irrigation immediately following planting and for several days is critical for good establishment of plug plants.

Typically, all of the flower blossoms that emerge shortly after planting are pinched off. This reduces stress on the newly planted crowns, improving plant vigor and leading to better yields next year. However, in an effort to offset the high initial cost of this system, some growers let these flowers, initiated in the nursery the previous fall, set fruit. This crop is usually quite small, but it may bring in a small return beyond its harvest cost. However, the resulting stress on the plants may have an impact on next season's crop. Plug plants will not flower soon after planting.

Several weeks after planting, runners will start to emerge from the crowns, stimulated by warm temperatures and long day lengths. All runners should be removed from the plants to improve plant vigor and to prevent the runners from rooting in the planting holes and along the edges of the mulch. Left to root, the runner plants will behave as weeds, competing with the planted crowns for light, nutrients and water, and interfering with spray applications. The runners may be removed with clippers, scissors or knives. Ear tag removers, plastic handles with a hook on the end which houses a razor blade, are inexpensive and work very well for this task. Prohexadione-calcium (Apogee®), a chemical which can reduce runner production, is allowed for use on strawberries in Canada, but has not yet been registered for strawberries in the U.S. Removal of runners can significantly increase yield and fruit quality, as well as improve harvest efficiency and pesticide efficacy. However, the labor costs of hand removal are very high, and thus have a significant impact on the profitability of the planting. In other plasticulture growing regions, the plants are grown during the fall and winter months, when strawberry plants produce few, if any runners, and therefore don't have to contend with this cost.

Nutrition

By incorporating much of the strawberries nutrient needs prior to planting, little if any additional fertilizer should be needed for the first two to four weeks. Once the plants have leafed out, they may use up to three pounds on nitrogen per week and also have high demands for potassium and/or magnesium, depending on soil types. These needs can be addressed with soluble fertilizers applied through the drip irrigation system. Often, we find that the plant needs are quite a bit lower than this. If plant vigor, including color leaf size and petiole length are good, chances are that little, if any fertilizer is required. However, it may be helpful to take leaf samples for analysis to determine actual nutrient content. Contact your Extension Specialist, or soil lab for details on leaf tissue testing and fertigation.

Day-Neutral Harvest

Day neutral varieties will fruit in the late summer through fall of the planting year and will provide off-season production for market and stand sales. Harvest is spread out and generally not well suited to pick-your-own marketing. The harvest season can be extended beyond early frosts by protecting the beds with rowcovers or low plastic tunnels. Once harvest is complete the plants can be prepped for winter if a spring crop is also desired.

Winter Protection

The beds will require winter protection, which is usually provided by applying synthetic fabric rowcovers over the plants in the fall. These may be applied as early as mid-September to extend the growing season and increase flower bud production. However, the light weight rowcovers often used for this purpose may not be adequate for winter protection. A 1.25 oz. fabric weight or heavier is needed to provide the needed insulation. The protective covers are applied after the plants have gone dormant in the late fall. These covers stay on until growth starts in the spring. Lighter weight covers can stay on until flowers start to emerge, but heavier covers should be removed earlier, as they can delay growth by not allowing adequate light through to warm the plants.

Spring Care

The use of black plastic and rowcovers will stimulate early growth in the spring, sometimes weeks earlier than matted row beds. While this may lead to an early harvest, it also increases the risk of frost injury to the flowers. After the flower buds emerge, pulling the rowcovers back over the beds when frost is threatening can provide a few degrees of protection. Overhead irrigation, applied either instead of the covers or over the covers during freezing temperatures can provide an even higher level of protection from frost injury.

Once the plants start growing again, light applications of fertilizer may be applied through the drip irrigation system to be sure there is enough available nitrogen, phosphorus, potassium, magnesium and boron; all important for early growth and fruit development. However, only 10 to 25 lbs. of actual nitrogen per acre is recommended prior to harvest to prevent excessive vegetative growth at this time, which can lead to fruit rot problems. Boron applications should not exceed 2 lb. per acre to prevent toxicity problems.

Harvest typically begins about three weeks after bloom. Harvest in plasticulture beds often begins two to three weeks earlier than matted row beds. Plants should be harvested two to three times per week, sometimes more often, to prevent fruit from becoming overripe. Watering between harvests can help maintain fruit size through the harvest period. Train pickers not to walk on the beds or kneel on the edges, as this will damage the mulch, creating wet pockets and weedy spots in the beds.

Renewing the Planting

It is important to note that the plasticulture system is often best managed as an annual system, i.e. the beds are plowed under after a single harvest (or two, fall and spring, in the case of day-neutral varieties). However, many growers in the Northeast have tried carrying plasticulture beds over for a second and sometimes third harvest year. To stimulate new growth while removing old growth, the plants are mowed off just above the crowns shortly after the harvest season is finished. The debris is swept off of the beds and removed from the planting or tilled into the soil between the beds. The beds are fertilized through the growing season (1 to 2 lbs. N/acre/week), and runners are removed as they appear. Winter protection is carried out as in the planting year. While the renewed beds will produce again for a second season, the fruit size and yield is often noticeably smaller, and the disease and weed problems become more challenging. In addition, controlling runners becomes even more labor intensive during the second growing season, because the plants are larger and have more time to produce them. Overall, harvest seasons beyond the first year tend to be less profitable, but may be viable if the additional labor cost and reduced yield can bring a higher net profit than re-planting.

Strawberry Variety Update – Day-Neutrals
Kathleen Demchak

Penn State Univ., 107A Tyson Bldg., University Park, PA 16802

Day-neutral strawberries can be described in a number of ways, and terminology used to describe them can be a bit confusing. For purposes of this talk, the term "day-neutral" is used to refer to strawberry varieties that bloom and fruit during the spring, summer and fall in our region. Day-neutral strawberries are often referred to as "everbearers" in nursery catalogs, and sometimes the term "remontant" is used to describe them in more technical information. Remontancy simply means that the plants are able to flower repeatedly, instead of just once in a growing season.

When day-neutral varieties are introduced, they are often referred to as "strong" or "weak" day-neutrals. Varieties that have "strong" day-neutral tendencies typically flower quite dependably during the summer and produce few runners. A "weak" day-neutral will take more of a break from production during the summer, and the plants will produce a lot of runners.

A number of day-neutral varieties were released decades ago, and most of them had some characteristic(s) that made them less than ideal for commercial production - usually small fruit, inconsistent production, or poor flavor. Thus, day-neutrals were only occasionally grown by growers in the eastern U.S., and usually on a very small scale.

Meanwhile, day-neutral varieties were being improved by breeding programs that serve larger industries, a logical step when one considers the importance of consistent supply in the wholesale market. Thus, most of the day-neutral varieties now grown in the northeastern U.S. are from non-proprietary breeding programs that serve larger industries, as reflected in the variety information below. Currently Eastern breeders are working to develop day-neutral varieties with greater disease resistance and other desirable characteristics suitable for eastern producers. The logic behind this becomes very apparent when one considers, for example, that strawberry growers in PA and NY produce only 4 and 3% of the strawberries purchased in these states, respectively.

Day-neutral varieties currently available from U.S. nurseries or expected to become available within a few years are listed alphabetically below:

<u>Albion</u> (Univ. of California, 2004). Currently one of the industry standards in the eastern U.S. Yields can be on the low side, as plants tend to remain somewhat vegetative. Is reported to respond well to additional fertilization beyond that typically recommended. Fruit tolerates handling well and is firm, but only pleasantly so when fully ripe and eaten fresh. A high percentage of fruit is marketable in open field, but percent marketable fruit and yields can be increased further with protected culture (low tunnels or high tunnels). Beautiful red color when

fully ripe, with an attractive sheen. Primary berries may be creased, but later berries are not. Susceptible to anthracnose fruit rot and develops some powdery mildew. Does not over-winter well, at least when fruited under low tunnels, though this problem was not noted in earlier plantings in open-field production. Patent information indicates resistance to verticillium wilt and Phytophthora crown rot.

Aromas (Univ. of California, 1996). In early PA trials, produced large fruit with bright red color but was too firm to be considered acceptable. Flavor was fair to good.

Cabrillo (Univ. of California, not yet available to nurseries outside of those in California). In California, is more productive than San Andreas and Monterey, with larger fruit, increased firmness, and tolerance of rain, and a very percentage of unmarketable fruit. Flavor is reported to be outstanding. Since untested in the eastern U.S., disease susceptibilities under eastern conditions are unknown – susceptibility to anthracnose crown rot may be a concern based on disease ratings in a California trial.

Diamante (Univ. of California, 1996). One of the parents of Albion, which you can see in its resemblance in fruit size, shape, and color. Fruit is large and very firm, but is low in sugar and flavor, and considerably less productive than ‘Seascape’.

Everest (Edward Vinson, U.K., 1998). Can be extremely productive, but fruit is small, dark, soft and loses flavor under hot summer conditions. Produces few runners. Very susceptible to anthracnose fruit rot and verticillium wilt.

Evie 2 (Edward Vinson, U.K., 2001). Fruit is large and attractive, with uniform appearance. However, it tends to be very light and soft with less flavor than most other day-neutrals.

Evie 3 (Edward Vinson, U.K., 2003). Similar to Everest in productivity, and Evie 2 in color and flavor, and softness.

Mara des Bois (Marionnet SARL, France, 1991). Berries are small, but nicely shaped with good color, very flavorful and aromatic. Considered by some to be a “gourmet” strawberry. Very susceptible to fruit anthracnose, so recommended for protected culture, or in situations where fungicides can be used to protect the fruit. Moderate yields.

Monterey (Univ. of California, 2008). Produces large deep red berries with good flavor and excellent size, similar to ‘Albion’ but a bit less conic. Somewhat more productive in total yields than ‘Albion’ Quite susceptible to powdery mildew (though less-so than ‘Seascape’). Noticeable susceptibility to fruit anthracnose is a concern, and decreases marketable yields.

Portola (Univ. of California, 2007). Small plants that just don't take a break during the summer, making this variety extremely productive. Unfortunately, productivity isn't the only thing that matters. Berries are large, but light-colored, soft, and extremely susceptible to fruit anthracnose.

Redstart (Michigan State Univ., 2016). Described as a "weak day-neutral", 'Redstart' is a cross of 'Honeoye' with 'Chandler'. It produced fruit for either 5- or 6-week harvest seasons in Michigan trials, but for 11-13 weeks in the Pacific Northwest, presumably due to milder summer temperatures. Productivity in Michigan was better than for 'Seascape' or 'Albion'. 'Redstart' fruit size in Michigan trials was intermediate to 'Seascape' and 'Albion', with flavor comparable to 'Albion' and firmness similar to 'Seascape'. Fruit was smaller than that of 'Albion', and lighter than that of 'Seascape'.

San Andreas (Univ. of California, 2008). Large fruit similar to Albion in quality, except for having a more blocky and often less symmetrical shape. Flavor and firmness where very good. Color is just a little lighter than for Albon.

Seascape (Univ. of California, 1991). Has been very productive in the East, producing large berries with nice red color that were very sweet. Was the standard day-neutral for eastern producers in the U.S. and Canada until 'Albion' or 'San Andreas' was adopted instead. Generally has overwintered well under row covers. Its main shortcomings are extreme susceptibility to powdery mildew, and a tendency to split with even limited amounts of rain. In these situations, berries continue to split in the cooler after harvest.

Sweet Ann (Lassen Canyon Nursery, California, 2012). Excellent flavor, but fall yields in PA were delayed due to possibly insufficient chilling, resulting in low yields in the planting year on two different occasions. Spring yields were intermediate to other varieties, and flavor was still very good, but less stellar than in the fall. This variety is reported to have good disease resistance, and requires additional testing.

Verity (Edward Vinson, U.K. 2012). According to European testers, has improved flavor over the other day-neutrals from this breeding program. According to the U.S. propagator (Nourse Farms), this variety requires high nitrogen for improved yields and is recommended for growers not growing under protected culture. Additional testing is needed.

Wasatch (Michigan State Univ., 2016). Described as a "strong day-neutral", 'Wasatch' is a cross between 'Seascape' and MSU 38 - a selection resulting from a cross of 'Tribute' and 'Honeoye'. It outyielded 'Seascape' in Michigan trials, with improved size and flavor as well. It outyielded 'Albion' as well, had improved color, similar flavor, and reduced firmness and size. It produced fruit for 8 weeks in Michigan, and 12 weeks in Washington, with yields increasing as the season progressed, especially in high tunnels where early season yields were low.

Low Tunnel Strawberry Production

Marvin Pritts

Horticulture Section, School of Integrative Plant Science
Cornell University, Ithaca, NY, mpp3@cornell.edu

A major limitation for strawberry growers is the short season when berries are typically available to sell. The first strawberries ripen in mid-June and harvest ends near the 4th of July. Rainy weather during these three weeks, especially on weekends, can have a significant negative financial impact on growers, particularly if they market through pick-your-own. It would greatly benefit growers if strawberries could be produced over a longer season, into the summer and fall, as this would extend the season and open up new markets.

In the 1980s, varieties of strawberries (day neutral) with the capacity to produce flowers during all day lengths (spring, summer and fall) were released to the public. While there was initial excitement with these new varieties and their flavor was excellent, grower interest waned because 1) yields were low, 2) fruit size was small, 3) berries were expensive to pick, and 4) tarnished plant bugs (TPB) damaged the ripening fruit.

A new generation of day neutral varieties was released in 2004. Although these originated from California, they were relatively well adapted to the Northeast, producing much larger fruits and higher yields than earlier releases. They produce fruit the year of planting and continue fruiting into the fall. After overwintering, they produce another flush of fruit in spring. The fall crop and the second-year spring crop can be protected from rain and cold temperatures by covering rows with plastic on metal hoops – a technology called “low tunnels.” The tunnel plastics not only exclude rain but they can decrease the amount of ultraviolet light and infrared radiation - reducing spore germination and heat load on the plants. The combination of day neutrals and low tunnels has the capacity to extend the strawberry season from 3 weeks to 5 months.

We have conducted studies with 1) various day neutral cultivars, 2) various plastic covers and netting, 3) varying planting dates, 4) varying fertility rates and 5) on-farm grower-cooperators. After several years of research, the following procedure is recommended for growing and producing day neutral strawberries.

Build raised beds (18 inches or wider) in late fall or early spring so they can be planted as soon as possible in spring, preferably by late April. Delaying planting until late May or Jun will significantly decrease yields the first year. Each bed should have a trickle irrigation line attached to a fertilizer injection system. Cover each bed with white plastic and plant ‘Albion’ in a staggered double row, with plants 9 – 12 inches apart in each row. While several other cultivars are available, ‘Albion’ has the best flavor and good size. Use a tool that will insert roots into the bed while disturbing the plastic as little as possible.

Fertilize the planting with 2 lbs of actual nitrogen per planted acre per week for the first few weeks after planting. Remove the flowers for the first three weeks, or until vigorous new leaves appear from the crown. Plant grass seed between the rows, or lay a landscape fabric or straw mulch to prevent mud from splashing on the berries.

Install tunnels when plants begin to throw new flower trusses. Cover the tunnels with 4 to 6 mil plastic, preferably with a type that excludes ultraviolet light and reduces infrared radiation. Dubois Agrinova (http://www.duboisag.com/) sells kits with plastic that has predrilled holes for ventilation when the plastic is lowered. The cost for the tunnel kits is $450 per 100 foot of row. This cost is recovered in the first year.

At least one side of the plastic should remain up under normal weather conditions to allow for pollination and to prevent heat build-up. Infrared-inhibiting plastic provides some shade which is beneficial for the plants, so allow them to be shaded by the plastic if possible. Lower the sides when the weather is cold or stormy and then raise them again when better weather arrives. A benefit of the plastic tunnels is the near elimination of Botrytis gray mold from water exclusion and inhibition of spore germination from the reduction of UV light.

Once plants begin to set fruit, increase the nitrogen to 5 lbs/acre per week. Failure to provide weekly applications of nitrogen is a major reason why first-time growers have lower yields than expected.

Plants will begin to fruit in late July or early August. Harvest the fruit at least twice a week. Peak yields will occur in September, with production occurring through October and even into November.

Once the temperature falls below 40F, lower the tunnels. If the temperature falls below 30F in mid-October, cover the entire field with row cover for the night to preserve ripening fruit. This will extend the harvest season should the weather warm again.

Once harvest is over, lower or remove the plastic and cover the beds with straw. ‘Albion’ does not overwinter well in cold weather. We are currently studying various methods of overwintering ‘Albion’ to reduce winter mortality. Remove the straw in late March/early April and allow these plants to fruit again. The tunnel can be used to protect from late spring frost.

Over the course of the first year with an April planting date, we harvest an average of 20,000 lb/acre, which is as much as a good June-bearing cultivar will produce in one season. Average berry size of ‘Albion’ is 15 grams, which is the size of a medium king fruit on a June-bearer. Flavor is excellent. Production peaks in September with two quarts (four pints) of berries per 10 feet of row, but in October plants consistently produced about a quart of berries every 10 feet of row until the weather turns consistently cold.

In spring of the second year, a large flush of fruit is produced about the same time or earlier as that of early June-bearers. Tunnels can be used to accelerate flowering if desired. Spring yields can be almost as much as the previous year's yield. We have not found it to be economical to hold over these plants into a second summer and fall. Rather, we grow them for about 15 months and then remove them. Summer heat is not conducive for second-year production.

We found that, while attractive, growers may not be able to "fit" such a crop into their farm operation since day neutrals require constant attention. Plastic has to be raised and lowered, plants have to be fertilized weekly, and once harvest begins, it lasts for months. However, the rewards can be great. Growers have reported gross sales of $50,000 per acre from Albion in New York State. Given that the cost of materials for an acre is about $44,000, sales can pay for the materials in the first year. In the second year, costs include plants, fertilizer, labor and harvest. Conservatively, this can be $20,000, but with sales approaching $30,000 or more, the margins are quite good. In future years, with the cost of the tunnels paid for, returns can be quite high.

Spotted winged drosophila damage has been minimal in our trials provided that fruit is harvested regularly and not left rotting in the field. In one trial we used netting in place of plastic to determine how it would perform when the sides were down continuously throughout the fall to exclude spotted winged drosophila. Surprisingly, the netting had many of the benefits of the plastic. Sufficient air movement occurred so that flowers were pollinated without bees. Enough moisture was excluded so that fruit rot was low, and enough heat was retained on cold nights to prevent early frosts and extend the season. There was no SWD damage on those fruit, but damage levels were low throughout the planting.

It is unclear why SWD seems to be less damaging to day neutral strawberries in New York than they are in other areas of the country and in certain locations in Canada. It is possible that preferred alternate food sources are more abundant in regions with less damage so the flies are attracted to other types of fruit. It is also possible that damage to day neutral strawberries will increase over time with changing weather patterns.

At this point in time, we believe that this technology will transform strawberry production in the Northeast as strawberries will be one of the few fall berries where the effort required to manage SWD is reasonable. Having large, flavorful strawberries available in the fall is an opportunity that many growers will want to take advantage.

Fungicide Resistance: How to Manage Gray Mold Issues

Laura McDermott

Cornell University Cooperative Extension
Eastern NY Commercial Horticulture regional program
415 Lower Main Street, Hudson Falls, NY 12839
lgm4@cornell.edu

Strawberry Fruit Rot Protection begins at Bloom

Dr. Cassandra Swett, Grape and Small Fruit Pathologist University of Maryland, provides extension support for growers in both Pennsylvania and Maryland through a cooperative agreement between the two land grant universities.

Our two main targets for bloom time protection of strawberries are gray mold/ Botrytis fruit rot, and, if you are growing susceptible varieties like Chandler, anthracnose fruit rot.

Fungicide Efficacy

Most fungicides are labeled for both pathogens, but if your main target is gray mold, you need to consider that the fungus has become resistant to several fungicides. If you use fungicides that the pathogen is resistant to, you will have no protection--it's essentially like missing a spray. Based on the fungicide resistance tests that Guido Schnabel conducted with Botrytis from Maryland, Topsin M is ineffective and at some sites, Scala is also ineffective.

Spray Guidelines to Manage Fungicide Resistance

Here's a strawberry spray guide that manages fungicide resistance, when your main objective is gray mold (Botrytis) protection:

Pre-bloom (crown rot protection)

Spray: Every 7-10 days

Rotating: Captan 50 WG or 80 WDG (group M)

With: Rovral 50 WG (Group 2) --this compound can only be applied once, and only pre- bloom

Early Bloom (10%) to fruit set

Spray: Every 7-10 days

Rotating: Elevate 50 WDG (group 17), CaptEvate (group M + 17), Switch 62.5 WG (group 9 + 12), Fontelis (group 7), Scala (group 12) and Pristine WG (group 7 + 11)

With: Captan, Thiram 24/7 or Thiram Granuflo (both group M)

An example: Captan+Fontelis, then Switch, then Captan, then Pristine, then Thiram, then Elevate, then Captan

After fruit set:

Spray: Every 7-10 days

Rotating: Captan and Thiram (both group M)

With: CaptEvate (group M + 17), Elevate (group 17), or Fontelis (group 7) -each applied only once during this interval.

Rates

For every compound, there is a range in the rate you can apply. For fungicides at risk of resistance (Switch, Pristine, Rovral, Scala), the lower rate is always recommended. For fungicides that are not at a high chance of resistance (Elevate, Fontelis, Captan, Thiram), the amount you apply should be adjusted, in part, based on how high disease pressure is. If it rained at least once since your last spray, and temperatures are between 65 and 75^{0} F, you will want to use the higher concentration. If, in contrast, it's been cooler than 65, warmer than 75 and / or dry, use the lower rate.

Timing

The same goes for how often you spray. We get a lot of rain this time of year, and every time it rains the fungus has a chance to infect plants. So long as it's raining about every week, plan to spray every 7-10 days.

Tips

- Control is improved when you rotate between Fontelis and Switch and when you tank mix Fontelis with Captan.
- One of the compounds in Pristine is the same FRAC group as Fontelis, so don't use these sequentially.
- Switch and Pristine are both highly effective, but are at high risk of resistance if they are used too often. Because of this, it is recommended that they are only used ONCE each year.

What about non-synthetic chemicals?

There is some interest in using non-synthetic chemicals for fruit rot control, as a rotation with synthetic chemicals, especially in post bloom control, and for organic management. One such compound is Regalia, a plant extract labeled for use on gray mold and anthracnose fruit rot in strawberry. Trials are lacking for strawberries, but in grape Regalia can be as effective as Pristine against Colletotrichum, and is moderately effective against Botrytis. In trials in California, disease control with Regalia is best when rotated with conventional compounds.

We are doing work on strawberry starting this year to evaluate Regalia and other bio- pesticides / biologicals, so we should have more information on this in future years.What about non-synthetic chemicals?

There is some interest in using non-synthetic chemicals for fruit rot control, as a rotation with synthetic chemicals, especially in post bloom control, and for organic management. One such compound is Regalia, a plant extract labeled for use on gray mold and anthracnose fruit rot in strawberry. Trials are lacking for strawberries, but in grape Regalia can be as effective as Pristine against Colletotrichum, and is moderately effective against Botrytis. In trials in California, disease control with Regalia is best when rotated with conventional compounds.

We are doing work on strawberry starting this year to evaluate Regalia and other bio- pesticides / biologicals, so we should have more information on this in future years.

Some helpful resources:

- Fungicide Resistance Management Guidelines for Vegetable Crops Grown in the Mid-Atlantic Region - 2015 (This guide includes strawberries).
- 2015 Southeast Regional Strawberry Integrated Pest Management Guide. Louws et al.

Dr. Cassandra Swett, Grape and Small Fruit Pathologist University of Maryland, provides extension support for growers in both Pennsylvania and Maryland through a cooperative agreement between the two land grant universities.

Irrigation and Fertigation for Strawberries

Trevor Hardy

Brookdale Fruit Farm Inc.
38 Broad Street Hollis, NH 03049
tractortrv@aol.com

Strawberry irrigation has recently seen two new products that are helping change the way we irrigate and move irrigation materials around the field. The 2016 and 2017 season have shown us both extremes a drought one season followed by a very wet spring the following season. Strawberry plants responded differently to both conditions, but the size of berries in wetter season of 2017 showed many growers the importance of water. Strawberry plants require around 1.5 to 2 inches of water per week between the bloom cycle to harvest. This amount of water helps maintain berry size and plant health through the growing season.

Advancements in new drip irrigation technology have significantly improved the uniform distribution of water in strawberry fields. The new drip product comes to us from Toro Ag and it is a new form of drip tape called Flow Control drip tape which is a pressure moderating drip tape. This product has two significant advancements in its design that helps strawberry growers in the northeast. The first advancement is the design of the flow path which is the channel in which water is distributed out through the drip tape. The flow control flow path being pressure moderating distributes water more uniformly throughout the field and can be used on longer row distances. Where most northeast strawberry producers are not fortunate enough to have 100% flat ground, this new drip tape prevents over saturation of soil in low points, reducing berry rot, and improving yield. This product allows a grower to irrigate uniformly across hilly terrain and helps conserve water by reducing run time for that irrigation cycle. The second advancement in the new Flow control drip tape is regulated flow output. After blossom when the berries need more water the typical 10 to 12 psi pressure regulators for drip tape can be swapped out for 15 or 20 psi regulators which increase the output per dripper of the flow control drip tape. This allows the grower to put more water out on the berries within the same timed irrigation cycle they use simply by increasing pressure. These two key features of improved uniformity and regulated output for an approximate increase in cost of drip tape per acre by $20.00 is a sound investment for berry production.

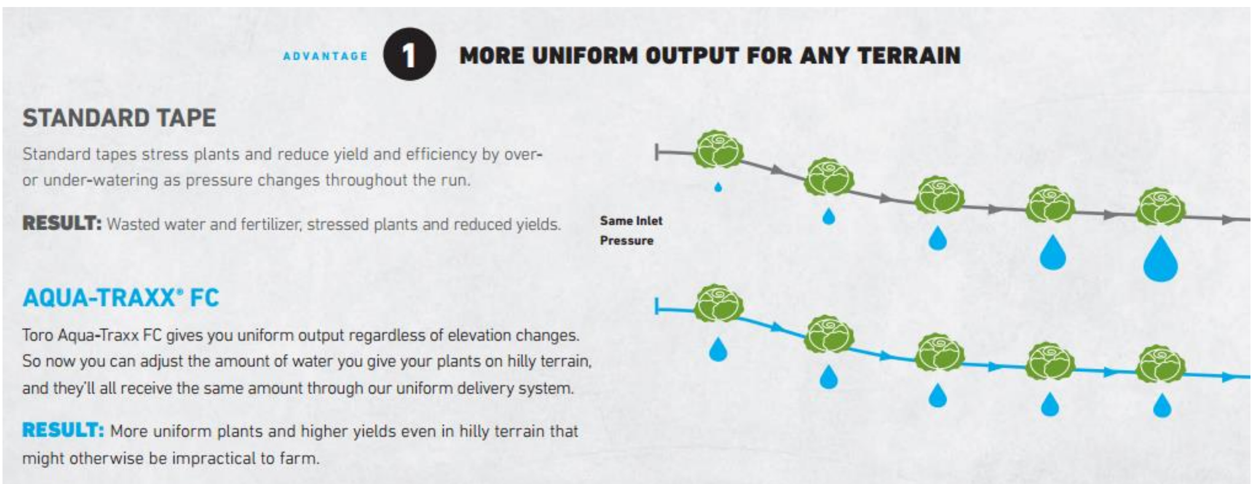
In both 2016 and 2017 seasons we also saw frost in New England. Most of the growers use overhead irrigation as a means for frost protection. This has typically been achieved by using aluminum pipe and screw in nozzles at varying spacing. This type of system has been used for many years at existing farm locations where the equipment was purchased greater than 30 years ago. This presents problems with costly upkeep of aluminum pipe and excessive labor for installation. The new products that has revolutionized overhead irrigation for strawberries comes from Netafim. The first part of this product is a new sprinkler called MegaNet. This sprinkler comes in various flow rates, but the most common one used for frost protection is the blue colored MegaNet at 1.97 gpm per sprinkler. The sprinkler design is similar to a rotary gear driven lawn sprinkler as comparted to the old swing arm impact sprinkler that many growers are used to using such as a Rain bird 30. This new design is an important feature in frost protection where the berries survive from the distribution of water to create ice on the plants to prevent them from freezing. The new Meganets positioned in a field with a square spacing of 24 feet x 24 feet can achieve over 90% uniform distribution of water. The old impact nozzles at a 30 x 30 spacing achieved uniformity in the 70% range. This improvement in uniformity means that more berries will survive in a hard frost / freeze event due to the improved uniform distribution and coverage of water. MegaNets can be adapted to be used in old aluminum pipe systems, but where they really make a difference is in the way they can be installed without using aluminum pipe.

Meganet installation can happen in 3 different forms. The first is directly into aluminum pipe. IF a grower already owns pipe, this is a cheap update. However, many new diversified growers do not have ample funds to invest in expensive aluminum pipe and fittings. MegaNets can also be installed in low density flat tube or “header pipe” that most growers use as a drip tape manifold. This allows a grower to use the same pipe they would need for drip as a supply line for the sprinklers, thus reducing the amount and kinds of pipes and fittings a grower needs in inventory to irrigate. The MegaNet stand comes with a barbed adapter that can be installed into a header pipe with a drip tape insert tool and the meganet sprinkler simply pushes onto this fitting. A fiberglass rod holds up the MegaNet sprinkler making set up an easy light weight installation job compared to lugging around a pipe wrench and heavy sprinklers for aluminum pipe. Netafim also has a new “header pipe” called Flexnet. This product when used with the Meganet system makes installation even easier. The Flexnet layflat product has ½ inch pipe thread fitting molded into the layflat every 6 feet. This allows the MegaNet stand to simply be screwed in a desired location for use, and the other holes get plugs. This makes achieving a 24 x 24 foot spacing simple with holes available every 6 feet. Connections are made from pipe to pipe by simple insert fittings or the addition of cam lock fittings. No more gaskets or hooks to worry about coming apart. The entire system also operates on lower pressure. A minimum of 25 psi is all that is needed. This allows growers to use smaller pumps and or frost protect larger areas with existing pumps. Having a layflat system also allows growers more flexibility to make small curves or bends in a field rather than being stuck with a 20 or 30-foot rigid piece of pipe. The layflat lines can also be driven over without causing damage to the pipe, not creating a run over pipe of bad aluminum pipe.

Fertigation and chemigation is made easier with the improvements in uniformity if either of the products above are utilized. Overhead improvements in uniformity makes the application of fungicides through the sprinkler system more accurate and effective. Drip system improvements allow for more precise feeding applications to be made through drip systems on both June bearing and plasticulture berries. Specific feeding rates and available products are all dependent on soil test and growing practice, however the effectiveness of these products improve with greater uniformity through the application method. A good practice to follow while feeding through a drip system is a 15-minute flush cycle of fresh water after injection to clean the drip lines. This prevents clogging and ensures material is not left in suspension in the drip system. For further information about new products or fertigation materials please visit our website at www.brookdalefruitfarm.com/Irrigation/

<u>Meganet with Flexnet image</u>

Toro Flow Control drip tape Graphic



The Midwest Apple Improvement Association (MAIA)
An Apple Breeding Program For All Growers

Bill Dodd

MAIA President
Amherst, OH 44001
billd@evercrispapples.com

The MAIA was formed over 20 years ago by a group of Midwestern apple growers looking for varieties that would be suitable for their climate. Bill Dodd of MAIA will explain how a group of small apple growers from small production states have created a breeding program that recently released the variety MAIA-1, that will be marketed under the trademarked name EverCrisp. 7 more new varieties have been released and will be available to plant in 2020.

Bill will share how MAIA developed their business plan and crafted it to include variety availability to all apple growers. The managed open release system that MAIA uses is the only model of its kind in today's world of controlled managed apple varieties.

Bitter Pit Control in 'Honeycrisp': Physiology and Mitigation Strategies

Lailiang Cheng

Section of Horticulture
School of Integrative Plant Science
Cornell University
Tel: 607-255-1779
LC89@Cornell.edu

'Honeycrisp' is highly susceptible to bitter pit, and up to 50~60% of the crop can be lost to bitter pit in some years. This talk will be focused on improving fruit Ca level and its balance with other nutrients to reduce bitter pit.

Bitter pit development is related to Ca deficiency in the fruit. From a physiological standpoint, it is the concentration of cell membrane-bound Ca that determines the membrane structure and function, but the exact physiological mechanism underlying bitter pit development is not completely understood. Our recent work shows that, compared with 'Gala', 'Honeycrisp' has a more acute partitioning of Ca between leaves and fruit, leading to a much lower Ca level and higher ratios of (K+Mg)/Ca and P/Ca in fruit. This imbalance of Ca with other nutrients might predispose 'Honeycrisp' to Ca deficiency and bitter pit development. Comparison of 'Honeycrisp' fruits with and without bitter pit indicate that imbalance of Ca with other nutrients is closely associated with bitter pit development, and peel nutrient ratios might have the potential to predict bitter pit susceptibility.

Mitigation of 'Honeycrisp' bitter pit has to take a comprehensive approach. Management strategies should focus on 1) ensuring soil Ca supply and root growth for adequate Ca uptake; 2) managing competition for Ca between vegetative tissues (shoots and leaves) and fruit via controlling shoot growth and cropload; 3) strictly controlling K and Mg levels to achieve proper balance with Ca; 4) making direct sprays of Ca to fruit. When Ca sprays are used to prevent bitter pit, it is important to apply enough Ca and frequent sprays are more important than making sprays at a particular time during the growing season. And 5) choosing a rootstock that imparts bitter pit tolerance to 'Honeycrisp'.

Apple Cropload Management.

Dr. Jim Schupp

Penn State Fruit Research and Extension Center
Biglerville, PA

Chemical thinning is a complex process that annually challenges the professional apple grower. In recent years, many growers have started using the Cornell Carbon Balance Model to assist them in managing the crop load of their trees. This useful tool is found on the NEWA weather website. It uses current and forecasted sunlight and temperature inputs to indicate the sensitivity of the developing apple fruits to chemical thinning. The model predicts whether there will be either a deficit or surplus of carbohydrate, making the trees in turn, either easier or harder to thin.

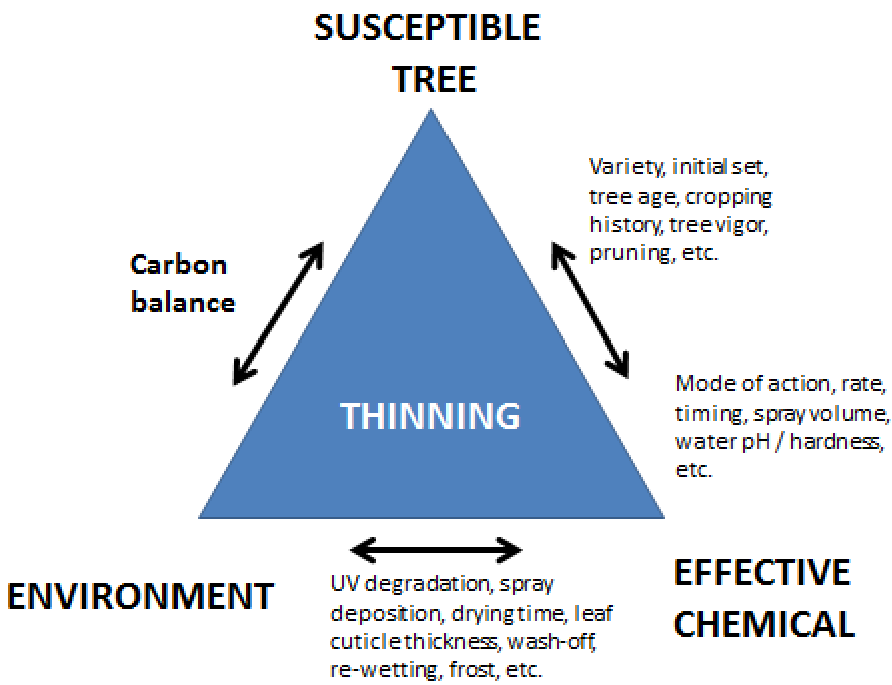
When the forecast is accurate for temperature and sunlight, the predictive power of the model is very good. We often note the 20:20 hindsight accuracy of the model in the off-season, when reviewing the results of completed chemical thinner trials and plugging in the actual recorded temperatures and light data for the thinning window. The carbon balance model does a good job of evaluating the effects of the weather on susceptibility to chemical thinners. But there is a lot more to the chemical thinning process than susceptibility.

Figure 1 illustrates the interactions between the chemical thinner, the environment, and the tree to obtain successful fruit thinning. Carbon balance accounts for the effect of the environment on the susceptibility of the tree. Environment also affects how the chemical will perform in a number of ways, which are listed across the base of the triangle. The environment, chemical thinner and the tree interact in ways not described by the carbon balance, as shown on the other two sides of the triangle.

Other key interactions affect chemical thinning activity. In order for a plant growth regulator such as NAA or 6BA to be effective, it must be absorbed by the leaf, transported to the site of activity, where it regulates some metabolic activity of the tree or the fruit with enough strength to influence fruit set. Temperature can affect each of these steps, such that thinners are much less effective during cold temperatures and act more strongly in hot weather.

It is good to have the carbon balance model to help describe how the environment may affect the trees, but the other interactions must also be understood well in order to have successful thinning.

Figure 1. The Chemical Thinning Triangle.



Killing Them Softly: Do Soft Fungicides Work?

Patricia McManus

Professor and Chair, University of Wisconsin-Madison, Department of Plant Pathology
pmcmanus@wisc.edu

Most apple growers, whether conventional or organic, novice or experienced, want to produce wholesome, attractive fruit in a manner that will minimize negative impacts on the environment. Over the past decade several "soft" chemistries and biological control products have been marketed for control of several apple diseases. How do they stack up to conventional fungicides and bactericides? This question has been addressed by several researchers in the eastern U.S., and some of the findings are discussed below.

For purposes of this presentation, a product is considered "soft" if one or more of the following criteria are met: (i) the manufacture makes "soft" or "green" claims in their advertising; (ii) the product is a biological control; and/or (iii) the product is approved by the Organic Materials Review Institute. Generally, products that meet any of these criteria have relatively low risk to human health and non-target organisms in the environment. This discussion will not include: (i) fungicides and bactericides that are considered "reduced risk" by EPA's conventional pesticide program (e.g., Pristine, Vangard); or (ii) copper and sulfur fungicides, even though they are effective in controlling certain diseases and are approved for organic production.

Three soft fungicides—Oxidate, Serenade, and Regalia—are the focus because they meet the following criteria:

1. EPA registered for use on apple and commercially available.
2. Tested in randomized, replicated, and statistically analyzed field trials.
3. Tested in more than one year, on more than one variety, and usually by more than one group of researchers.
4. Tested alone (usually), rather than mixed or alternated with conventional fungicides. As discussed later, however, they might fit best in a rotational program.
5. Test results have been published in *Plant Disease Management Reports*, a repository for results of field trials on fungicide and bactericide efficacy.

Field trials were conducted over the past decade by university researchers in various states east of the Mississippi River. For each field trial and each disease, a soft product was rated "good" if it controlled disease better than the untreated control AND was similar to the standard conventional fungicide treatment. A soft product was rated "fair" if it was better than the untreated control, but not as effective as the standard conventional fungicide. A soft product was rated "poor" if its performance was similar to or worse than the untreated control. The results from multiple trials were tabulated to produce an overall performance rating (Table 1) for each of the three soft fungicides as "stand alone" products (i.e., not alternated or mixed with conventional fungicides).

Table 1. Summary of soft fungicides for disease control efficacy

Soft fungicide	Disease	Performance Rating
Oxidate (2.0, Broad Spectrum Bactericide/Fungicide)	Powdery mildew	Fair-Poor
	Scab	Fair-Poor
	Sooty blotch/flyspeck	Fair
Serenade (ASO, MAX, Optimum, Opti)	Sooty blotch/flyspeck	Variable, Good-Fair-Poor
Regalia (alone or mixed with JMS Stylet Oil)	Powdery mildew	Fair-Poor
	Scab	Fair
	Sooty blotch/flyspeck	Fair-Poor
	Fruit rots	Fair-Poor
	Rusts	Good, but tested in few trials

A glance at Table 1 could be quite discouraging for an apple grower who wants to use soft fungicides. However, several points need to be considered:

1. The trials were often done in “high inoculum” research orchards on varieties that are highly susceptible to the various diseases. In a commercial setting, the disease inoculum pressure would probably be lower, and at least some varieties might have some resistance to the diseases. For example, scab research is usually conducted on highly susceptible varieties such as Delicious and Rome, rather than the more resistant Honeycrisp. In a low inoculum orchard and/or on varieties that are only moderately susceptible to scab, products with a “fair” rating might be good enough.
2. Table 1 summarizes the efficacy of soft fungicides as “stand alone” treatments. This was done because when soft fungicides are integrated into a program with other products, it’s impossible to determine “who’s doing the work.” But in fact, several research trials have shown that alternating soft and conventional fungicides can result in excellent disease control.
3. The trials summarized here were not done in organic orchards. Some critics would argue that biocontrols (e.g., Serenade) and inducers of plant defense (e.g., Regalia) perform better when the entire orchard system is organic.

In summary, the soft fungicides reviewed here were generally less effective in controlling apple diseases than conventional fungicides. Season-long reliance on such products would be risky. However, if your orchard has not had significant levels of a particular disease and/or your varieties are at least somewhat resistant to that disease, then the soft fungicides might provide adequate control. Likewise, if your customers are forgiving of a few blemishes and value your efforts to use low-impact disease control methods, then soft fungicides might be a good fit.

Making the Most of a Buckwheat Cover Crop

Thomas Björkman

Section of Horticulture, Cornell University, Geneva, NY
tnb1@cornell.edu

Buckwheat has been used to suppress weeds on Northeastern farms for 400 years. The practice had been used here for a century and a half by the time George Washington and Thomas Jefferson corresponded with each other about how well it worked on their farms. It still works.

On modern farms we have different tools, a different market, and different economic constraints; so buckwheat will be useful in different situations. Buckwheat has high value on 21st century farms because it controls weeds economically and in a way that adds significantly to the other weed control practices that are available.

Expected benefits

Suppress summer annual weeds. Seeds of summer annual weeds germinate but are suppressed, which reduces next year's weed seed bank. A strong stand of buckwheat suppresses all summer annuals. Weeds should be very rare and only a few inches tall. If the buckwheat starts growing slowly, or there are gaps, the weeds that most often escape are redroot pigweed, lambsquarters, and barnyardgrass. Buckwheat is a strong suppressor of ragweed and purslane. It does not control weeds after it has been killed.

Reduce perennial weeds. Some perennial weeds, especially quackgrass, are weakened by mid-summer tillage and recover poorly in a stand of buckwheat.

Improve soil condition. Buckwheat improves soil aggregation through secretions from its extensive network of fine roots, which leaves the soil mellow. The effect is fairly short-lived, so it is worth taking advantage of with the following crop. The mellowing can be stabilized by following with an aggregate-stabilizing crop, such as ryegrass, that has a large mycorrhizal root system.

Keys to success

A fast start. The buckwheat must beat the weeds. The practices that assure a fast start are:

- letting the soil warm up
- irrigating if the soil is very dry
- sowing as shallow as possible while covering the seed.

No gaps. Weeds will grow in any gaps over 10 inches wide. Most gaps form when the seeder fails, when broadcasting unevenly or covering with a tool that moves the seed, when the seeds are eaten by insects attracted to fresh residue, or when hard spots in the soil prevent germination, and when water puddles in the field in the week after sowing. The practices that eliminate gaps are:

- Prepare the field to eliminate hard soil and lumps in the seeding zone
- Allow crop residue to decompose
- Sow with precision.

Kill on time. If the cover crop is to be killed by mowing, exact timing is critical. The crop needs to come into full bloom (typically 35 days after sowing) so that it does not resprout from the lower nodes. It should not have started to make seeds (typically 40 days from July plantings, 45 or 50 from June plantings), because they will mature and grow. Incorporation extends the effective time until the first seeds are viable, about 45 days.

Three scenarios where a buckwheat cover crop has particular value.

Following early vegetables

After early vegetables have been harvested, the growing season allows excellent cover crop growth to stop the weeds that would otherwise grow, and to improve tilth rather than letting the soil erode.

Goals

- Suppress or reduce weeds
- Improve soil condition

Decision Making

Use buckwheat if the answer to these four questions is Yes:

1. Is your main goal reducing weed pressure or improving soil condition?
2. Is the field open long enough (6–7 weeks between vegetable harvest and fall crop)?
3. Are you planting between early June and early August?
4. Is the field free of herbicide carryover? (No Atrazine, Pursuit, Sandea, Permit or Reflex)

Procedure

Give buckwheat an opportunity to out-compete the weeds.

1. Loosen soil, but don't overtill.

2. Wait about a week for decomposition to avoid gaps in a reduced stand. If the soil is dry, irrigate about 1" a few days before planting.

3. Drill at 50 lb/ac, 1 inch deep; shallower if soil conditions allow. Broadcasting is possible, but to avoid gaps it must be done with great care. Spread evenly using 70 lb/ac. Use shallow incorporation, such as with a drag or chain, to give the buckwheat a faster start than the weeds.

4. After a week, inspect the field and reseed any gaps over 1 foot in diameter.

5. Mow no later than 10 days after plants begin to flower (about 6 weeks after seeding).Alternatively, leave the crop to reseed, or to harvest grain with a combine.

6. Plant a fall crop, or a winter cover crop to preserve improved tilth.

Bring idle land into production

The goal is to bring land into production, especially for vegetables—a high-value crop with low tolerance for weeds. Land that has been idle usually has good soil aggregates, but organic matter needs to break down and the weed seed bank needs to be reduced.

Early plan. For most idle ground, use a double crop for best weed suppression.

1. Spring: Till field when moisture is ideal for working the soil.
2. Mid-May: Harrow at about 2 weeks to break clumps and kill weed seedlings.
3. Late May: Harrow after soil is 65°.Sow buckwheat at 70 lb per acre (broadcast and scratched in) or 50 lb per acre (drilled). Don't leave gaps for weeds to grow.
4. Early July: Incorporate buckwheat 6 weeks after sowing and reseed a few days later. *Or* Late July: Incorporate buckwheat 8 weeks after sowing. Let volunteers establish.
5. Fall: Sow winter cover crop into frost- killed buckwheat, or lightly incorporate live buckwheat. If possible, avoid tilling by using no-till drill or broadcasting on surface. Buckwheat should leave the ground mellow enough that the cover crop will take without tillage.

Late plan. For soil that dries slowly in the spring.

Gentle soil handling is followed by a single crop of buckwheat with an option to harvest for grain.

1. June: Till field when the moisture is ideal for working the soil.
2. June and early July: Allow residue to decompose for 3-4 weeks. Harrow at about 2 weeks to break clumps and kill weed seedlings.
3. Early to Mid-July: Sow buckwheat at 70 lb per acre (broadcast and scratched in) or 50 lb per acre (drilled). Don't leave gaps for weeds to grow.
4. Mid to Late August: Mow six weeks after sowing, or harvest for grain 10 weeks after sowing.
5. Late August to early September (October if harvesting grain): Sow winter cover crop into combined or frost-killed buckwheat; or lightly incorporate live buckwheat and wait one week. Sow winter cover crop with no-till drill or broadcasting on the surface. Buckwheat should leave the ground mellow enough that the cover crop will take with minimal tillage.

Prepare for strawberries

In the growing season before establishing strawberries.

Requirements

• Management that allows few weeds.
• An open field in spring

Procedure

1. Till the ground some time in mid-spring when the soil works up easily.
2. Plant in late May or early June. Prepare a good seedbed so the soil is loosened several inches deep and not lumpy. Drill 50 lb/ac, 1 inch deep or less. Broadcasting is possi- ble, but to avoid gaps it must be done with great care to spread evenly using 70 lb/ac. Use shallow incorporation, such as with a drag or chain, to give the buckwheat a faster start than the weeds. Good ground cover is a must for weed suppression.

3. Mow after 45 - 50 days, after immature seed have begun to form.
4. Replant as before, or if the soil is moist and there is time, allow second crop to grow from volunteers. If the soil is dry, irrigate about 1" a few days before planting.
5. Mow the second crop within a week of flowering. Plant a winter cover crop (annual ryegrass, oats) in late August or early September.
6. Till soil the following spring and plant a new strawberry crop.

Additional notes for strawberry growers

The cover crop procedures described here will let you meet multiple goals.

- Reduce annual weed seed bank and weaken perennial weeds in strawberry beds
- Reduce time spent weeding
- Break disease cycles
- Improve soil health

The summer cover crop works particularly well for growers who control weeds aggressively. It eliminates an opportunity for weeds to escape in many otherwise solid weed control programs. Growers who are less attentive to weeds will often see less benefit. Nevertheless, even a modest reduction in weed pressure can save many hours of hand-weeding.

This article is derived from Björkman, T., R. Bellinder, R. Hahn and J.W. Shail. 2008. Buckwheat cover crop handbook. Cornell University. www.sare.org/content/view/full/69469 based on work funded by a Northeast SARE grant.

Growing Sunn Hemp as a Cover Crop

Jody Bolluyt

Roxbury Farm, Kinderhook, NY 12106
www.roxburyfarm.com jody@roxburyfarm.com

Before 2000, our land was in conventional potatoes. As a result our soils are low in organic matter, have high levels of phosphorus, and we have issues with purslane and foxtail. We need to increase our soil health without adding more phosphorus. Using high biomass cover crops is a way for us to accomplish this goal.

We find that for weed control a series of annual crops with bare fallows in between works better than a long term cover crop like clover. For the summer cover crop window we like to grow Sorghum-Sudan because of its ability to produce huge amounts of biomass. We try to grow a grass/legume mix for cover cropping and we weren't able to find a legume that could keep up the Sorghum-Sudan. We tried forage soybeans, cow peas, and 4010 Field Peas and we found that the Sorghum-Sudan out competed all three of these. Sunn Hemp filled this gap in our cover crop selection; it grows 6 ft to 10 ft tall, produces large amounts of biomass, doesn't produce seed that could become a weed problem, and can grow well in sandy soil and soils with low organic matter.

We seed Sunn Hemp and Sorghum Sudan after the soil temperatures have reached 65 degrees F. We found that in order to have a good stand of Sunn Hemp you need to seed a much higher rate than on the seed bags. We seed 20 lbs of Sorghum Sudan to the acre and 50 lbs of Sunn Hemp. Sunn Hemp needs between 60 and 90 days to grow to full size before temperatures go below 30 degree F.

We use two different methods with Sorghum-Sudan/Sunn Hemp mix. One is to allow the plants to grow to full size without any mowing. After the first hard frost both plants are dry and dead so we wait to mow them until after a hard frost. We leave the mowed plant matter on the surface of the soil over the winter to allow any weeds seeds that matured to be more readily eaten by mice or birds or to freeze. The plant matter acts as a mulch to protect the soil from winter and spring weather. The following spring we no-till drill a mix of peas and bell beans into the residue. This provides the fertility needed for our fall broccoli, cabbage, and cauliflower.

We did try working under a section of the mix in the spring to grow an early planting of sweet corn. This didn't work very well as the nitrogen in the soil was tied up while the cover crop matter broke down. The sweet corn suffered from lack of nitrogen. By waiting to plant vegetable crops until late summer we avoid this issue.

Our 2nd method is to cut the Sorghum-Sudan and Sunn Hemp mix when it is green, just after the Sunn Hemp flowered. The cover crop was 10 ft tall at this point so we couldn't use our rotary mower. Instead we used our hay bine and then went over the windrows with a shredder mower to cut the stems into fine pieces. Another way to accomplish this is to use a silage chopper on the windrows. After the plant matter was finely chopped we worked it under and then planted oats & peas so we could use the field for early spring and summer crops the following season. With this method you need to leave enough time to allow the sorghum-sudan and Sunn Hemp to break down a bit in order to create a seed bed for your oats and peas.

We find that Sunn Hemp is great tool for us to build organic matter in our soils. Our methods do require larger equipment to work under the very tall plants that we allow to grow. We haven't tried mowing the Sorghum-Sudan/Sunn Hemp mix multiple times in order to keep it from becoming so tall and fibrous. We know that works for Sorghum-Sudan but we don't have personal experience with mowing Sunn Hemp. There are some farmers who use the Sunn Hemp as forage or hay and they can get regrowth when there is enough soil moisture.

Multi-Species Cover Crop Mixes at Burnt Rock Farm
Justin Rich

Huntington, VT

Cover crops are one of the primary tool growers have to maintain and improve soil health. They have positive effects on chemical (e.g. via N fixation), physical (e.g. via increased aggregate stability), and biological (e.g. via improved N mineralization and disease suppression) components of the soil.

Depending on a farm's particular situation, cover crops can be managed so as to maximize different effects of soil health. Our main goal in our current cover cropping system is to increase the biological activity and disease resistance while trying to maintain organic matter (OM) levels in our light-textured soils. A secondary goal – depending on timing and cash crop to follow – is to fix atmospheric N with legumes.

We target many of our cover crop systems to increase plant diversity, which in turn will increase microbial diversity in the soil. Just as different animals prefer different plants, different soil microbial communities are associated with different plant species. There is anecdotal evidence to support that increasing the diversity of plants (and therefore microbes) helps increase OM levels to a greater extent than would an equivalent amount of biomass generated by a single-species cover crop or by a high-residue cash crop (e.g. sweet corn).

Plants, and the root exudates they release into the rhizosphere surrounding their roots, are the main source of energy for the microbial community. Plants release sugars into the soil – or give sugars directly to mycorrhizal fungi whose hyphae are allowed to enter the root – in exchange for the microbes giving hard-to-access mineral nutrients to the plant. The more plant-microbe relationships we have occurring in the soil at once, the more soil niches are filled by these beneficial microbes, and the fewer physical niches left available to pathogenic microbes in the soil.

In summer on our farm, a typical cover crop mix seeded in mid-late June (following incorporation or harvest of a winter rye cover, or following recently plowed sod) would be sorghum x sudangrass + annual ryegrass + oat + pea + crimson clover. Mowed twice over the course of summer, this mix will winterkill in our location and leave easily incorporated residues the following spring for an early cash crop. If the cash crop the following year is planted after mid-June, we will add yellow blossom sweet clover and significantly reduce the other species in that early summer mix. The first year will have a highly diverse mix of plants, and the sweet clover will survive the winter and generate significant amounts of biomass and fixed N from April-June. Once plowed under it will provide adequate N for a mid-summer seeding of greens, carrots, beets, or other fall crops.

If ground needed for early spring planting is available to cover crop the previous August or early September, an oat + pea + sorghum x sudangrass mix is planted. The combination of warm and cool season species in this mix allows for rapid ground cover to be established in the heat of late summer, with the sorghum x sudangrass giving way to the oats and peas after the first hard frost, which will winterkill in November in our region.

Much of our acreage is planted to late season covers. Given our short growing season, by the second week of September our options are limited to the hardier covers if we want to make the effort worthwhile. Following earlier fall crops like onions and potatoes (harvested by early-mid September), we will mix winter rye + oats + annual ryegrass + hairy vetch. The amount of vetch varies with how early we can seed, and predicted termination time in the spring. Vetch seed is not inexpensive so only seeded if established early enough in fall and allowed to grow deeper into spring. Oats add some diversity to the mix and will grow twice as tall as rye in September-November before winterkilling. After ~9/20 we do not include vetch due to concerns about survivability.

How to Buy High Quality Cover Crop Seed

Keith Berns

Green Cover Seed, Bladen, NE
keith@greencoverseed.com

Cover cropping has become a staple practice for many growers that want to use them for weed suppression, nutrient cycling, nitrogen fixing, or soil building. As with any crop, cover crops can only be as good as the seed that is planted. In this session, we will look at factors to consider when sourcing cover crop seed.

Seed Quality Factors

1. How the seed was grown and harvested
    a. Weather during growing and harvest can affect seed quality
    b. Harvest equipment and conditions
2. How the seed was processed
3. Cleaning is critical to seed quality and purity
4. How the seed was stored
5. Heat, rodents, insects

How to Read a Seed Analysis Test

1. Germination: Hard Seed, TZ, test date
2. Purity: Inert, Other Crop, Weeds
3. Seed Count

Commonly Asked Questions and Concerns

- Buying Local vs Raised Local
    - Local not as important for cover crops as it is for cash crops
- Organic vs non organic
    - Sourcing organic can be difficult
- Treated vs untreated
    - Be sure to ask!
- GMO vs non GMO
    - Very few GMO's used as cover crops but always ask!
- Certified vs Non Certified
    - Few cover crops are certified but that does not mean that they are not of high quality

Growing and saving your own seed

- Weed control
    - Cleaning weed seeds out of large seeded crops is much easier than small seeded crops.

- Harvesting
  - Most cover crops are very easy to grow but many are very hard to harvest due to being indeterminate in nature
- Cleaning and processing
  - Can be difficult without proper equipment. Uncleaned seed is not worth the risk due to weeds and other contamination.
- Storage
  - Can be difficult if trying to keep multiple varieties
- Legality
  - Most covers are "public domain" varieties but not all. Check the PVP status when in doubt.

Don't be afraid to spend a little extra to purchase

1. Quality
2. Diversity
3. Service
4. Knowledge
5. Convenience
6. Integrity

An Integrated Approach to Grow & Market Crops for Ethnic Markets

Frank Mangan, Zoraia Barros & Heríberto Gody-Hernandez

Stockbridge School of Agriculture, 416 Paige Lab
University of Massachusetts
Amherst, Mass. 01003
fmangan@umass.edu

Introduction

Immigration has always been a source of U.S. population growth. Starting in the 1970s, the center of origin for the majority of U.S. immigrants has shifted from temperate Europe to tropical and subtropical regions of the world (Latin America, Asia and Africa). In 2014, 42.4 million immigrants constituted 13.3% of the total U.S. population, the largest percentage in 100 years. This figure is projected to rise to 18.8% by 2060. More than 10 million immigrants and 8 million U.S. born children of immigrants live in the states of the Northeast Megalopolis, representing 33% of the total population of this region. A large percentage of recent immigrants have settled in urban as opposed to rural/farming areas. Latinos, for example, represent 48% of total public school enrollment in the seven largest cities in Massachusetts (Figure 1).

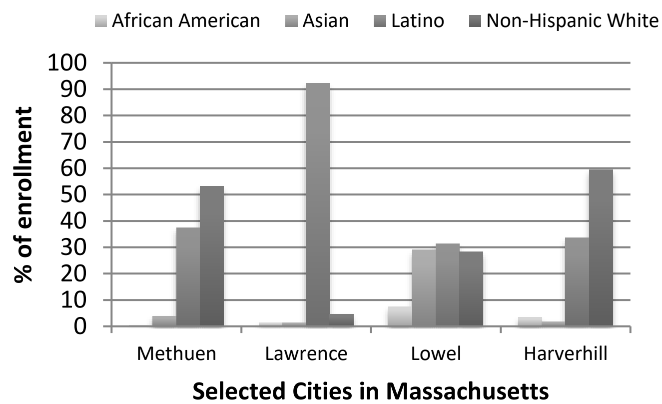


Figure 1: Percentage of students by race/ethnicity enrolled in four public schools in Massachusetts in 2016-17:Methuen, Lawrence, Lowel, Harvehill. Source:

As expected, the increasing populations of ethnic/immigrant groups in the United States have created tremendous growth in the demand and sales of food products popular among these consumers. The ethnic food market in the United States grew 69% from 1997 to 2002, and this expansion is increasing. Latinos and other recent ethnic groups living in the United States tend to cook at home more frequently compared to non-Hispanic whites and thus do more shopping for fresh produce.

Access to culturally appropriate foods is a critical element of food security for immigrants and their U.S. born descendants, who can be expected to share at least some of their parents' cultural traditions and food preferences. However, many of the subtropical and tropical vegetables and herbs that are an integral part of traditional diets are not widely grown in the U.S. and are largely unknown to commercial farmers in the Northeast except for those who belong to immigrant or ethnic minority groups.

Despite their subtropical or tropical origins, many ethnic vegetable and herb crops are potentially adapted to production in the Northeast because of the region's high summer temperatures and long days. For example, more than 70% of the 35,000 acres of vegetables grown in Massachusetts are devoted to crops of subtropical or tropical origin (e.g. squashes, tomatoes, peppers, sweet corn, USDA Census, 2012).

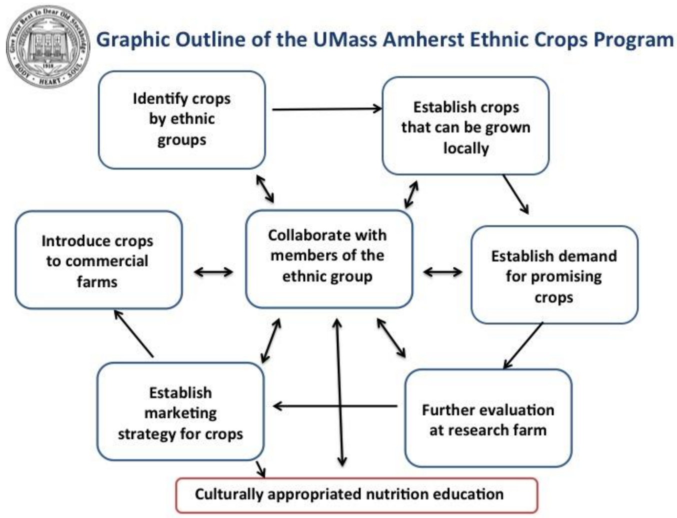
The UMass Ethnic Crops Program

At the University of Massachusetts Amherst, we have evaluated dozens of crops popular among immigrant groups for production and sales in New England since 2000. Over the years we have established a system used to choose the most successful crops to be grown and marketed by commercial farmers in New England. Figure 2 provide a flow chart representation of this system. Here are key steps of the process:

a. Collaborate with members of the target ethnic group. This has been an essential component to our work. Every immigrant community has leaders who speak the language and culture of the target ethnic group and can be important liaisons for farmers who want to grow and market crops popular among the specific ethnicity. We have worked with many of these community leaders in our work, including market managers, owners of small ethnic stores, chefs, health professionals, priests among many others. Usually it is someone that has been in the U.S. for a longer time than many others in his/her community and is in a better position to not only translate language but also culture.

These community leaders can provide a range of key information needed to be successful in growing and marketing crops popular by each ethnicity. Examples are where and how to promote the specific crops. We have used this input to promote crops using ethnic newspapers, radio, cable stations among other promotional venues.

b. Evaluate crops at the UMass Research Farm and in markets before recommending the specific crop for farmers to grow. One of the first steps in the process to evaluate a new crop is to grow it at our research farm. We want understand how well the crop grows in our climate, days to harvest, insect and disease pressure, among many other essential components of crop growth. We also investigate the postharvest physiology of the crops we are working with, packing, storage, quality and shelf life. Once we know we can successfully grow a specific crop successfully at our research farm, we'll grow a larger amount in order to introduce it to markets that cater to the specific community.



We'll then work with the target markets to answer the following questions:

- How popular is the crop?
- What is the quantity that can be sold?
- What is the price point?
- What is the highest price the community is willing to spend?
- What are the best methods to promote the availability of this new crop to the target community?

By using this system, we have successfully introduced several new crops for commercial production in Massachusetts and other states and regions. Examples include jiló, garden egg, water spinach, *calabaza*, *ají dulce*. Detailed information on these crops is available at www.worldcrops.org.

c. Research-based information on how to grow, pack and market new crops popular among immigrant and ethnic groups

When we are confident that there is an opportunity to produce a new crop in New England, we put this research-based information on www.worldcrops.org, a website started with funding from the USDA SARE program. Our goal for the information on this site is to provide commercial farmers all the information they need in order to both grow and market these crops successfully. In many cases we bring the reader to the New England Vegetable Management Guide (https://nevegetable.org/) when the crop is the same genus and sometimes species of the "ethnic" crop on this site.

We have organized this site according to countries in the world. One reason for this organizational structure is that many ethnic groups are concentrated in specific cities or neighborhoods. For example, Holyoke Massachusetts has the largest Puerto Rican population as a percentage of any city in the United States. In this case, a grower who wants to grow and market crops for the Latino population in Holyoke would want to check out the crops under "Puerto Rico" on www.worldcrops.org.

Feeding Diversity: Lessons Learned from Okra Production in Ontario

Dr. Viliam Zvalo

Vineland Research and Innovation Centre
Vineland, Ontario, Canada

Changing demographics and evolving culinary preferences of Canadians have created growing demand for new vegetables such as okra.

In order for Canadian vegetable growers to capture the full value of these emerging markets, domestic production of these vegetables must increase. The primary objective of this project was to increase seasonal field production capacity for okra.

Okra continuesto attract new growers, and existing growers who see their crop acreage expanding to meet demand from retailers and consumers. Okra performed well across various test sites representing different climatic regions, with the best results achieved in Ontario, Quebec and British Columbia.

Methodology

Okra

Work from the 2015 field season showed that okra can be successfully grown in Southern Ontario and right across Canada. Production practices need to be refined to optimize the entire production process. Four okra varieties were selected and tested in 2016. These included an open-pollinated variety (Clemson Spineless), and three hybrids with higher yield potential and earlier maturity (Elisa F1, Jambalaya F1 and Lucky green F1). These varieties encompassed several 'pod types', including the longer bhindi-style okra and shorter, ridged pods which are currently predominant in most retail stores.

Results from 2015 showed that spacing is critical for optimizing yield of okra. In addition to the four different in-row spacing regimes tested in 2015 (25, 30, 45 and 55 cm), another spacing of 38 cm was also added. All trials were established in double-rows planting as the yield from a single row planting would be too low to make the system commercially viable. Raised beds were spaced 180 cm from centre to centre.

Nitrogen has a major influence on the yield and health of okra plants. Six rates of nitrogen - 25, 50, 75, 100, 75 (late) and 100 (late) kg N/ha plus a no fertilizer control - were evaluated for effects on yield. Except for the 25 kg rate, 50 kg N was applied prior to planting and the remainder was applied through the drip irrigation system. 75 (late) and 100 (late) received the same amount of N as 75 and 100 kg/N ha however, fertilizer application was delayed for 2 weeks after pod initiation. Phosphorus and potassium were applied based on results from a soil test and published fertility recommendations for okra (from the USA).

Similar to eggplant, okra is also susceptible to soil borne diseases. The impact of fumigation was tested by comparing the yield potential of okra varieties grown on fumigated and non-fumigated land.

In traditional okra producing regions, crop establishment is achieved through direct sowing. Due to the short growing season in Canada okra has typically been grown using transplants. This adds to the cost of production so a trial was established to quantify the impact of direct sowing vs. transplanting on okra yield.

In addition to our trials at the research farm of Vineland Research and Innovation Centre, twenty-three growers from five provinces (BC, MB, ON, QC and NS) participated in okra and/or eggplant on-farm trials. The results were again very encouraging. Okra and eggplant grew very well in all provinces. The 2016 growing season was in general warmer and longer than usual, which was positive for okra and eggplant cultivations. Growers were provided with seeds, planting instructions, monthly research updates for okra and eggplant and the Research Scientist visited research sites in BC, MB and ON.

Results and Discussion

Among the four varieties tested Clemson Spineless 80 produced the highest yield (18.92 t/ha) followed by Jambalaya F1 (17.26 t/ha), Lucky Green F1 (16.84 t/ha) and Elisa F1 (15.32 t/ha). Statistical analysis of the four varieties showed there were no significant differences among the four treatments. Pods from Clemson were harvested when they are around 10 g in weight whereas pods from Jambalaya and Lucky Green were 8.4 g and 8.7 g respectively. Elisa produces slender bhindi type okra pods that are generally preferred while the pods are still tender. These were harvested at an average weight of 7.5 g/pod.

Okra grown at a closer spacing produced higher yields than those planted at a wider spacing. Planting at 25 cm spacing produced 50.9 pods in Clemson and 64 pods for Jambalaya with the remaining two varieties in between. Similar yields were achieved at 30 cm spacing (differences not statistically significant from 25 cm), but 20 percent more transplants are required for the 25 cm spacing; the increase in yield may not be sufficient to compensate for the additional cost of transplants. While planting at 55 cm spacing increased the average number of pods in all varieties, with the lowest number in Lucky green (89.2) and the highest number in Jambalaya (102.7), total yield was lower as there were fewer plants per unit area. Total yield across the four varieties on 25 cm spacing was 21.46 t/ha and decreased to 17.23 t/ha on 55 cm spacing.

The nitrogen response curve shows that the highest yields were achieved when plants received 75 kg N/ha. Use of additional nitrogen did not increase yield and furthermore yield declined at the highest rate tested. Although statistical analysis showed there are no significant differences between the various N rates, there is a numerical trend with increasing N rate, up to 75 kg N/ha.

Late application of N has no visible affect on yield. Yield from these two treatments was similar to that obtained in the other treatments with similar N rates applied prior to and through fruiting.

Fumigation is essential for okra production when soil-borne pathogens are present. The yield potential of okra was severely impacted by the presence of soil-borne diseases. Under disease pressure, Elisa F1 yielded 0.41 t/ha, Jambalaya F1 yielded 1.01 t/ha, Clemson yielded 0.59 t/ha and Lucky Green F1 yielded 0.83 t/ha. Yield from all four varieties is <10% of that realized in 2015 and is only a small fraction of the comparative yield obtained in 2016 on fumigated soil.

When okra was directly seeded, the production of okra pods was delayed by two to three weeks compared to transplanted plants. Overall, the direct seeded okra yield was 40 % and 22 % lower for Jamabalaya F1 and Lucky Green F1, respectively. Direct-seeding can save up-front costs associated with the production of transplants and in a good year these cost-savings may compensate for reduced yield.

Similar to the results from 2015, there was a marginally significant effect on yield when plastic tunnels were used on okra compared to the control and row cover treatments. However, there was no significant difference in yield between plots covered with plastic or row covers.

Lessons Learned:

1. When planting early in cooler climates, row covers increased the yield of eggplant by up to 20% and they had a similar effect on okra production.
2. Clemson Spineless 80 produced the highest yield (18.92 t/ha) followed by Jambalaya F1 (17.26 t/ha), Lucky Green F1 (16.84 t/ha) and Elisa F1 (15.32 t/ha).
3. Considering the cost of transplants and yield as factors, the optimum in-row plant spacing for okra is 30 cm or 12”.
4. Nitrogen requirement for okra was around 75 kg N/ha; further increases did not improve yield and resulted in a net decline in yield at the highest rate tested.
5. Soil borne diseases significantly decreased okra yield. Okra yield on non-fumigated plots decreased by as much as 90% compared to fumigated plots.

Acknowledgments:

I would like to express my sincere gratitude and appreciation to my research technicians, namely Derek Pearson, Gillian Limebeer and Ramesh Eerpina for their hard work and dedication on this project.

I would like acknowledge Agriculture and AgriFood Canada for funding this project through Growing Forward 2, A Federal- provincial- territorial initiative.

Saffron: A Good Fit for New England?

Margaret Skinner, Bruce L. Parker and Arash Ghalehgolabbehbahani

University of Vermont North American Center for Saffron Research and Development
661 Spear Street, Burlington, VT 05405-0105
Email: mskinner@uvm.edu **Tel:** 802-656-5440
Website: www.uvm.edu/~entlab/Saffron/Saffron.html

Fig. 1. Saffron flowers ready for harvest; stigma (red arrow),

Saffron (Crocus sativus L.) is the most expensive spice in the world, with a retail price of as much as $5,000/lb. It is commonly used as a food flavoring and coloring agent in Mediterranean and Asian cuisine, but also is believed to have medicinal properties, which increases its economic value above other spices. It is reported to be an anti-carcinogenic agent, effective against depression and to reduce blood cholesterol levels and mitigate arteriosclerosis. Saffron is made from the flower stigmas, which contain hundreds of aromatic volatile and nonvolatile compounds, most importantly crocins, picrocrocin and saffranal (Fig. 1). In 2015, the US was the 3rd largest importer of saffron, bringing in >37 tons valued at $55 million. Unlike most crocuses, saffron blooms for 2-4 weeks from October to November, then continues to grow vegetatively over the winter, before going into dormancy from May to September. Once planted, the corms continue to grow in the same place for ~6 years, after which the beds are dug up and the secondary corms are replanted.

Saffron is adapted to arid and semi-arid regions and is somewhat resistant to cold, tolerating a low temperature of around -4°F. The origin of this crop is thought to be in the eastern region of Iran where over 90% of global saffron production occurs. However, saffron has been produced by the Pennsylvania Dutch since the 1700s, suggesting it is suitable for cultivation in much of the Northeastern US. Until now saffron was not considered a viable US crop, either because of unsuitable climatic conditions or high labor costs. While labor costs to harvest and process saffron are relatively high, these activities take place for 4 weeks in late fall when demands from other field work are less. Other labor inputs during the year are negligible after the first year.

From 2015-2017 we conducted research to assess the productivity of saffron and its ability to survive the winter in a high tunnel in northern Vermont. Two cultivation methods were tested: in plastic milk crates (12 x 12 x 11 in) and in the ground (Fig. 2). Our theory was crates could be removed in the spring when the saffron corms are dormant, and stored until September. This would allow growers to use the premium high-tunnel space for other high value crops from March – September.

Fig. 2. Saffron production methods, in crates (left); in ground (right).

Methods. Our research was done at a private farm in St. Albans, VT (USDA plant coldhardiness zone 5a [-20 to -15°F). Saffron corms were obtained from a Pennsylvania grower (zone 6b [-5-0°F]) and planted in early September at a density of 100 corms per m^2 (11 corms/crate). Two strips of weed cloth were secured within the crates to prevent the soil from spilling out. Top soil (fine sandy loam) from the site was put in the bottom to a depth of 4 in. Corms were planted tip side up in the top soil and covered with 2 in. of top soil and then 4 in. of an organic perennial blend potting mix containing compost and sandy soil. For the in-ground treatment, wooden frames were constructed to make raised beds. Four inches of top soil were placed in the frames, and the corms were planted as described for the crate treatment. In both years the blooming period started in mid-October (~48 days after cultivation) and ended in late November. Flowers were harvested every two days to obtain high quality saffron. After harvesting, stigmas were separated from the flowers by hand and air dried. The dehydrated stigmas were weighed to determine yield.

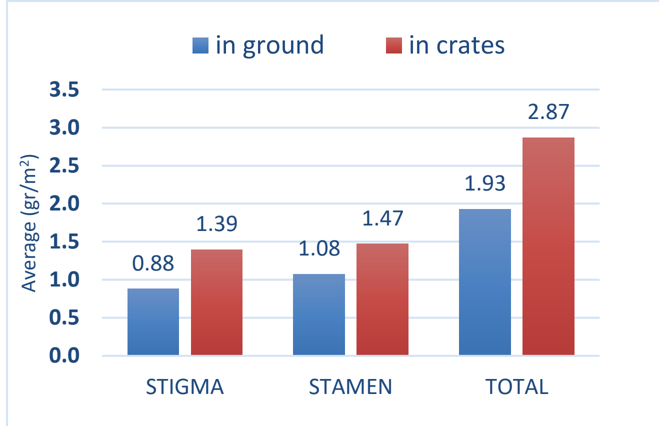


Fig. 3. Dry weight of stigmas and stamens

Results. Based on Yr. 1 results, saffron yield (stigmas only) averaged 0.88 – 1.39 grams per sq. meter (Fig. 3), and was significantly higher from corms grown in crates than in raised beds. Most of the flowers were harvested in the first 20 days of the bloom period. Our yields were greater than that reported in other traditional saffron growing regions. For example, in Iran, yields are ~0.34 gr/sq. meter, and in Spain yields of ~0.6 are common. The retail price of saffron in Vermont health food stores is $19/gr. Based on the yield obtained in Vermont, saffron could generate revenues of $100,000/acre, which greatly exceeds revenues from most other vegetable crops often grown in high tunnels (Est. revenues: saffron: $4.03/ sq ft; tomatoes: $3.51/sq ft; winter greens: $1.81/sq ft.).

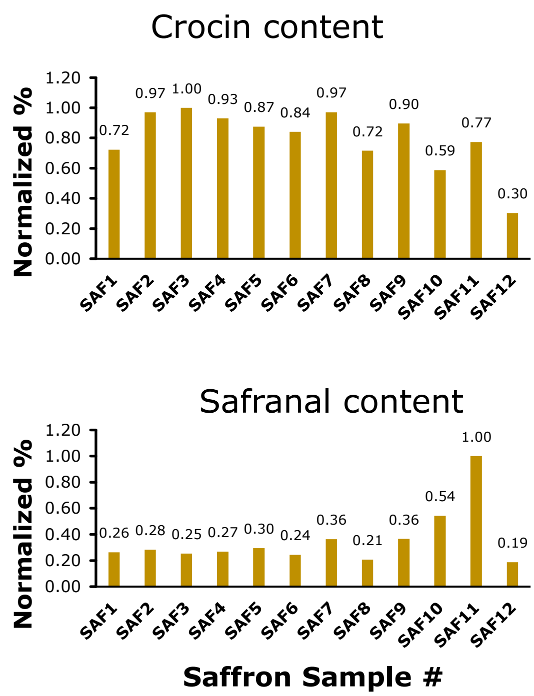


Fig. 4. Crocin and safranal content for samples harvested in VT (SAF1-8), PA (SAF9), Iran (SAF10), Spain (SAF11) and Italy (SAF12).

The market price for saffron varies with the quality of the crop. Therefore we arranged for chemical analysis of our saffron and samples from Pennsylvania, Iran, Spain and Italy to compare quality. In general, the content of two important saffron components—safranal (responsible for the characteristic bitter taste) and crocin (produces the yellow-orange color)—in saffron grown in Vermont were generally equal to that from other traditional saffron-growing regions (Fig. 4).

We also evaluated corm survival and yield in the spring of 2016. Almost two times more healthy corms were harvested from the crates than from the raised beds. Rodent feeding was a major factor in reduced corm yield in the beds. However, the corms from the raised beds were 1/3rd heavier than those grown in the crates.

Grower Interest. Our results clearly suggest saffron could be an ideal crop to expand diversification of small-medium-size farmers in much of the US. As a result of media coverage of our research, growers throughout the US have contacted us expressing interest in growing saffron. In response, we established the North American Center for Saffron Research and Development, set up Saffronnet (an email list for growers interested in production) and held the first saffron workshop in March 2017. There are over 280 subscribers from across the US, Canada and Europe on Saffronnet, and more are added every week. Over 100 participants attended the workshop, and many had to be turned away because of limited space. Saffron is essentially a new crop for most of the US, and best management practices are largely unknown. To gain insights into stakeholder priorities, we conducted a grower survey. Around 95% of the respondents intend to grow saffron in the next 5 yrs. When asked how they would grow it; 57% said in a greenhouse or high tunnel, while 64% will grow it in the field. When asked what would help them most with saffron production, 94% said they need production guidelines, and 82% wanted to know more about marketing options. Despite the limited baseline information about saffron cultivation, this fall hundreds of thousands of saffron corms were purchased by US growers who are producing it for the first time.

Future Research. Many questions remain regarding how to maximize revenues from saffron production in the Northeastern US. Whereas our research demonstrated the potential of growing saffron in containers in a high tunnel, some feel field production is required to obtain sufficient yields and revenues. We have initiated grower-participatory research to evaluate field production of saffron in Vermont. Given the interest from growers throughout New England and beyond, we also want to investigate market opportunities for various saffron-based products. Finally, if saffron is shown to be a suitable crop for high tunnels and/or the field, strategies for increasing the efficiency of production must be investigated. Currently, this crop is extremely labor intensive, which is partly why the price is so high. There are likely ways to automate flower processing that will reduce the cost of production without sacrificing quality.

Acknowledgements. Support for our saffron research was and/or is provided by the Vermont Department of Agriculture Speciality Crops Program; Univ. of VT College of Agriculture & Life Sciences; Center for Lake Champlain Watershed Research Innovation and Implementation, St. Albans, VT; American Meadows, Inc., VT; Herb Society of America; Hans Rottveel, Roco Saffron; Charles Cantrell, USDA ARS; and Peter Johnson, Director, Amish-Mennonite Center for Sustainable Agriculture, Wenham, MA. Any opinions, findings, conclusions, or recommendations expressed in this presentation are those of the authors and do not necessarily reflect the view of the U.S. Department of Agriculture or other funding sources.

Culinary Breeding: A New Way to Look at Specialty Crops?

Lane Selman[1] & Lindsay Wyatt[2]

[1]Culinary Breeding Network / Oregon State University
2240 N Interstate Avenue, Suite 200. Portland, OR 97227
laneselman@gmail.com

[2]Johnny's Selected Seeds, 955 Benton Ave. Winslow, ME 04901
lwyatt@johnnyseeds.com

Often times, it is not a high priority for seed companies to engage with or consider the unique needs and preferences of organic farmers and their customers during the plant breeding process. To ensure success, organic farmers need varieties bred under organic conditions in order to select for traits including weed competitiveness, disease resistance, organic nutrient management and stress tolerance. Organic customers demand superior flavor and culinary attributes and have an appreciation for uniqueness, quality and novelty. Incorporating chefs, farmers, produce buyers and other stakeholders into the plant breeding process gives breeders deeper insight into preferred traits while increasing awareness and understanding of organic plant breeding among a broader audience.

In 2012, Lane Selman created the Culinary Breeding Network (CBN) to convene breeders and stakeholders to discuss and identify traits of culinary excellence for vegetables and grains. The trademark event of the CBN is the annual Variety Showcase event, with a goal to increase communication in order to develop more relevant and desirable cultivars for all parties. Attendees have the opportunity to taste commercially available cultivars, provide feedback on breeding populations, and exchange ideas and perspectives with breeders.

Event attendance has increased more than five-fold in the four years it has been held to 540 attendees at the 2017 Variety Showcase. Attendees have been exposed to over 200 commercial cultivars and 170 breeding lines of vegetables and grains. Seed companies report significant sales increases as a result of the events. Farmers report that new knowledge and experience gained at this event impact their work by expanding networks, changing their buying practices, and better informing their decisions. Creating a venue for interactive exchange of specific needs has resulted in a greater understanding for breeders of what consumers want and, for all other participants, a greater understanding of the important role breeders play in the food we eat.

Inspired by the work of Lane Selman and the Culinary Breeding Network, the Northeast Seed-to-Table Initiative (NESTI) began in June 2016, when a group of Johnny's Selected Seeds employees passionate about culinary breeding formed a partnership with Colleen Hanlon-Smith and the Unity Food Hub. NESTI is a network of farmers, chefs, breeders, and other stakeholders working to strengthen the local Maine food system by sharing expertise with one another through tasting events and dialogue. Its mission is to align breeding goals, grower needs, and market demand for unique, flavorful, high-performing varieties by involving all the interested parties in an open, creative, and constructive forum.

In its first year, NESTI held the first annual Seed-to-Table Variety Tasting Event, hosted guest speaker Lane Selman for a day-long culinary breeding workshop, and conducted a culinary breeding focus group with local grower and chef partners. In its second year, NESTI coordinated partnerships between growers, Johnny's plant breeders, and chefs to trial and evaluate new Johnny's breeding material and present it to the public at the second annual Seed-to-Table Variety Tasting Event. Moving forward, NESTI goals include holding additional public-facing educational events as well as small grower-chef-breeder tasting events and focus groups to gather feedback on potential new vegetable varieties that Johnny's breeders can use to develop and release varieties that better meet grower and consumer needs.

Participation in culinary breeding trials and events can help growers in a diverse range of ways. NESTI has acted in a networking capacity by connecting interested growers to Johnny's plant breeders, allowing them to evaluate pre-commercial varieties, give feedback that shapes which products are released, and get a preview of upcoming releases. NESTI also acts as a forum in which growers can make their needs known to plant breeders, resulting long-term in new varieties that better reflect local and regional grower needs. In addition to meeting grower needs, varieties developed with culinary breeding feedback are also better tailored to consumer preferences, with the goal of increasing both direct-market sales and wholesale to restaurants and other local businesses. Culinary breeding events can also create more immediate consumer demand for new and existing varieties and act as a networking opportunity between growers and local restaurants. Finally, the public education aspect of culinary breeding events helps to increase overall understanding of the food supply chain and drive demand for locally-grown, high-quality vegetables, fruits, and grains.

Current Management Strategies for Managing Sweet Corn Worm Pests

Galen P. Dively

4112 Plant Sciences Bldg, Department of Entomology
University of Maryland, College Park, MD 20742
galen@umd.edu

Corn earworm is the primary ear invader of sweet corn, followed by European corn borer, fall armyworm, and sap beetles. Infestation levels in New England vary with the year, time of season, and farm location. For instance, infestations of earworms and armyworms result from migrant moths carried northward on storm fronts into the region during mid to late summer. Population pressure is generally higher on farms along coastal New England, and lower and more variable inland. Corn borer pressure varies depending on the number of generations, and more recent infestations have been lower due to regional population suppression in areas of high Bt field corn adoption. Sweet corn producers rely on timely pest monitoring and insecticide sprays to control these ear-invading insects. However, insecticide control programs are costly, potentially pose exposure risks to the applicator and farm workers, and require considerable time and management to successfully implement.

The cheaper pyrethroid (Group 3A) products have been the popular choice but their control efficacy has declined in certain areas due to resistance in corn earworm populations. Resistance monitoring in the South has shown near 50% reduction in control efficacy against this pest compared to when pyrethroids first came on the market. Spray mixtures of Lannate® (Group 1A) plus a pyrethroid are often used to circumvent the resistance problem and improve control of fall armyworms, cutworms, and sap beetles. Rotations and mixtures with different active ingredients, such as Coragen (Group 28), Radiant (Group 5), Entrust and Blackhawk (Group 5), as well as premix products (i.e. Besiege (Group 3A + 28) are also increasingly used and can provide good control. However, the reality is that pyrethroids no longer provide enough ear protection on many farms, so it is becoming necessary to switch or rotate to alternative products. For all insecticide products, timing the first spray at early silking, applying subsequent sprays on a schedule based on moth activity, and achieving adequate spray coverage of the ear zone are prerequisites for effective insect control. Most corn earworm eggs are laid directly on the silks; once larvae hatch, they quickly move down the silk channel and begin feeding on the ear tip, where they are protected from insecticidal sprays. Thus, it is absolutely necessary to target larvae before they enter the ear by treating silk tissue when moth pressure is high. Timing sprays for corn borers and fall armyworms is less critical because their eggs are laid on corn leaves, thus the period of larval exposure to sprays is much wider. Still, effective control depends on getting enough insecticide to the target larvae at the right time, with the proper spray coverage, and without interference from weather events.

The problems and challenges with foliar insecticide applications can essentially be eliminated with Bt sweet corn, which expresses insect-active toxins from the bacterium, *Bacillus thuringiensis* (Bt) in tissues of the entire plant. This technology has revolutionized the way many corn insect pests are managed, particularly European corn borer, which is virtually 100%

controlled by Bt sweet corn. However, the expressed toxins alone do not always provide 100% control of corn earworm or fall armyworm, and thus supplemental insecticide sprays are often needed to ensure quality ears, especially during high moth activity. There are three types of Bt sweet corn commercially available: Attribute® hybrids (expressing Cry1Ab toxin), Attribute® II hybrids (expressing Cry1Ab and Vip3A), both from Syngenta Seeds, and Performance Series™ hybrids (expressing the Cry1A.105 and Cry2Ab2 toxins) from Seminis Seeds.

Attribute® hybrids have been commercially available since 1996, and acreage has increased significantly with the introduction of fresh market hybrids (i.e. BSS0977, BC0805, WSS0987, GSS0966) and availability of 25K seed units for smaller producers. However, efficacy of these Cry1Ab expressing hybrids has been variable for controlling corn earworm since 2008. Research findings from 22 years of monitoring changes in field efficacy in 89 untreated Attribute® sweet corn plots in Maryland provide strong evidence of resistance development in corn earworm populations to the Cry1Ab toxin. When first introduced, expression of Cry1Ab toxin provided greater than 95% control of all worms, with very minor injury to a few kernels at the ear tip and only early instar larvae if present. The ear protection allowed producers to eliminate pre-silk treatments and reduce insecticide applications during silking by 70 to 90%. However, ear damage and larval survival have progressively increased since 2000. The percentage of Attribute® ears damaged increased from less than 10% in 1996 to an average of 79%, based on 18 trials of untreated plots conducted in 2017 (Table 1). This reduction in control efficacy is unrelated to corn earworm pressure, because moth activity has actually declined over the past decade. Many sweet corn producers have stopped growing Attribute® hybrids or are applying insecticide sprays to compensate for the reduced efficacy.

The Performance Series™ pyramided Bt sweet corn expresses three insecticidal toxins: Cry1A.105 and Cry2Ab2 to control worms, and Cry3Bb1 to control rootworms, as well as herbicide tolerant traits. Common hybrids are Temptation II, Obsession II, Passion II, and SV9010SA. Field trials of Obsession II compared to nonBt Obsession I were conducted in Maryland from 2010 to 2017, alongside Attribute® sweet corn at the same locations. When this Bt sweet corn was first evaluated, control efficacy was similar to the level of ear protection by Attribute® hybrids in the late 90’s, providing 100% control of fall armyworms and more than 95% control of corn earworms, with very few surviving larvae and only minor injury on the ear tip. However, control efficacy of earworms rapidly declined during the last four years, showing average unacceptable levels of 74% damaged ears in six late plantings in 2017 (Table 1).

Attribute® II sweet corn expresses a new Bt gene combination to broaden the spectrum of activity and reduce resistance development. Hybrids available are Remedy, Aspire, Milky Way and Protector. Introduced commercially in 2013, this sweet corn expresses a novel vegetative insecticidal toxin, Vip3A, from *B. thuringiensis*, pyramided with the Cry1Ab toxin, along with herbicide tolerant traits. The Vip3A toxin is highly effective against a range of important pests including black cutworm, fall armyworm, corn earworm, and western bean cutworm. Of 22 field trials in 2017 comparing Attribute® II hybrids with non-Bt hybrids in seven states, less than 1% of the ears were damaged, indicating near 100% control efficacy of all ear-invading worms (Table 1). In comparison, the percentage of ears damaged by older larvae in non-Bt sweet corn, planted side-by-side without insecticide protection, averaged 90%. The expressed toxins in Attribute II have no effect on sap beetles; however, the absence of worm damage that attracts beetles significantly reduces the infestation risk of this pest.

Current field performance of Bt sweet corn is summarized as follows. First, all Bt sweet hybrids provide excellent control of corn borers, eliminating all whorl, tassel and silk sprays directed solely for this pest. Furthermore, there is no evidence of any change in corn borer susceptibility to the Cry or Vip toxins. Secondly, the herbicide tolerance traits in these hybrids offer a weed control advantage over non-Bt hybrids. Attribute® sweet corn still provides good control of fall armyworm during pre-silk growth stages but only moderate ear protection; no effective control of western bean cutworm; and variable but generally poor to fair control of corn earworm. Performance Series™ sweet corn provides very good control of fall armyworm during the vegetative and ear development stages but no effective control of western bean cutworm and only poor to fair control of corn earworm. Timing of supplemental sprays in Attribute® and Performance Series™ sweet corn is less critical and wider spray intervals are generally allowed compared to non-Bt sweet corn under the same insect pressure. In both types, fresh silk tissue is consistently more toxic to newly hatched larvae, causing intoxication and delayed growth; so those larvae that survive are exposed longer before entering the ear. Pyrethroids and other insecticides may actually work better because larvae are weakened by the Bt intoxication. The first spray can be applied at full silk, usually three or four days later than the first application in non-Bt sweet corn. A second spray 3 to 4 days later may be necessary if heavy moth activity continues, some-times three applications are needed. Attribute® II sweet corn provides excellent control of all foliage feeding and ear invading worms, thus no insecticidal sprays are required, except for secondary pests such as sap beetles, rootworm adults and Japanese beetles.

Field-evolved resistance and associated reduction in control efficacy reported here confirm findings from studies in the South showing evidence of developing resistance to Cry toxins in Bt field corn and cotton. However, corn earworm resistance may be localized in the New England because Attribute® and Performance Series™ hybrids may still provide fair to good control of corn earworm in some areas, depending on where the migrant moths originated from southern sources. Clearly, the high adoption rate of Bt field corn and cotton, with the Cry1Ab toxin being used since 1996, has contributed to the selection pressure on earworm populations. Additionally, moderate dose expression of Cry1Ab and related Cry1Ac toxins in these crops, decreasing refuge compliance, and potential cross resistance between Cry toxins, altogether have contributed significantly to the evolution of resistance. Unfortunately, corn earworm resistance to the Cry toxins is likely to increase, and spread, with the shift to ‘refuge in bag’ field corn hybrids that contain only 5% non-Bt seeds, and reduced refuge size (from 50% to 20%) in the South where Bt cotton is grown. Due to northward influxes of potentially resistant moths from southern source regions, the risk of further evolution of resistance in the entire Northeast will likely increase and may compromise the efficacy and durability of the Bt sweet corn technology, particular at risk is the Vip trait.

Table 1. Summary of insect control efficacy of different Bt hybrids compared to non-expressing isolines. Data compiled from individual field trials of untreated plots conducted at 15 locations across seven states (NC, VA, WVA, MD, DE, NJ, and NY) in 2017.

Hybrid[a]	Bt traits expressed	Number of trials	% of clean ears	% of ears damaged by corn earworm	% of ears damaged by corn borer	% of ears damaged by fall armyworm
Remedy	Cry1Ab+Vip3A	17	98.7	0.6	0.0	0.1
Milky Way	Cry1Ab+Vip3A	6	96.8	0.2	0.0	0.0
Obsession II	Cry1A.105+Cry2Ab2	7	25.7	73.8	0.0	0.0
BC0805	Cry1Ab	18	23.8	79.0	0.1	1.9
Obsession I	Non-Bt isoline	6	4.3	95.7	0.0	0.3
Providence	Non-Bt isoline	18	12.6	84.4	3.6	6.1

[a] Trials of Milky Way, Obsession II, and Obsession I were conducted only in Maryland.

The Potential for Using a Sonic Net to Reduce Damage by Birds to Sweet Corn

John P Swaddle

Institute for Integrative Bird Behavior Studies
Biology Department
College of William and Mary
Williamsburg, VA 23187-8795
Tel. 757 221 2231
jpswad@wm.edu

Birds from the “blackbird” group, including red-winged blackbirds, brown-headed cowbirds, and European starlings, cause substantial damage to sweet corn crops across North America, This damage might be more than $100 million annually. While there have been numerous attempts to limit this damage, including the application of visual startles and loud acoustic cues, most have been met with limited success. In part, this is because blackbirds, like many other birds, quickly habituate to stimuli that carry no real threat. Some of the more promising trials include post-ingestive repellents, through which birds can learn to avoid noxious-tasting corn. This approach builds on the natural processes of birds learning about their environment and making optimal decisions about where to forage.

Here we build on our knowledge of the natural ecology of blackbirds, to use acoustic masking as a way of deterring blackbirds from food sources. As birds select their habitat, they are reliant on acoustic information to communicate within flocks and to listen out for predators. Acoustic masking is when background noise interferes with hearing and degrades the information that each bird can acquire. In our experimental trials, European starlings exposed to masking noise greatly increase their vigilance, indicating that the inability to listen out for predators makes them hyper-aware. While they are scanning for predators, they reduce their feeding and, if given the option, prefer to feed in locations that do not contain the masking noise. In this case, we reduced food damage by starlings by approximately 50%.

In field trials, we deployed a highly localized (by using directional speakers) masking sound, which we term a Sonic Net. In wild situations, birds have real predatory threats all the time, hence the Sonic Net increases their perception of predation risk and birds choose to leave the Sonic Net area. At a long-term application at an airfield, we saw 80% reduction in the presence of birds—most of which comprised blackbirds.

We are currently planning for crop-based (sunflower) trials where we treat both the crop field and the nearby cattail marsh where the blackbirds roost. We intend to deter birds both from feeding and roosting sites to diminish crop damage. It may be that treating the roost is as effective as directly treating the crop.

I will also review the design of the Sonic Net relative to blackbird target species and how our ideas can and have been applied to sweet corn. The Sonic Net has been applied in several commercial agricultural settings, including sweet corn, grape, and cherry, as well as in aquaculture. Reports from producers and farmers back to the commercial company that is marketing the Sonic Net appliances have been positive. In particular, the sweet corn producer has reported an approximate 85% reduction in the damage to ears of corn—with reductions in damage caused by both birds and deer. In this situation, the producer reports a marked increase in productivity, in part because the reduced damage has saved tremendous time in not having to cut off the damages ends of corn cobs when preparing the crop for sale, in addition to fewer of the ears being damaged at all. There may also have been some deterrence effects of the Sonic Net on skunks.

Selecting the Right Varieties on Our Farm

Paul Gove

Gove Farm
925 Mechanic St
Leominster, MA 01453

Gove Farm is a 45 acre farm, family owned and operated for over 100 years. Our motto is "We grow everything we sell" so our farm stand is open mid-June through the end of October. We grow about 28 acres of sweet corn, only sold retail, and the challenge is to have perfect corn from as early as possible every day until the end of the season.

Our customers like the more traditional synergistic bicolors, not super sweets, so we have an ever changing list of varieties we sequence through the Summer.

Varieties for 2017, in order of maturity, were as follows:

- Latte
- Sweetness
- Sweet Chorus
- Espresso
- Temptation
- Cuppa Joe
- Cappuccino
- Allure
- Kaching
- Essence
- Providence
- Cameo

How to Design Cover Crop Mixes for Improving Soil Health

Keith Berns

Green Cover Seed
Bladen, NE
keith@greencoverseed.com

If Soil Health is the goal, Crop Diversity cannot be ignored or overstated

1. Plants were created to grow in diverse ecosystems
2. Resilience comes from Diversity
3. Balanced "diet" for soil biology
4. Balance: because even good things (legumes, brassicas) when not used in moderated balance can be harmful

Get 4 Things Right

1. The Right Species
2. The Right Inoculants
3. The Right Seeding Rates
4. The Right Seeding Time

Answer 4 Main Questions

1. What Are The Goals/Concerns?
    a. Soil health – biological life
    b. Supplemental grazing
    c. Increased fertility/organic matter
    d. Nitrogen capture/cycling
    e. Additional lasting residue/cover
    f. Weed suppression/disease cycle
    g. Erosion control
    h. Compaction breaking/deep roots
2. What Are The Environmentals?
    a. Rainfall or irrigation
    b. Evapo-Transpiration (ET)
    c. Growing season
    d. Soil type and condition
    e. Seeding method
    f. Previous crop and next crop
    g. Previous herbicides
3. What Is The Timeframe?
    a. Spring - fallow ground or prior to a spring crop (chemical/mechanical termination)
    b. Early Summer - (frost or chemical/mech. termination)
    c. Late Summer – (frost termination)

    d. Fall - After fall crops (frost termination or over-wintering)
4. What Is The Budget?
    a. Low (less than $20/acre) (Low seeding rates – very few legumes)
    b. Medium ($20 - $30/acre) (Average seeding rates – some legumes)
    c. High ($30 - $40/acre) (High seeding rates – high legume %)
    d. Higher ($40 - $60/acre) (special use: organic N production, nematode control, perennials, etc…)
    e. NOTE: Add 30-50% if broadcasting seed and not drilling

SmartMix Calculator Demonstration

The smartest mix of cover crops for your field is the one that you custom design for your field! That is the premise behind Green Cover Seed's powerful SmartMix Calculator 5.0. You choose your goals, we help you select the cover crops that meet the goals and we custom mix it just for you! SmartMix is unique within the industry, with immediate feedback on price and goal fulfillment along with a suite of mix attributes.

https://smartmix.greencoverseed.com/mix/create

Weed Management in Mixed and Segregated Cover Crop Residues

Dan Brainard[1] and Carolyn Lowry[1,2]

[1]Michigan State University, Department of Horticulture
1066 Bogue St, East Lansing, MI 48824
email: brainar9@msu.edu

[2]Currently a Postdoctoral Associate at University of New Hampshire

Cover crop residues can be a useful tool for maintaining soils, conserving soil moisture and suppressing weeds in reduced tillage vegetable production systems. However, these residues can also interfere with crop establishment and create weed management challenges. To address these tradeoffs, we have been experimenting with integration of various “zonal management practices”, including strip tillage, segregated plantings of cover crop mixtures, and targeted mechanical cultivation.

Segregated cover crop planting. For the last several years, we have been experimenting with alternative planting arrangements of 2-species cover crop mixtures. In these segregated cover crop plantings, mixture species are planted in alternating strips corresponding to the in-row and between-row zones of the crop planted the following year. This practice is sometimes referred to as “strip intercropping”, “zonal planting” or “precision cover cropping” and variations have been tested in several other cropping systems (Schonbeck and Morse, 2006; Gruver and Clayton, 2014). Our first experiments with segregated cover cropping were conducted in strip-tilled sweet corn. We compared full-width mixtures of cereal rye and hairy vetch to segregated plantings in which vetch was planted only in the in-row zone, and rye only in the between-row zone of the following sweet corn crop (Lowry and Brainard, 2016 and 2017).

Why bother with this more complicated planting system? We hypothesized that 1) by restricting vetch to the in-row zone, nitrogen would be available in the sweet corn root zone without feeding weeds in the between row zone and 2) by restricting rye to the between row zone, residue would suppress weeds between rows without interfering with crop establishment in-row. In general our results in sweet corn have supported these hypotheses, although the size of these effects has often been smaller and more variable than we’d hoped. Subsequent studies have examined the effects of segregated plantings of other cover crop combinations including rye and crimson clover, and oats and oilseed radish before various crops including cabbage, peas, snap beans and acorn squash.

Combining cover crop residues and mechanical weed control tools. A thick mulch of cover crop residue can suppress weeds. However, in New England and Northern parts of the Midwest, it is often difficult to produce sufficient biomass to get season long suppression. For example, previous research suggests that at least 3 tons/acre of dry cereal rye residue is needed for season long weed suppression (e.g. Mohler and Teasdale, 1993). Relatively short growing seasons, and uneven distribution of residues after mowing or crimping often result in patches within fields with inadequate residue to prevent flushes of weeds. In strip-tilled and zonal cover cropping systems, the in-row zone is also intentionally left bare to facilitate crop establishment. In these systems, additional weed management tools are needed to prevent weed competition (Brainard et al. 2013). Herbicides can be effectively used to minimize these problems in many vegetable crops. However, in organic production systems, or in crops with limited herbicide options, growers need to identify other options.

In our organic strip tillage systems, we have used a combination of flame weeding pre-emergence and various mechanical cultivation tools as needed to suppress weeds. For weeds emerging in-row, we have tested torsion weeders and finger weeders either belly-mounted under a cultivating tractor, or rear mounted on floating arms on a steerable toolbar. Finger weeders have provided good to excellent control when timed appropriately, and have been able to handle surprisingly large amounts of residue. To control the full width of the in-row zone, we have used a Kress Star Hoe or Bezzerides Spyder Weeder in front of the finger weeder. In the between row zone, we have typically gotten 3-4 weeks of suppression from flail-mowed rye residue, and then used a Lilliston-type rolling cultivator as needed to take care of late emerging weeds.

Using this combination of strip tillage, zonal cover cropping, and targeted mechanical cultivation, we have been able to reduce the number of tractor passes, retain cover crop residues for soil moisture retention and gradually increase soil organic matter, while minimizing yield losses due to weeds. However, these systems require investments in time and equipment, and do not work well for all vegetable crops, so proceed with caution, and armed with information!

References

Brainard, D.C., E. Peachey, E. Haramoto, J. Luna and A. Rangarajan. 2013. Weed ecology and management under strip-tillage: Implications for Northern U.S. vegetable cropping systems. *Weed Technology* 27: 218-230.

Gruver, J. and A. Clayton. 2014. Researchers evaluate precision cover cropping. Midwest Organic and Sustainble Education Service (MOSES). https://mosesorganic.org/farming/farming-topics/field-crops/researchers-evaluate-precision-cover-cropping/

Lowry, C.J. and D.C. Brainard. 2017. Rye–Vetch Spatial Arrangement and Tillage: Impacts on Soil Nitrogen and Sweet Corn Roots. *Agronomy Journal* 109: 1013-1023.

Lowry, C. and D.C. Brainard. 2016. Strip-intercropping of rye-vetch mixtures affects biomass, C:N ratio, and spatial distribution of cover crop residue. *Agronomy Journal* 108: 2433-2443.

Mohler, C. L. and J. R. Teasdale. 1993. Response of weed emergence to rate of *Vicia villosa* Roth and *Secale cereale* L. residue. Weed Res. 33:487–499.

Schonbeck, M., and R. Morse. 2006. Using manually-operated seeders for precision cover crop plantings on the small farm. Information Sheet no. 4-06. Virginia Assoc. for Biological Farming, Red Oak,VA.

Optimizing Compost and Fertilizer Rates in Organic Reduced-Till

Nicholas Rowley

Research Associate in Vegetable Production
University of Maine Cooperative Extension
Highmoor Farm, P.O. Box 179, Monmouth, Maine 04259
nicholas.rowley@maine.edu

Introduction

Farm management practices that focus on the promotion of soil health while limiting the degradation of soil structure and the conservation of the environment are key components in the philosophy behind organic production.

A combination of tools and techniques can be used to promote soil health. And which to use depends on soil characteristics, the crop and what works well within the current production system of the farm. Reduced tillage is a broad term for methods such as zone-till, deep zone-till, shallow till, Etc. These practices serve as a middle ground between conventional tillage and no-tillage. What these practices have in common is that they reduce soil disturbance some way by intensity and/or frequency.

Another factor to consider is the delivery of supplemental nutrients to a crop. Ideally, using efficient and effective rates of nutrient amendments leads to both increased crop yields and decreased potential for environmental nutrient pollution as well as lower overhead production costs.

Reduced Tillage

Reducing intensive tillage has been widely adopted in the past century, particularly in large scale conventional agronomic crops in the form of no-till. More recently, interest and adoption has grown among smaller-scaled growers to reduce soil disturbance and ultimately reap the benefits of reduced tillage. These benefits include soil building properties which lower bulk density and increase both soil organic matter and nutrient retention. In turn this lowers the amount of fertilizer inputs (particularly N, P, K) needed to meet crop nutrient demands. Reduced tillage limits compaction, saves time and restricts non-renewable energy consumption of fossil fuels by lowering or eliminating in field passes with mechanical equipment.

While there are surely potential economic and environmental benefits in reduce tillage, there may also be some factors which effect farm operations and nutrient availability. Reduced tillage typically leaves a greater amount of plant residue on the soil surface which may interfere with planting, seed bed preparation and light mechanical cultivation. This residue may also affect the soil temperature which is a driving force behind soil microbial functions. Furthermore, the lack of incorporation of soil residue may affect microbial activity in the rooting zone of the plant; causing slower decomposition of previous cover crops and the subsequent release of nutrients.

Availability of Compost and Organic Fertilizers

Compost is a vital part of a sustainable waste stream and is used in agriculture as a soil amendment or a mulch. Compost is often used and thought of as a fertilizer; however, this is a misconception. Compost while being a potential source of macro nutrients such as N, P, K may supply very little in terms of N to the crop, but may supply 50% of total P and as high as 100% total K. This is dependent on environmental conditions and the feedstocks that were used to create the compost. Both effect the microbial community which carries out mineralization and nitrification. These processes convert nutrients from unusable organic forms into inorganic forms that can be incorporated into the plant. The accepted general analysis of most compost is 1-1-1, which is low considering many conventional and organic fertilizers.

Organic fertilizers share similarities with compost. Many certified organic fertilizers supply nutrients in an organic form which also must undergo the same transformations to inorganic forms to be usable to the plants. Again, this process is dependent on the soil environment and the material the fertilizer is composed of. Some organic fertilizers, for example bloodmeal, are considered "fast acting" meaning the fertilizer mineralizes quickly and may be available in a matter of a few weeks. While others may take considerably longer to undergo this transformation.

Optimizing Nutrients in Reduced Till

There are two ways to consider nutrients in a reduced tillage system. On one hand there is a lack of incorporation of soil amendments such as compost, fertilizer and green manures. Which makes us wonder, are the nutrients getting into the soil where they can be available for uptake by the roots? And on the other hand, there is the potential to maintain soil organic matter by reducing soil disturbance. Which depending on the soil environment and percent organic matter may supply somewhere between 60-80 lbs. of N acre^{-1} per year in the Northeast.

In 2015 and 2016 we performed an experiment that looked at nutrient optimization in the first year of a field going into organic reduced tillage. Permeant sod was tilled in the prior year and then cover-cropped with oats at 100 lbs. acre^{-1}. The crop we chose was 'Honey Bear' acorn squash (*Cucurbita pepo*). Tillage was carried out with a Yeoman plow (essentially, a 2' sub-soiler with a rolling basket). Rates of compost measured by lbs. of N acre^{-1} were applied at 0, 40, 80 and 120 lbs. of N acre^{-1} (10-15, 20-25, 30-35 yd^3 acre^{-1} respectively). All rates of the compost were split into two distinct application patterns, banded in a 12" strip or broadcasted across the entire bed.

Bloodmeal fertilizer (13-0-0) at total rates of 40 and 80 lbs. of N acre^{-1} were also applied separately and in combination with compost applications. Timing of application was another factor where 40 lbs. of N acre^{-1} from bloodmeal was applied before planting and 40 lbs. was applied as a midseason season side-dress coinciding with first flower.

When we thought about optimizing amendments we considered rate and application for compost and total N rate and timing for the bloodmeal fertilizer, as well as, any effect the combination of either one had on both fruit number and yield.

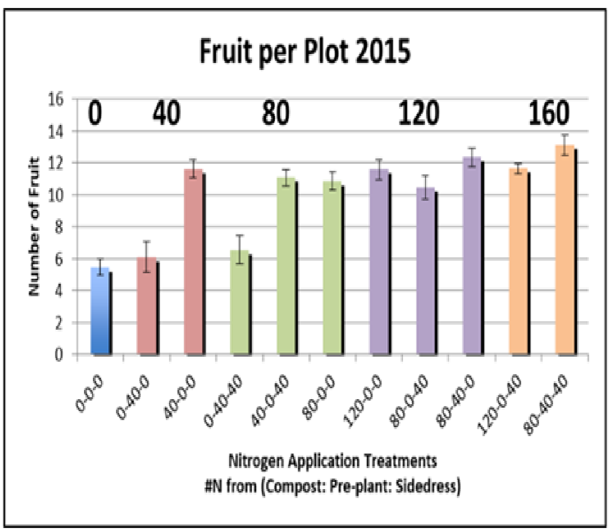
Compost and Location

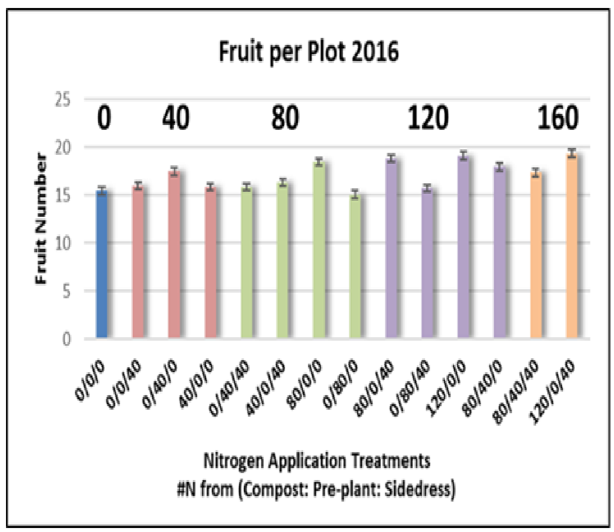
We had mixed results between years of our experiment. In 2015 adding compost at the 40 lbs. N acre^{-1} rate (10-15 yd^3 acre^{-1}) significantly increased yields and fruit number from our control (no compost or fertilizer added). However, there was no additional benefit gained in the same season by adding compost at either the 80 or 120 lbs. N acre^{-1} rates (20-25, 30-35 tons acre^{-1} respectively). In 2016 significance was only found when adding the highest rate of compost for yield and the two highest rates for fruit.

In both years of our experiment it didn't matter whether we applied the compost in a banded pattern or spread it evenly over the whole bed. Suggesting that same season benefits from compost did not rely on incorporation.

Fertilizer, Timing and Compost/Fertilizer

In both years we found no significance when using a nitrogen fertilizer in reduce till compared to not using one at all. We also were unable to detect any difference between applying fertilizer before planting, side-dressing or a combination of the two. When looking at the combination between fertilizer and compost; both years showed no significant difference between treatments for fruit number and yield. Although, there was a general increasing trend for fruit number with the increase in total nitrogen applied. Lastly in 2015, there was a significant increase in fruit number and yield when using compost compared to bloodmeal applications targeting the same N application rate (40, 80 lbs. N Acre^{-1}); however, similar findings where not observed in 2016.





Main Considerations

- Reduced tillage conserves organic matter, which may increase N credits provided by the soil limiting the amount of additional nutrients needed.

- Compost contains very little readily available N for plants close to application however, as much as 50% of P and 100% of K can be mobile.

- There was no difference between banding or broadcasting compost suggesting incorporation of the compost did not matter in our experiment.

- Blood meal fertilizer was ineffective in our study perhaps because of N not being the most limiting nutrient in our fields.

- Squash is a moderately heavy feeder (110-140 lbs. N per season) our experiment produced suggested yields (5-7 tons per acre, *New England Vegetable Management Guide 2016-2017 edition*) by using only a 40 lbs. N acre^{-1} compost rate (10-15 yd^{3} acre^{-1}). Additional amendments had no further effect, suggesting that optimizing rates can reduce farm inputs in reduced tillage following an oat cover early in the transition from conventional tillage, while maintaining acceptable yields.

- Compost applied at the same target N rate as bloodmeal fertilizer produced greater yields in one year of our experiment. Most likely due to the compost supplying another limiting nutrient (P) that the fertilizer did not contain.

Comparison of Reduced Tillage Strategies for Small-Scale Organic Vegetable Systems

Anu Rangarajan[1], Ryan Maher[1], Brian Caldwell[1], Margaret McGrath[1], Zachary Sexton[1], Dan Brainard[2], Mark Hutton[3], Nicholas Rowley[3]

[1]Cornell University, Ithaca, NY
[2]Michigan State University, Lansing MI
[3]University of Maine, Monmouth, ME

A comprehensive soil health management plan integrates multiple practices, such as cover crops, organic soil amendment and reduced tillage (RT). Ideal RT systems for vegetables must provide good seed-soil contact, soil temperatures, moisture and fertility to support desired quality, have effective weed control options, and support yields and timeliness of harvest. In more northern climates, no-tillage systems are risky for vegetables, due to cooler soils, poor soil seed contact, and few weed control options. In organic systems, nutrient availability can further limit success. Yet both organic and conventional vegetable farmers are interested in reducing tillage to promote soil health. How might growers transition to reduce tillage systems on their farms? Where can they adapt these RT approaches for different crops, or insert RT strategies at different points during their rotations? Anything we can do to reduce tillage in a field and over time moves us in the right soil health direction.

Benefits to Reducing Tillage

- Build soil health
- Improve soil water retention and use
- Improve farm labor and fuel use efficiency
- Ensure long term soil productivity
- Maintain yields and soil quality through weather extremes
- Reduce soil erosion

For the last ten years, we have focused on zone-till systems for vegetables grown in northern climates. We have preferred zone tillage over no-till or roller crimper-based systems primarily to ensure weed control flexibility during the season. No-till with rolled down cover crops cools soils, affecting earliness of vegetables, and severely restricts options for cultivation for weeds when there are escapes. Zone or strip tillage systems can overcome many of the constraints of no-till but adoption requires rethinking rotations, finding or adapting tillage tools and planters, and changing weed management.

Integrating cover crops with zone tillage is challenging in organic systems. While we know that cover crops can provide numerous soil health benefits and may provide some weed control, the management of the cover crop residue can be problematic. In our RT systems, we flail the cover crop, to allow in-season flexibility of cultivation. Depending on the type and management of cover crops, there may be very different amounts of cover crop residue that will require managing in the spring. Winter killed cover crops represent the easiest transition into a RT system. What are different management strategies for overwintered cover crops that proceed organic vegetable grown in zone tillage?

For the last two years, we have looked at this question of managing a cover crop of overwintered legume (hairy vetch or crimson clover) and cereal rye prior to a zone tilled organic cabbage crop. We tested these cover crops planted as mixtures or in strips. Strip planting was done to strategically place the legumes in a band where the cash crop was to be planted. This would also minimize the amount of rye biomass and rye roots in the planting area- to improve soil conditions for the cash crop. These plots were flail mowed and residue left on the surface.

When the cover crops were planted as mixes, we tested three termination strategies: 1) flail mowing and leaving on soil surface, 2) flail mowing and removing the residue with a forage harvester, 3) flail mowing and then rototilling the cover crop into the soil (standard practice). A treatment of straight vetch with no rye was included as an additional comparison. All of the treatments were then tilled using a zone builder prior to transplanting 'Farao' cabbage in late June. The field was certified organic for history and management.

The organic cabbage yields were similar between the rototilled and the surface residue cover crop systems for the mixes tested. Removal of the aboveground portion of the other mixes, however reduced yields of cabbage. A sidedress N of 60#N as bloodmeal supported a moderate (2 T/a) increase in yields in all cover crop combinations except the vetch only treatments.

Vetch planted without rye provided less than half the above ground biomass, but significantly higher total N contribution (125 lb/a) compared to vetch with rye (100 lb/acre). Cabbage yields were also highest with the vetch only cover crop, regardless of cover crop management strategy (surface, removed, incorporated). Removing the vetch residue did not reduce yields, indicating N fixed by vetch in roots was adequate for good cabbage production. This vetch might have other on-farm uses, perhaps as forage or mulch in other vegetables.

The rye –clover cover crop had the highest overall biomass but resulted in lowest yields regardless of cover crop management strategy. In this case, we suspect that the cover crop was not terminated at the best time for N release. Differences in maturity among species in a cover crop mix can make it challenging to pick the optimal time for flail mowing to kill the mix.

While cabbage yields were similar when cover crops were either planted in mixes or strips, the latter were easier to plant and manage. In summary, we found that

- Zone tilled cabbage into a surface residue of cover crops yielded similarly to those rototilled.
- Removing the above ground portion of the vetch and clover with rye mixes removed N and reduced yields
- Vetch only cover crop maximized cabbage yields prior to zone tillage
- Strip-planting cover crops facilitated zone tillage but not lead to higher yields
- Supplemental N sidedress improved yields where cover crop C:N ratios were high

Tarping Soils to Minimize Tillage and Reduce Weeds

Ryan Maher[1], Anu Rangarajan[1], Mark Hutton[2], Brian Caldwell[1], Mark Hutchinson[2], and Nicholas Rowley[2]

[1]Cornell University, Ithaca, NY 14853
[2]University of Maine, Monmouth, ME 04259
Contact - Ryan Maher, rmm325@cornell.edu

There is a growing interest in using tarps as a weed management tool on small-scale organic vegetable farms. Tarps are impermeable, durable black plastic, often sourced as silage bunker covers, that are used to suppress weeds between crops. They are secured to the soil surface using techniques similar to floating row covers, left in place for weeks at a time, and then removed before planting. Their durability allows for reuse over multiple seasons. Tarping practices can take many different forms. When growers are preparing beds with conventional tillage they are using tarps as a stale seed bed technique. With adequate moisture, weed seeds can germinate in warm soil and eventually die when starved for light. If the soil is not disturbed for planting, or not enough to bring up new weed seeds, farmers report reduced weed pressure for the crop during the season. They are also finding greater flexibility with crop planning by preparing beds in advance, sometimes the previous fall, and holding beds idle with tarps until planting in spring.

Organic vegetable production can be heavily reliant on tillage to control weeds but also for killing cover crops, breaking down residues, and creating a warm, fertile seed bed for planting. Research at Cornell University and the University of Maine has been investigating how tarping practices can help reduce or even replace tillage. This work is evaluating the agronomics and economics of reduced tillage practices for permanent beds in Freeville, NY and Monmouth, ME, over four years. Tarping in no-till production was compared to no-till without tarping and conventional rototilling to monitor changes in weed suppression, soil processes, labor use and crop productivity (2015-2016). Tarps were applied a minimum of six weeks ahead of planting cabbage and winter squash. Crops were grown in straw mulch, compost mulch and without mulch to evaluate tarping under different no-till production methods.

Tarps have shown to kill pre-emerged weeds and create weed-free planting conditions without soil disturbance. The greatest improvements in weed suppression were seen in the unmulched crop. They reduced labor for hand weeding by 70% - 80% (yr 1 and 2) when compared to no-till without tarps, largely by suppressing winter annual weeds and requiring less time for bed preparation. However, tarping also dramatically reduced the amount of weeds present at crop harvest (yr 1), which may be attributed to better management of the weed seed bank in tarped systems.

Tarps had a dramatic effect on spring soil conditions ahead of crop establishment. They increased spring soil temperatures in both unmulched and mulched soils. When tarps were removed, plant-available soil nitrogen in un-mulched, tarped soil was 2-4 four times greater than tilled soils depending on the year. They had a greater effect on soil nitrate when applied overwinter, which may be related the exclusion of precipitation, less water infiltration, and to reduced leaching losses. Tarp effects on crop yields depended on the location but yields were similar to or greater than the other tillage systems in both years. They had the largest effect on compost mulched soils, suggesting they may increase the availability of nitrogen from slow release nutrient sources.

Tarping could be a valuable tool for organic farmers to effectively minimize tillage while improving weed control and crop productivity. Ongoing research is addressing how tarps can be integrated with cover crops, the effectiveness of tarps in managing surface residue, and reduced tillage tarping practices for small seeded crops.

Plum Variety Evaluation in Maine – Growing and Tasting

Renae Moran & Angela Myracle

University of Maine Highmoor Farm
Monmouth, Maine
rmoran@maine.edu
angela.myracle@maine.edu

From Plum Production in Maine, Univ. of Maine Cooperative Extension publication #2034
https://extension.umaine.edu/publications/2034e/

With many different plum varieties available, consider winter hardiness and disease resistance for easier management, and fruit quality and ripening date for easier marketing.

There are two general types of cultivated plum that vary in eating quality and when they ripen. Most Japanese plums (Table 1.) ripen in summer. They have a juicy texture and an intense fruity flavor. The varieties vary considerably in fruit size and color. Colors vary from yellow to red to dark purple in the skin and flesh. European plums (Table 2.) ripen from the end of summer into fall. Their flavor is much sweeter, but the texture is more firm than Japanese types. They are generally yellow or purple-skinned with yellow flesh.

Table 1. Important traits of Japanese plum (*Prunus salicina*) varieties, listed in order of ripening.

Variety	Cold hardiness	Ripening date	Black knot resistance	Bacterial leaf spot resistance	Fruit quality
Spring Satin plumcot	poor	mid July	good	fair	good
Early Golden	fair	late July	fair	poor	excellent
Methley	fair	early August	poor	fair	fair
Shiro	good	early August	fair	poor	poor
Luisa	unknown	August	unknown	good	unknown
Ozark Premier	good	August	unknown	fair	good
Obilinya	good	mid August	excellent	good	excellent
Beauty	unknown	August	unknown	fair	unknown
Superior	excellent	early Sept.	good	fair	good
Toka	excellent	early Sept.	good	fair	excellent
LaCrescent	excellent	early Sept.	good	poor	poor
Kahinta	excellent	late August	good	poor	fair
Alderman	excellent	September	good	fair	good
Wickson	unknown	September	unknown	unknown	good

Abundance	good	early Sept.	unknown	fair	good
Black Ice	fair	mid Aug.	good	good	good
Vanier	good	mid Sept.	fair	good	good
Elephant Heart	unknown	September	unknown	unknown	good

Table 2. Important traits of European plum (*Prunus domestica*) varieties, listed in order of ripening.

Variety	Cold hardiness	Ripening date	Black knot resistance	Bacterial leaf spot resistance	Fruit quality
Rosy Gage	good	August	fair	good	excellent
Castleton	good	Early Sept.	fair	good	good
Early Italian	good	Early Sept.	good	unknown	good
Stanley	good	September	poor	fair	good
Green Gage	unknown	September	good	unknown	excellent
Transparent Gage	good	Late Sept.	poor	good	fair
Cambridge Gage	good	Late Sept	poor	good	good
Ouillans Gage	good	August	poor	good	fair
Long John	good	Late Sept.	poor	good	good
Italian (Fellenburg)	good	Late Sept.	good	fair	good
Valor	good	Early Oct.	poor	good	excellent
Gras Ameliorat	good	Early Oct.	poor	good	good
President	unknown	October	good	good	good

For easy management, plant varieties according to ripening date within the orchard. Early varieties may need to be harvested before the final insecticide spray since late ripening varieties can be attacked by apple maggot and spotted wing drosophila if left unprotected. Inter-planting varieties that ripen at different times can lead to yield loss due to insect damage. Yield loss also happens in many varieties with heavy rain as fruits ripen. Shiro, Methley and Superior are very susceptible to rain cracking. Despite high yield in these varieties, large yield losses can occur in years with frequent and heavy rain in summer. Other varieties with a greater chance for rain cracking are Elephant Heart and Cambridge Gage.

Some further observations on select plum varieties (listed in order of ripening):

JAPANESE PLUMS (Prunus salicina, nigra and americana)

- **Early Golden** - attractive, yellow-skin with red blush, harvested in late July. On the small size, texture can be slightly mealy, but sweet. Overall rating – good.
- **Methley** - red-purple skin, harvested in early August. Small fruit size but good flavor, however, mushy, red flesh. Overall rating – fair.

- **Obilnya** - harvest in mid-August. Medium size, good flavor, purple-red skin, firm, orange flesh. Overall rating – excellent.
- **Kahinta** - yellow-red skin. Harvest mid-August. Large size, tart flavor. Firm, golden flesh but mealy texture. Overall rating – good.
- **Superior** - late August harvest with red skin. Medium size, tart flavor with firm, yellow flesh. Overall rating – good.
- **Toka** (aka 'Bubblegum') - red skin, harvested in late August. Small size, aromatic, with firm, yellow flesh. Overall rating – good.
- **Vanier** - early September harvest with yellow-orange skin. Large fruit. Tart, slightly astringent. Has firm, yellow flesh. Overall rating – good.

EUROPEAN PLUMS (Prunus domestica)

- **Rosy Gage** - yellow-green skin, harvested in early August. Small size but sweet flavor. Firm, golden flesh. Overall rating – good.
- **Castleton** - purple skin, harvested mid-August. Medium size, balanced flavor with firm, golden flesh. Overall rating – excellent.
- **Longjohn** - late September harvest. Large fruit with sweet flavor. Dark purple skin with firm, golden flesh. Overall rating – good.
- **Valor** - dark purple skin with harvest in early October. Firm, golden flesh with balanced flavor. Large fruited. Overall rating – excellent.
- **Gras Ameliorat** - late harvest in mid-October. Purple-red skin, small fruit size.

Peach Systems: Trials, Tribulations, and What the Future Might Hold

Dr. Jim Schupp

Penn State Fruit Research and Extension Center, Biglerville, PA

The ideal peach training system would be productive and pedestrian, precocious and produce high quality, well-colored red fruits. At the same time, the ideal system would be easy to teach to laborers, and compatible with mechanization.

Current peach production practices are labor-intensive, requiring multiple trips through the orchard to dormant prune, hand thin, hang OFM mating disruption, summer prune, and for multiple (often 3) harvests. The traditional approach to training and pruning peach trees in the eastern U.S. has been the low headed open vase, at low tree densities of 113 to 173 trees per acre (Figure 1). In this system, trees are pruned severely, using bench cuts to spread the scaffolds at a wide angle and keep the canopy within 9 feet of the ground. This allows growers to maintain a pedestrian orchard.

The pedestrian objective of the open vase exerts a heavy toll on economic returns. Low tree density equates to low precocity and production of low yields. The severe pruning required by open vase further reduces early bearing and its vigorous regrowth requires that it must be summer pruned to produce fruits of marketable red color. V-shaped canopies such as Tatura, Kearney V (perpendicular-V), Quad V, and Hex V, have been shown to be more productive and more compatible with the natural growth habit of trees. Severe bench cut pruning is not required, and V trees come into bearing earlier as a result. Even a modest increase in early yield per tree is multiplied 2.5 to 3 times because of the higher planting density.

V systems are simpler to manage, and more compatible with mechanization (Figure 2). The high-to-moderate planting density increases the amount of productive bearing surface of these systems, producing higher yields than open vase. V systems are inherently tall, and require the use of a ladder or platform to access the upper canopy. This adds to the cost of labor, although use of mechanical string thinning and labor platforms lessens the additional expense. Refer to Table 1 for a summary of the comparison of open vase and V-canopy systems.

Both vase and V systems have challenges inherent to the natural tree form of the peach tree. Peach bears fruit on 1-year-old wood, so a substantial amount of annual vegetative re-growth is needed to generate a new bearing surface each year. The pattern of growth in peach is acrotonic, meaning most of the new growth occurs in the outer portion of the canopy. This growth pattern is an inherent trait, and it is amplified by the species' intolerance of shade. Shaded portions of a peach canopy grow weakly, fail to flower, and quickly die off. As a peach tree matures, its bearing canopy migrates up and out of reach from the ground.

Migration of the bearing surface can be slowed, but not eliminated, by pruning with bench cuts in the open vase system. The heavy bench cuts required to keep the trees short result in strong local invigoration of the canopy and increase shading. Early season shading reduces flowering the following year, and late season shading reduces red fruit coloration. The strong regrowth that results from heavy pruning must be counteracted with summer pruning once or twice a season to prevent severe shading effects.

In the taller V systems, the acrotonic growth pattern and shade intolerance of peach makes it challenging to renew new fruiting laterals within reach of workers on the ground. Peach does not readily renew fruiting branches from short stubs as does apple. As a result, short sections of 2-year-old wood (secondary branches are stubbed back to the most proximal fruiting lateral. This increases the complexity of the canopy and of pruning decisions, which is counterproductive to the original intent of the simplified pruning rules of the V systems.

There is not presently an ideal peach production system, as all of them have flaws. Furthermore, our 2007 trial of open vase, perpendicular V, quad V and hex V systems in Pennsylvania showed that, at prices received for fresh market peaches from 2009-2015, all 4 systems were profitable. That doesn't mean that there isn't much difference among these systems.

In this trial, V systems came into full production 3 years sooner than open vase, were 50% more productive over the 8 year trial, and produced 20% more red fruit. Depending on planting density V systems were 16% to 54% more profitable. Unlike apples, the most intensive (and expensive) perpendicular V system wasn't the best. Moderate planting density with quad V training created more bearing surface, and more peaches per acre than the perpendicular, with 29% fewer trees (346 versus 484) per acre.

Low-headed open vase trees still fit in special circumstances. For instance on hillside sites with steep slopes, or in financial circumstances when the enterprise needs to minimize planting costs.

For the present, we recommend a quad V peach training system spaced at approximately 7 ft. between trees and 16-18 ft. between rows. Quad V is productive, precocious, and produces higher packout, with a system that is easily taught and compatible with mechanization. That leaves "pedestrian" as the only pin still standing when the characteristics of the quad V are considered. For information on training trees to quad V see: https://extension.psu.edu/innovations-in-peach-training-systems. This Learn Now video is available in Spanish or English and can be used for employee training.

What about the future? In the near term, several dwarfing rootstocks may provide a measure of success with keeping peach trees shorter. In particular, some of the Controller series from UC Davis show promise. Controller 8 has been the best in PA trials, producing a precocious tree that is 70% the size of Lovell, with the same level of productivity as seedling peach trees and great survival. Our results to-date indicate that trees on Controller 8 rootstock are putting more energy into fruit and less into vegetation, which is necessary for more efficient production on dwarfed trees. Another rootstock in this series, Controller 7, also shows promise. If trees with 70% vigor could be managed at 70% shorter canopy height, then the vast majority of fruit will be within reach from the ground.

In the long term, we must continue to study techniques for further reducing labor inputs through mechanization. In the 1980s, a "meadow orchard" system was described and tested. Peach trees were planted at very close density and mechanically harvested, by cutting off the entire tree at harvest, much like combining corn. Even in regions with an extended growing season, [Georgia (US), and Israel], it wasn't possible to grow annual crops of quality peaches. In Israel it could be accomplished only with early maturing cultivars, and even then, fruit maturity was delayed and fruit quality suffered when the growing of annual crops was attempted.

The meadow orchard system was modified to two scaffolds at 2 ft. x 6 ft., and named the "intensive system". Initially it looked much like the perpendicular V, except that one of the two scaffolds was pruned to a short stump while dormant, leaving the second to bear fruit the following season, while the other side regenerated. By alternating removal of the 2 scaffolds, the trees maintained enough vigor to produce adequate flowering, fruit set and yield. Since the canopy of an intensive system will never be more than two years old, it follows that the orchard would remain pedestrian. Concerns with the intensive system include lower tree survival, rapid development of mineral nutrient deficiencies, and small fruit size. One limitation of the intensive concept is the lack of small machinery to deal with the very tight spacing. Modifications of this system should be investigated further.

Table 1. Comparison of relative differences between traditional open vase and higher density V canopy production systems for peach.

Characteristic	Open Vase	V shaped canopy
Tree density per acre	100 – 172	242 – 544
Establishment cost	Low	Moderate
Need for irrigation	Beneficial	Essential
Final canopy height	7' – 10'	12' - 14'
Pedestrian orchard?	Yes	No
Set crop potential with pruning?	Feasible	Precise
Compatibility to mechanization	Low	High
Years to full production	8 -9	5-6
Yield (bushels per acre)	350 – 450	550 - 670
Average fruit size (Loring)	3.5"	3.25"
Average red color (Loring)	50%	70%
Relative income	"100% of standard"	"116% - 154% of standard"

Figure 1. The open center-trained tree has been the industry standard for over 150 years.

Figure 2. Quad V peach systems are productive and compatible with technology.

What's Bugging My Peaches?

Dean Polk

Rutgers Agricultural Research and Extension Center
121 Northville Rd, Bridgeton, NJ
deanpolk@njaes.rutgers.edu

Introduction: As any fruit grower knows, peaches are susceptible to a number of arthropod and disease pests. There are at least 12 insect and mite pests listed in most state and regional production guides, and another 6 different diseases. Additionally, many spray guides list all possible pests that might be present for each separate cover spray. The objectives of this presentation are to focus on only those insect and mite pests that are most likely to be present and require management; and what we can do to keep the system in balance in order to minimize the number of pests that require management.

Primary, Key and Secondary, Direct and Indirect: Primary or Key pests are those insects and mites (and diseases) that you know are going to be there every year and cause the most economic damage. These are usually direct pests, in that they feed or damage the fruit itself, causing a direct loss of yield or market quality. Indirect pests are those that damage the tree and foliage, and contribute to a loss of tree vigor and therefore fruit quality, size or color, and perhaps reduced bud counts and a reduced crop size for the following season. Secondary pests may be either direct or indirect, but are usually brought on by specific weather and environmental conditions, or management practices that the grower may use for primary pests. Examples of key direct pests include oriental fruit moth and plum curculio. Aphids are usually considered indirect pests. Various scale insects are usually considered secondary pests, as are flower thrips.

The following lists key pests in the general order in which they appear during the growing season, with notes on their life cycles, monitoring and management options. Specific pesticide programs are not included for lack of space, and identification photos are included in the live presentation.

Oriental Fruit Moth (OFM):

The adult is a small grayish, mottled moth about ¼" long. Young larvae are cream colored with a black head, and grow to about 5/16" long. Older larvae have a brown head capsule, and are slightly pink.

Full grown larvae overwinter in bark crevices, ground cover, and in fallen or mummified fruit. After pupating in March, the first adults are found by mid to late April in southern NJ. There are 4 to 5 generations per year with flight peaks occurring during the first week of May, mid-June, mid-July, and late August.

First flight adult females lay eggs on the young leaves of terminal growth. After egg hatch, first brood larvae bore into new growth stems and leaf petioles, and emerge several weeks later. Larvae may feed up to 6 inches down the shoot, or they may exit and enter a new shoot before maturing. During this process, the growing shoot and terminal leaves wilt and bend over.

After larval emergence, the entire tip and its leaves dry up with the tip completely bent over. The injury is known as flagging. Flagging injury stimulates lateral growth below the point of injury. This can inhibit good scaffold formation in young trees, and provide wound sites for pathogens. Crooked branches may also result from terminal feeding, but is usually of minor importance. After the first brood of larvae mature, the second flight starts to repeat the process, but this time eggs may be laid on the fruit. As petioles and growing terminals mature, third and fourth brood eggs are laid mostly on the fruit.

Fruit injury is more critical than terminal flagging, and may occur either early in the season on young fruit, or later after pit hardening to final swell. Injury is rarely seen on young or green fruit in sprayed blocks, but may still be found at harvest from later generations. Larvae will usually enter the fruit from the shoulder to the stem. As the larva bores into the fruit, gum and frass are exuded from the wound area. As the gum ages, a sooty mold may form on it, turning the entire wound area black. Larvae may occasionally enter fruit through the inside of the stem, and therefore leave no wound area, except for a small mark at the stem end of the picked fruit.

Monitoring and Treatment - Monitoring should be done by a combination of the following methods. Pheromone traps combined with temperature monitoring: Prior to first adult emergence (mid to late March) pheromone traps such as Pherocon 1C wing traps or delta traps should be placed in the orchard. Use no less than 2 traps per orchard. Larger farms require more traps. Degree days (DD), base 45^0F, must be recorded in order to predict proper insecticide timing. A max./min. thermometer, or electronic recording device may be used. To be more efficient use the NEWA system or subscribe to a service like Skybit®. Degree day accumulation should start at the first sustained adult trap catch. This is used as the biofix point, and all accumulations are counted from this date. Depending on the insecticide being used, the first OFM spray should be applied after an accumulation of 170-200 DD. A second application should be made at 350-375DD. Table 1 summarizes the model timings, but is only good for the first 3 generations. Traps should continue to be monitored every 7 days. If trap counts exceed 6 to 8 moths per trap per week, then additional insecticides may be needed. This usually does not happen until later in the season during the 4th generation. Applications should be assumed to last 10 days to 2 weeks, depending on weathering. Since adult trap catches usually exceed threshold around a flight peak, applications will be centered around these times.

Flagging counts: Ten trees should be examined in each block for the presence of flagging, and the number of flags per tree recorded. This should be done on a weekly basis. No flagging should be found when sprays are properly timed and applied. Experience has shown that when more than 3-4 flags per tree are present, then fruit damage is likely from future generations.

Fruit counts: Weekly examinations should be made of about 200 fruit in each block. As the season progresses, special attention should be paid to the stem ends of the fruit. Fruit is examined for fruit moth injury the same time it is examined for other insect or disease injury.

Figure 1 - Degree day (DD) spray targets from biofix for oriental fruit moth.*

Generation	Conventional	Intrepid	Diamides	Mating Dis.
1	170-200 350-375	Same as conv. insecticides	100-150 300-325	Just prior to first flight.
2	1150-1200 1450-1500	1100-1150 1400-1450	1075-1150 1375-1450	NA
3	2100-2200 2450-2500	2050-2100 2400-2450	2025-2150 2375-2450	NA
4	Monitor traps. Late season BMSB materials also control OFM			
*New Jersey Tree Fruit Production https://njaes.rutgers.edu/pubs/publication.asp?pid=e002				

Plum Curculio (PC):

Adults are about 1/4 inch long, small dark brown weevils with long snouts about 1/4 to 1/3 the length of the body. There are 2 prominent humps on the backs of the wing covers that make the entire insect look ‘bumpy’. Larvae are curved, yellowish-white to cream colored, with a brown head capsule, and a light brown shield behind the head. Larvae often appear ‘C shaped’ and legless. Fully grown larvae are 1/4 to 3/8 inch long.

Adults overwinter in and around orchards, hedgerows, nearby woods, and other protected places. They become active in the spring, usually just prior to bloom. Activity and mating is temperature dependent. They are seen when average temperatures reach 50 to 60^{0}F for at least 3 to 4 days or above 75^{0}F for at least 2 days. Adults first feed on developing buds, flowers, shucks, setting fruit and young fruit. Eggs are laid from 1 to 2 weeks after emergence, usually at shuck fall and shortly thereafter. The female eats a small hole in the fruit, deposits an egg in the hole, and makes a crescent-shaped cut below the egg. This creates a "C" shaped egg scar. Eggs hatch in 2 to 12 days, with larvae feeding in the fruit for 1 to 3 weeks. Full grown larvae exit the fruit, and burrow 1 to 2 inches into the soil where they construct cells in which to pupate about 2 weeks later. About 2 weeks after pupation (1 month after entering the soil), new adults emerge. There are often 2 generations per year in the PA/NJ/MD area, but one generation per year in northern NJ, New York and New England.

Untreated or wild (crabapple, wild plum, blueberry, and other wild fruits), and cultivated hosts will sustain all of the above injuries. Early feeding signs on the flowers, shucks, and developing fruit, as well as egg scars, can be present in commercial plantings, especially on outside rows near overwintering sites. Visible injury from the egg scars will be present throughout the season. Actual first brood larval injury will cause fruit drop, while second brood injury will usually not cause drop, but will provide a fruit source for brown rot and other diseases to develop, and leave a small hole in the fruit. Larvae are seldom seen in managed orchards. However, when using mating disruption practices for oriental fruit moth where insecticide is pulled for prolonged periods of time, extra scouting is often needed to watch for PC injury.

Monitoring and Treatment - Monitoring should be concentrated from just after bloom through 3 weeks after shuck off. Monitoring can be done with a beating tray by holding a large square yard cloth beneath the tree and beating on a branch 3 times. A dark gray to black pyramid trap, similar to the pyramid traps used for BMSB monitoring, can be placed on the edge of the orchard to monitor adult activity. However, trap catch results and beetle activity within the trees have not been able to be correlated. Fruit should also be examined by counting a minimum of 200 fruit per sample for egg scars or feeding injury in the 10 tree sample site. Early control of the overwintering generation is critical so that egg laying is avoided. Petal fall sprays applied too late are often the cause of egg scar injury seen later. The degree day model developed in New York has been effective in New Jersey in peaches. The model uses a 50°F base and dictates fresh spray residue up to 308 DD_{50} after McIntosh petal fall, or full bloom for other apple varieties. Therefore the last insecticide would be applied about 10 days prior to reaching 308 DD. A Michigan State model uses degree days starting at January 1, but recommends start timings for insecticide sprays (Figure 2). Under high pressure, sprays need to be continued to 400 DD or shortly after. Timing partially depends on the insecticide being used.

Figure 2 - MSU Selected control Materials and initial DD timing for plum curculio.*

Compounds	Crop	Rate	Crop Stage and Initial Control Timing (DD50)*
Guthion 50W	Pome fruit Cherries	2 lb 2 lb	Petal fall (approx. 250 DD) Petal fall (approx. 175 DD)
Imidan 70W	Pome fruit T. Cherry	3 lb 2½ lb	Petal fall (approx. 250 DD) Petal fall (approx. 175 DD)
Actara 25WG	Pome fruit Stone fruit	4½ oz 4½ oz	Petal fall + 3-5 days (approx. 300 DD) Shuck-off (approx. 250 DD)
Calypso 480SC	Pome fruit	4 oz	Petal fall + 3-5 days (approx. 300 DD)
Assail 30SG	Pome fruit	6 oz	Petal fall + 3-5 days (approx. 300 DD)
Clutch 50WDG	Pome fruit	3 oz	Petal fall + 3-5 days (approx. 300 DD)
Avaunt 30WG	Pome fruit	5 oz	Petal fall (approx. 250 DD)
Surround WP (Not Recommended For Cherries)	Pome & Stone Fruits	Usually 16 lb by First Cover	Start a base before bloom with solid coverage.
Rimon (targeting codling moth)	Pome fruits	20-40 oz/A	200-250 DD
*Degree days accumulated starting Jan. 1. http://msue.anr.msu.edu/news/plum_curculio_management_and_spray_timing			

Tarnished Plant Bug (TPB) and Other Catfacing Insects:

TPB is the most important catfacing insect in the mid-Atlantic region. Other principal catfacing pests include the green, brown, and dusky stink bugs, and more recently brown marmorated stink bug (BMSB). TPB nymphs are pale yellow-green insects from 3/16" to 5/16" long. They are about the same size as aphids, but may be distinguished by the segmented abdomen, and the presence of wing pads. Adults are about 1/4" long and 1/8" wide, flattened and oval in shape. Wings are folded flat over the body, and are a mottled brown, with some yellow. On the back side of each wing there is a yellowish triangle with a brown to black spot on the posterior tip. Stink bugs are much larger than tarnished plant bugs. They are broad insects with a flattened, shield-like body. The thorax narrows towards the front just in back of a small head. Long piercing, sucking mouthparts are held straight under the body, folded under between the legs. The brown stinkbug about ½ inch long, the others are about ¾ inch long.

TPB adults overwinter under bark and leaves, and around alfalfa and other legumes, or around a number of other weeds. There are three or more generations per year. Both nymphs and adults feed by sucking plant juices from the feeding site. Adults become active in the spring as buds begin to swell, and first feed on expanding buds, and to a minor degree on terminal shoots. Adults continue to feed during bloom and after fruit set. Prior to shuck split, feeding injury causes bud and flower drop. Very little fruit drop is seen after shuck split to shuck fall, but the fruit is injured. Native stink bugs also overwinter as adults and cause similar injury.

Early season "catfacing" injury results from tissue death at the feeding site, while the fruit continues to grow around the site leading to deformed fruit. Injured areas may be fuzzless, corky, and depressed, and may have a small amount of dried gum in the center. As fruit matures, additional injury can appear as scarring, gummosis or bleeding, and shallow water soaked areas at the feeding site.

Monitoring and Treatment – The most reliable monitoring method for TPB and other catfacing insects is done with both direct fruit damage counts and orchard floor sweep net counts. Count the number of damaged fruit by sampling 200 fruit across 10 trees. In addition to plant bug activity, it will also pick up leafroller and fruit moth injury, as well as diseases. Both old and new plant bug feeding should be recorded. Recent feeding is not callused over, and is often gumming either in small lumps, or in a single strand exuding from the fruit. There may be a number of injury marks on the same fruit. The detection of fresh injury is critical, since it enables changes in the spray program before further injury may occur. Sweep sampling gives the best indication of the catfacing insects present in the orchard and ground cover. This method picks up nymphs as well as adults, and therefore can be used to help predict population growth. Since sweep sampling does not include those insects in the trees, it must be used as an indicator for a pest population that can move into the trees given favorable conditions such as mowing, discing or raking. Sampling should be done with a heavy duty sweep net, taking at least 50 180^{o} sweeps per sample site, or per block. Sampling should be biased towards the thicker ground cover and weeds that are blooming or have seeded.

Ground cover and weed management is an important part of plant bug control. Many plant bugs also prefer alfalfa, vetch, and herbaceous weeds. The presence of these weeds increases the chances of having damaging plant bug populations, especially if weeds are allowed to bloom and develop seeds. We have found that by eliminating broad leaf weeds with Stinger®

or like generic, catfacing insect populations are almost eliminated. When this is combined with mating disruption for OFM, the pack-out is cleaner and the insecticide bill is lower.

Other Insects and Mites:

Other insects may include Japanese beetles, tufted apple budmoth and other leafrollers, green peach aphids, San Jose scale, white peach scale, peachtree borer and lesser peachtree borer, flower thrips and western flower thrips, and several species of mites. Please see the phenology table below for general peach and nectarine pest timing.

Recommended Peach Varieties for New England

Tom A Callahan

Currently, we are propagating 125 Peach and Nectarine Varieties for the Direct Market and Commercial Pack Industry. The 2014, 2015, and 2016 seasons gave us an opportunity to evaluate many new varieties for both winter and spring hardiness. Listed below is an overview of varieties based on those findings and Grower Feed Back, suggested for the New England market.

EARLY SEASON YELLOW PICKS

DESIREE®, FLAMIN' FURY ® PF 5D BIG, EARLYSTAR®

GLENGLO™, FLAMIN' FURY® PF 8 BALL, SENTRY (CT ONLY)

EVELYNN™ (NEW LOW ACID)

REDHAVEN, STARFIRE®, JOHN BOY®, FLAMIN' FURY® PF 15A, FLAMIN' FURY® PF LUCKY 13

MID SEASON YELLOW PICKS

FLAMIN' FURY® PF 17

CORALSTAR®, GLOHAVEN, CANADIAN HARMONY, BOUNTY, SWEET-N-UP

CONTENDER

FLAMIN FURY® PF 23

LATE SEASON YELLOW PICKS

CRESTHAVEN, MESSINA® (CT ONLY), GLOWINGSTAR®

SELENA™, TIANA™, ENCORE

LAUROL

EARLY SEASON WHITE PICKS

SUGAR MAY

JULY ROSE™

MID SEASON WHITE PICKS

WHITE LADY

LATE SEASON WHITE PICKS

SUGAR GIANT, BLUSHINGSTAR®

AUGUST ROSE™

FLAT PEACHES

H13-23 (Not named, suggest to trial)

BUENOS® II

SATURN

GALACTICA

TANGOS®
TANGOS® II
Series of 3 new White fleshed Flats from Italy that have not yet been named. (Suggest to trial)
WHITE NECTARINES
JADE™
SILVERGEM®
ARCTIC GLO
SILVERGLO™
EMERAUDE™
YELLOW NECTARINE
EASTERNGLO
AVALON™
BRIGANTINE™
NECTAFEST
SUMMER BEAUT
SUNGLO
FANTASIA (CT only)

15 Years of Peach and Nectarine Variety Evaluation at the UMass Orchard

Jon M. Clements

UMass Amherst/UMass Cold Spring Orchard
393 Sabin Street
Belchertown, MA 01007
jon.clements@umass.edu

Shortly after arriving at the University of Massachusetts Amherst as Extension Tree Fruit Specialist in 2000, I began planting peach variety and planting system evaluation trials at the UMass Cold Spring Orchard in Belchertown, MA. Impetus for this activity was my familiarity with hi-density peach systems and varieties while working for Michigan State University from 1998-2000 as Berrien County Extension, MI Horticulture Agent. In that County, there were two major peach breeders, Annette and Randy Bjorge, breeders of the Fruit Acres (FA) series of peaches, and Paul Friday, breeder of the PF series of peaches.

These plantings I made fell into three peach/nectarine blocks: first, a perpendicular-V block, planted beginning in 2000, with mostly named and numbered peach varieties from the Fruit Acres (FA) "Stellar" breeding program (International Plant Management cooperating); second, another perpendicular-V block planted beginning in 2002 with varieties added through 2015 that are mostly sourced from Adams County Nursery (ACNursery), including test selections from the Rutgers University breeding program (Joe Goffreda) and the USDA/Kearneysville breeding program, with ACNursery having exclusive marketing rights; and third, a Paul Friday (PF) "Flaming Fury" block with some of his more recent and exciting peach introductions planted in 2014, and also including some new, named varieties (including nectarines) from ACNursery.

Over the past 15 years beginning in 2002 through 2017, I made many – both casual and more rigorous, including entering multiple fruit quality parameters into a database – observations on tree hardiness, fruit quality at harvest, and training systems on all three blocks. Let me tell you about all three of the plantings individually, highlighting what I feel are some of the important lessons coming out of them.

First, the FA block planted beginning in 2000 and more trees added in 2001. Tree spacing was initially 8 by 15 feet, then it was inter-planted such that there was only 4-5 feet between trees. Over 54 different named and numbered selections were eventually included in this ¼ acre planting, which was trained to a perpendicular-V:

- Named FA "Stellar" varieties (https://www.fruitacresfarm.com/stellar-peaches), just about all of them were planted. (Except Autumn Star and Sweetstar.) Earlystar and Brightstar were planted when they were numbered, FA-101 and FA-102 respectively. Rootstocks were Lovell and Bailey. Also, Summer Beauty nectarine was included in this planting, but I was never particularly impressed with the yield on those nectarine trees.
- Noteworthy varieties and selections included Earlystar, Risingstar (a vigorous tree), Blazingstar, and most of the others except Redstar and Allstar which I was not that impressed with. Blushingstar is a nice white-flesh peach.
- Yields on these perpendicular-V trees varied quite a bit from year-to-year. Again, Earlystar and Risingstar were predictably good, as was Blazingstar. The rest were more

variable. All suffered significant flower bud injury during January 2004 when the temperature dipped to -12 F.

- Many, many numbered FA selections were inter-planted in this block, however, to my knowledge, none of them have become named. Some were very late harvest, into early September. Quality and productivity was all over the place, but it is a moot point as I don't suspect any of them will ever be released as named varieties.
- One interesting note was the variety MSU 26, which is now named 'Beaumont,' introduced by my friend out of Michigan State University, Bill Shane. A nice, freestone peach, perhaps more suitable for the processing market. But I'd plant it for retail too.
- ALL the FA named peach varieties could be planted in a block that spans the harvest season from very early (Earlystar) to rather late (Sweetstar in particular) and are recommended.
- This block of trees was completely removed several years ago.
- Publication "New Peach Variety/Selection Plantings and Evaluation When Grown to the Perpendicular-V" http://umassfruitnotes.com/v70n3/703-a4.pdf

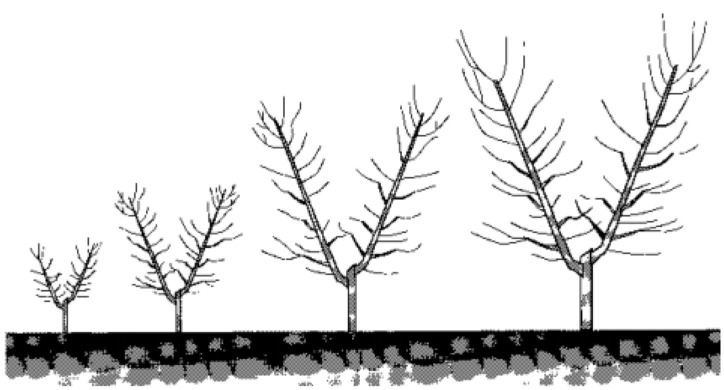
Second, the ACNursery block planted beginning in 2002 and 2003, and then ongoing removal and planting until just recently:

- This ¼-acre block was initially planted as a perpendicular-V and included many Redhaven trees. I have been given lots of grief over the years about hi-density peaches planted to perpendicular-V, but I am convinced it's a good way to go, with high early yields because it's quick to fill space. But, no large limbs can be tolerated, and trees have to be picked with a ladder. I think the perp-V orchard is good for about 10 years, and then it is time to think about replacing. Inter-tree shading is a bit of an issue. Redhaven trees included in this block are still productive with fruiting wood to the bottom of the trees.
- Initially planted with HoneyKist, HoneyBlaze, CountrySweet, and Jonasweet, these are sub-acid varieties from the Zaiger breeding program in California and supplied by ACNursery. Only CountrySweet (yellow peach) and HoneyKist (yellow nectarine) cropped regularly. HoneyBlaze and Jonasweet were removed after a few years of light or no cropping. CountrySweet was a very nice peach, good yields, good flavor, and was popular with the harvest crew and the farm sales stand at the UMass Orchard. HoneyKist was a nice nectarine, good yields, had some fruit finish issues (but not too bad). A reminder these are both sub-acid, which is a flavor many customers might not be accustomed to. The downfall of these two varieties is susceptibility to BACTERIAL SPOT which was a constant battle! I have come to the conclusion it is not worth fighting bac spot and cannot recommend ANY bac spot susceptible varieties (from California) that will be grown in this region. The CountySweet and HoneyKist trees are completely gone now, and replaced with numbered test selections. Jade, a white nectarine from France was also included, and was interesting, however, I can't recommend it because of light cropping.
- This block has been subsequently planted with many numbered selections from ACNursery and Rutgers or USDA/Kearneysville breeding programs, beginning in 2008 and ongoing. These trees are planted very close together and trained to a tight (4 feet between trees) central-leader. Of note here are NJF-16 and NJF-17 "donut" peaches, which have been named TangOs-I and Tangos-II respectively. TangOs-I seemed easier to

grow and I liked it better. These donut peaches are quite vigorous, need heavy hand thinning, and are particularly susceptible to brown rot. I'm not aware that any of the other test selections planted, and there are many, have been named and introduced by ACNursery. Most of the Kearneysville (KV) selections have been poor croppers, suffer from bacterial spot, and are columnar/upright/vigorous. Can't find much redeeming with them at this point, but I have heard Sweet-N-Up which is from KV is very nice once you figure out how to prune it. There are some interesting and good peaches in here, stay tuned, we are still actively evaluating this block of numbered selections.

Third, and most interestingly now, is a half-acre block of some of the latest Paul Friday "Flaming Fury" peaches (http://www.flaminfury.com/) planted in 2014. These trees, sourced from Stark Bros. Nursery, are being trained to a quad-V (4, steep leaders), spaced at 8 by 18 feet, and are mostly on Lovell rootstock. There are thirteen PF varieties planted here, along with a few new named varieties from ACNursery. This orchard only first cropped in 2017 – in 2016 fruit buds were killed during the Valentine's Day "massacre freeze."

- PF varieties included in this block, most with 10 trees per variety: PF 5D Big (-24 days from Redhaven harvest); PF 8 Ball White (-10); PF 9A-007 (0); PF Lucky 13 (+5); PF Super Duper (+13); PF 19-007 (+17); PF 22-007 (+20); PF 24C Cold Hardy (+22); PF Paramount 24 (+22); PF 28-007 (+32); Fat Lady (+40); PF Legendary (+40); Big George (+50); Ka Ching nectarine (+50); and Fashionable Late (+54).
- ACNursery/Rutgers new named varieties included in the block are: July Rose (NJ 354, -6); Scarlet Rose (NJ 355, -4); Silver Gem nectarine (NJN 100, -13); Avalon nectarine (NJN 101, -11); and August Rose (NJ 356, white peach, +24). These are on Bailey rootstock.
- Initial harvest observations suggest that most all the PF peaches are very good, in particular the early-mid season varieties, which included: PF 5D Big, PF 8 Ball White, PF 9A-007, PF Lucky 13, PF 19-007, PF 22-007, and PF 24C Cold Hardy. The later harvested varieties I thought were largely ho-hum, not bad, maybe I was just peach-weary by then?
- Wow, most of the ACNursery named selections were very nice. Although I only have seen fruit for one year, I already wouldn't hesitate to recommend them.



Perpendicular-V peaches (http://ucce.ucdavis.edu/files/datastore/391-540.pdf)

Innovations in Greens Washing - With An Eye On Food Safety

Rob Rock

Upstream Ag
Pitchfork Farm
PO Box 783, Burlington, VT 05402
Rob.rock.pitchfork@gmail.com

Rob is co-owner of Pitchfork Farm, located on the Intervale in Burlington Vermont. Pitchfork Farm produces 14 acres of organic mixed veggies primarily for direct sale to restaurants. For the last 10 years at least 50% of Pitchfork's revenues have come from cut baby greens – triple washed, packed, and delivered as a ready-to-eat product. Rob has dealt directly with dozens of chefs, produce buyers at grocery stores, and institutional buyers, and has reflected on nearly every aspect of producing greens like mesclun for customers who regard it as a value-added product (in the sense that it should be ready-to-use directly from the walk-in cooler without further processing by the customer).

We'll focus on some of the aspects of post-harvest handling that include making sure your products are grit free, as well as dried down to correct levels before packing for the maximum freshness of the greens. We'll also talk a little bit about efficiencies and some of the new techniques being experimented with on Pitchfork Farm, including wash water filtration and adding automated DIY conveyors to the wash line.

A big topic to be covered will be the pros and cons of using a converted washing machine to spin dry greens, especially as we are fast approaching a time when we may be facing stricter food safety regulations. We'll also talk a bit about some of the challenges of converting and maintaining washing machine spinners.

In the winter away form the farm Rob designs and builds farm equipment under the name Upstream Ag. He has been experimenting quite a bit over the last couple of years with greens post-harvest handling technologies, and will have a couple of new innovations to present with the hope of getting some feedback directly from growers. The development of these technologies has been supported in part by grant funding from the Vermont Agency of Agriculture Food and Markets, with the aim of producing tools that can be reproduced by growers in kit form.

Greens Equipment from Seeding to Harvest at Jericho Settlers Farm

Christa Alexander & Mark Fasching

Jericho Settlers Farm - Jericho, VT
farmers@jerichosettlersfarm.com

We progressed from hand seeders (earthway) and hand harvesting (knives) both in the field and in high tunnels for our greens. Today we direct seed with a tractor mounted seeder and harvest with our walk behind greens harvester and in some cases the Farmers Friend quick cut greens harvester. As a result of this progression, time spent seeding and harvesting is largely a one person job.

Method	2002 – 2008	2009- present
Bed prep	Rototiller	Bed shaper
Fertilization	Hand broadcast	Drop or cone spreader
Seeding	Earthway seeder	Sutton Ag 3pt seeder
Cultivation	Hand and hoe work	Flame weeder, tine weeder
Harvesting	Knives	Walk behind greens harvester
		Quick cut greens harvester
Post harvest cooling	Cool bot room	Refrigerated truck to walk-in cooler

In the beginning, we made beds with a rototiller and seeded greens such as spinach, lettuce mix and meslcun with an earthway seeder making multiple passes (up to 8 lines) on a seed bed. Weed cultivation was done by hand or hoe and harvesting was conducted with knives. This system took a lot of time, was not very precise, and much of it was handwork. As a result profitability was not great.

In the past 8 years greens production and profitability took a huge leap when we purchased a used walk behind greens harvester and Sutton Ag 3pt seeder from a farm in 2009. The combination of seeding 17 lines of seeds per bed in one pass and cutting the full bed width of greens 20 to 30 days later allowed us to increase our production. The reduction of time and persons in seeding and harvesting increased profitability.

Bed Shaping

Today we use a Lesche Bed Shaper that forms a slightly raised bed, 42 inches in width with little soil structure disturbance. The bed shaper is much faster and less destructive than a rototiller. As a result we reduce weed seed disturbance.

Fertilization

We may fertilize beds individually with a drop spreader that spans the greens bed, or with a cone spreader that broadcasts out to a 50 ft width allowing us to shape up to 8 beds within that width. Fertilization is from incorporation of a cover crop and/or pelleted chicken manure.

Seeder

Our tractor mounted seeder made by Sutton Ag Enterprises allows us to seed in one pass from 1 to 20 lines. Steel rollers ahead and behind the seeding shoes make for a flat bed with great seed to soil contact.

Cultivation

Most if not all cultivation is done prior to fertilization and bed shaping. We generally will define a field block for successions of greens, turn it over prior to bed prep and continue tine weeding the block prior to seeding beds. The first beds of spring may also be flame weeded prior to seeding. Since greens are harvested within 20 to 30 days we don't need to cultivate tire tracks.

Harvesting

Harvesting both in the field and in our high tunnels is conducted with the walk behind greens harvester. This harvester is similar to an Ortomec harvester and has rubberized treads which ride on top of the bed, a bandsaw cutting blade up front and conveyor behind blade to move greens to totes sitting on a platform. The harvester is moved with a joystick. Occasionally we will use the quick-cut greens harvester if harvesting a short section of greens.

Post-harvest cooling

During the field season, totes of cut greens are moved directly from the harvester and stacked into a refrigerated box truck. Box truck temperature is maintained around 50 deg F. Later in the day totes are brought up to the wash pack barn with other harvested crops and put into our walk-in cooler maintained at 37 deg F.

Why are My Greens Brown? 2017 Disease Update

Ann Hazelrigg, Ph.D.

PSS Department, Jeffords Hall
63 Carrigan Drive, UVM, Burlington, VT 05405
ann.hazelrigg@uvm.edu

This talk will include an overview of brassica and leafy greens diseases from seedborne issues through harvest. Diseases will include black rot, damping off, wirestem, white mold, club root, fungal leafspots, downy mildew, bottom rot and head rot. Non-infectious problems will also be mentioned including Boron and Calcium deficiency plus oedema. Basics on how pathogens cause disease will be covered as well as how to identify the diseases in the field and how manage them before and after planting using IPM strategies. Management options covered will include hot water seed treatment, rotation, sanitation, use of resistant varieties, etc.

Growing Specialty Brassicas for Fresh Market Sales

Jan van der Heide

Bejo Seeds, Inc.
1088 Healey Road, Geneva, NY 14456
j.vanderheide@bejoseeds.com

While sales of traditional cabbage are level or slightly declining, we see a steady increase of specialty Brassicas. The surge in sales and consumption of kale in recent years has exposed consumers to stronger Brassica flavors, and has led to increased interest in other Brassicas. Marketers are asking the question: “What is the new kale?”

We see increased interest in Brussels Sprouts, Cauliflower, Kohlrabi, but also different types of easier-eating (softer leaves) heading cabbages.

Growing traditional heading cabbage is not particularly challenging, as long as growers select the proper varieties for the intended use (fresh market, close spacing (small heads), processing, storage). Soils should provide about 200 pounds of Nitrogen per acre for a full-season crop, and pest control recommendations are widely available for conventional growers. Pest control options are more limited for organic growers, but there are good varieties available with resistance to specific pests and diseases that can be very good options for organic growers.

Specialty Brassicas can be trickier to grow, as some specialty Brassicas can have limited adaptation ranges (sensitivity to bolting, sensitivity to high temperature, specific cultural practices, etc.)

Small Cabbages

There is still a good market for large cabbage, but that market is focused primarily on processing (coleslaw, shredded cabbage, sauerkraut). Most consumers prefer smaller cabbage heads (up to 3 pounds) that can be used up in a single meal for a small family.

The size of cabbage heads can be manipulated by planting plants closer together and limiting the productivity of each plant. But, not all varieties can handle closer spacing. The plants of more vigorous varieties will compete with their neighbors in the row, and there will be winners and losers. There will be some plants that will produce big heads, and other plants that will be overwhelmed by their neighbors and not produce any heads at all.

Choose varieties with small frames for production of smaller heads. These varieties will not produce big heads, even when given plenty of room. These varieties will produce a full crop of small-medium sized heads, with excellent uniformity.

Varieties: KOSARO (red, 60 days), INTEGRO (red, 75 days), FARAO (55 days), REACTION (100 days), TRAVERO (red, 100 days), KLIMARO (red, 95 days)

Mini Cabbages

You can take the production of smaller heads to an extreme and produce mini-cabbage. Reduce fertility for production of mini-cabbages: use very little to no Nitrogen, half the normal rate of K, and normal rate of P. This reduced fertility prevents any chance of competition between the plants, and ensured good uniformity.

Varieties that are well suited for production of mini-cabbage are: TIARA (48 days), KATARINA (45 days), OMERO (red, 52 days), REACTION (95 days, storage), CANDELLA (97 days, storage), TRAVERO (red, storage), ALCOSA (50 days, savoy), CARAFLEX (65 days, pointed)

Brussels Sprouts

Use land that is not too fertile, and not too poor. You will need to control the crop and its development with fertility, so you need some flexibility and room to move on the fertility front.

Brussels Sprouts should be planted as early as possible, because they need to make as long a stalk as possible before the longest day (late June). This means that all fertility should be applied in the early season to stimulate rapid plant development and growth.

Stop fertilizing after mid-June. The plants should use up all the fertility by season's end. This way the plants will mobilize the nutrients that are needed for development of the sprouts out of the leaves. The leaves will turn yellow and fall off, leaving a naked stem with beautiful sprouts for easy picking, or for sales as whole stalks with sprouts.

Avoid stress during the growing season. The plants will need water during the hottest period of the summer. Lack of water will result in calcium deficiency in the developing sprouts (similar to blossom-end rot in tomatoes), and these sprouts will break-down at maturity (they turn brown and "funky" – the sprouts will be covered in Alternaria, but this Alternaria is a secondary infection of weakened tissues as the result of Calcium deficiency.)

It will take you several years to figure out how to grow Brussels Sprouts; it is not easy and you will need to learn to "read" the crop.

Try these varieties: MARTE (mid-season, vigorous, easy growing, follow the above tips), DAGAN (mid-season, strong stems, upright, vigorous – may need just a bit of N to help the sprouts stay green at the end of the season), NAUTIC (strong stems, later maturity (Christmas), leaves shed very nicely), DIABLO (later maturity, medium sprouts).

Cauliflower

Like Brussels Sprouts, Cauliflower is also tricky to grow. The secret is NO STRESS. You will need to grow a nice, strong plant first. This means even soil moisture (irrigation), good and constant fertility, and some luck. Cauliflower needs cool temperatures to form a head. This means that some varieties will postpone flowering when the summer is warm, while other varieties can be triggered into flowering by just a bit cooler night-time temperatures. As a result, it can be very frustrating to predict when your cauliflower crop will be ready for harvest. (Variety A may be earlier than variety B in year 1, but year 2 might give you very different results!) If you live in areas with warm summer you should focus only on fall cauliflower, and be prepared to cut cauliflower as late as December.

Varieties: BERMEO (summer), FLAMENCO (summer, early fall), ADONA (summer, fall), ALTAMIRA (late summer, fall), TOLEDO (late summer, fall0, SKYWALKER (fall). VERONICA (Romanesco, late summer/fall), PIRAMIDE (Romanesco, fall/early winter).

Heat Stress (Broccoli)

The very young flower buds of Broccoli are easily damaged by high temperatures. This results in uneven development of the flower buds and produce ugly heads. BEJO is collaborating with the Eastern Broccoli Project (Thomas Bjorkman, Cornell) to develop broccoli varieties with better heat and stress tolerance, and we are making good progress.

The variety BURNEY is one of the first BEJO varieties to come out of this project, and it has very good stress tolerance (reliable flowering, excellent uniformity, good field holding, nicely domed head, bit coarse bead, minor purpling). This variety should really be planted in the most stressful period of the growing season (July/August). BURNEY is OK in the cooler parts of the season, but there are plenty of other varieties that are also OK then. The best use of BURNEY is to extend your broccoli production into the most stressful part of the season.

Thrips

Even insecticides cannot control Thrips reliably! Thrips damage (slightly raised blisters/scar tissue) on the leaves makes cabbage look “dirty” and difficult to market. Some cabbage varieties make these blisters as a reaction to feeding by thrips, or make these scars in reaction to tiny growth cracks as the cabbage heads begin to fill and build up internal pressures. Other varieties have either have stronger tissues, or do not react as strongly to thrips feeding.

You will notice that most cabbage is nice and clean while the heads are still young and not quite fully filled, but that thrips damage shows up rapidly as soon as the cabbage is a bit over-mature.

Therefore, to minimize thrips damage, cut the cabbage while still a bit immature (and store in your cooler until ready to market), and select varieties with good thrips tolerance.

Varieties: BENELLI (round, fresh market, 80 days), EXPECT (round, storage, 100 days), flat cabbage (cabbage rolls, stir fry: GUNMA 70 days, TAMARINDO 80 days, NOKTA 90 days),

PASSAT (78 days, processing), TYPHOON (90 days, processing, FM)

Black Rot

The only way to control Black Rot is to work with clean seed (ask your seed supplier!), work in a clean greenhouse for plant production, use a <u>good crop rotation</u>, and choose varieties with tolerance to Black Rot. The boxing cabbages BRONCO, RAMADA and EXPAT have some tolerance to Black Rot, CAPTURE (fresh market) and EXCALIBUR (processing, FM) have very good resistance, and the kale varieties DARKIBOR, WINTERBOR and STARBOR have medium tolerance.

Evolving Cultivation Strategies at Roxbury Farm
Jody Bolluyt

Roxbury Farm, Kinderhook, NY
www.roxburyfarm.com
jody@roxburyfarm.com

Cultivation for weed control is one aspect of our over-all weed control strategy. Our vegetable fields are rotated out of vegetable production every 2 to 3 season for a whole year in a series of cover crops with bare fallow periods. Each field is also in a cover crop of some kind during each production year. We also strive for the proper plant density for shading out weeds. When talking about cultivation it is all about using the right tool at the right time and creating the right soil conditions for good weed control. Our cultivation objectives have always been the same, control the weeds before you can see them. The introduction of more precise equipment from the Netherlands and Germany has helped us to do a better job of reaching this objective.

Our first step is to have a good seed or plant bed. To accomplish this we used raised beds. We have used a Buckeye bed former to create a perfectly flat and smooth bed top surface. We used to use this tool to make one bed at a time. We now have a machine that makes three rough beds in one pass and the Buckeye is now used to make the final pass to form the smooth raised bed. Creating three rows at once makes it easier to have straight beds and fit eight beds into our permanent planting sections. (We have 50 ft wide permanent planting sections separated by 10 ft wide grass strips.)

After the raised bed is formed we want to seed or plant into as weed free a surface as possible. We use the stale seed bed technique by tilling the soil just as deep as we will be seeding or transplanting. We went from using a basket weeder to accomplish this to a Steketee Combination Seed Bed Maker. Using the basket weeder did not give us enough control over the how deep we were cultivating so we continued to bring up weed seeds from deeper in the soil. The Steketee machine can be adjusted to the exact depth to control weeds and to create a firm surface for the seed or transplant roots to sit on. This give us better seed to soil contact for good germination or root to soil contact for our transplants.

After seeding or planting we want to be able to control weeds before we can see them. For the first cultivation we use a basket weeder or a HAK steerable cultivator. The HAK is on the back of the tractor and the person riding the cultivator steers it to get as close as possible to the crop. There are a series of knives that shallowly till the soil to destroy any germinating weed seeds without bringing up new weed seeds from deeper down in the soil. Being able to steer the HAK also allows us to get right up next to the crop so we have a wider swath of weed control.

After the primary cultivation we want to try for in-row weed control or a more aggressive tool for the weeds we missed with the first cultivations. We have two tool bars with different knives, sweeps, or 2-tine cultivators that we can easily adjust to accomplish this task. We purchased them from Market Farm. But they are not very precise nor do they do in-row cultivation. We have used the Bezzeride torsion hoes that do some hilling to bury in-row weeds or the Bezzeride torsion gangs that lightly disturb the soil in between the plants but on their own can't control the majority of the in-row weeds. We now use a HAK finger weeder tool. We have a front-mounted cultivator with knives and torsion gangs that break up the crust and control weeds in between the rows. The knives are lined up with the finger weeders on the rear of the tractor as we are using the fingers blind. The fingers on the back of the tractor get in-row weeds. If done at the right time with the right soil conditions we can get 97% weed control. We find that the HAK finger weeders don't work as well on heavy soil unless it is very dry. On our sandier soils the finger weeders work great.

We also use plastic mulch for a number of crops. To get good weed control in this system we use a Hillside cultivator with hydraulic controls so we can throw just the right amount of soil up onto the edge of the plastic to bury the germinating weeds. After we cultivate two or three times we then mulch the wheel tracks with straw. We have a Teagle bale processor on our 3 pt hitch so we can shred the mulch directly into the wheel tracks. We then rake it so that we have a good covering on the edge of the plastic.

Our problem crops are potatoes, green beans, and sweet corn. We are surrounded by hay fields and alfalfa fields so after the first cutting of hay leaf hoppers invade our potato field. We have good weed control until the plants go down from leaf hopper burn. Once there no shade canopy we struggle to keep our potatoes weed free. With green beans we have a hard time controling the weeds that germinate right up next to the green bean plants. We don't often have time to hand weed beans so this continues to be a struggle. We can keep our sweet corn weed free until the plants are too tall for our cultivation tools. We find there isn't enough shade to prevent weeds from germinating after our last cultivation.

Our hope is in future seasons we can incorporate some no-till systems and more mulching with these three crops and some of our fall brassicas and winter squash. Our soils are very low in organic matter because how the land was farmed by previous farmers. We have doubled the organic matter to 2.5% to 3% and we would like to continue that trend. But, in order to achieve that we need to reduce the tillage and cultivation we do to grow our crops. Planting into rolled and crimped cover crops and using more mulching will help us achieve that goal.

Stacking Tools for Improved Weed Control

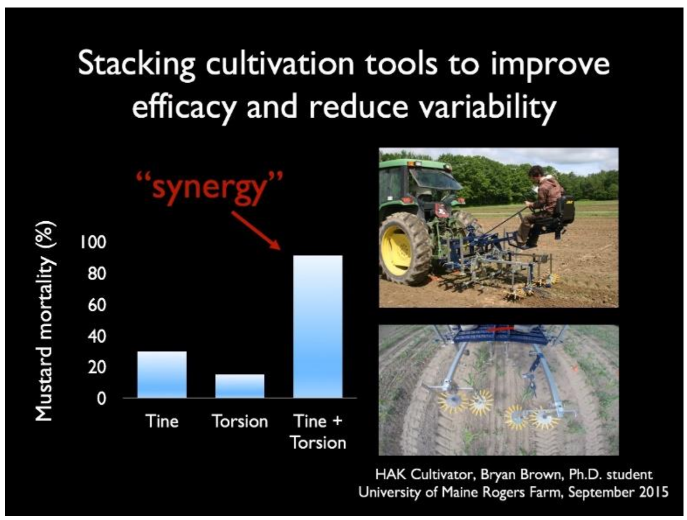
Eric Gallandt[1] & Bryan Brown[2]

[1]Professor of Weed Ecology and Management
School of Food and Agriculture
University of Maine
5722 Deering Hall
Orono, ME 04469-5722
gallandt@maine.edu

[2]Integrated Weed Management Specialist
New York IPM Program, Cornell University
New York State Agricultural Experiment Station
630 W. North Street
Geneva, NY 14456

bryan.brown@cornell.edu

Physical weed control, i.e., cultivation, is the cornerstone for weed management in organic and diversified vegetable cropping systems. Considered to be both "art" and "science," cultivation efficacy is a function of complex interactions of tools, soil, weeds and crops. A fundamental problem with cultivation is that efficacy, the proportion of weed seedlings killed, is often low and highly variable. This problem can be addressed simply with multiple passes, for example, killing 60% of established weeds with each cultivation event until the resulting density is satisfactory. Alternatively, tools with different designs can be "stacked," and deployed simultaneously to exert their various disturbance profiles and presumably seedling-killing mechanisms.



We recently compared efficacy of intra-row weed control with tine, torsion and finger weeders in test crops of corn, using condiment mustard (*Sinapis alba*) as a surrogate weed. The tools were tested individually, and in all possible two- and three-way combinations. The stacked combinations consistently resulted in better weed control than did the individual tools, with frequent evidence of synergy, i.e., efficacy greater than predicted by simply additive effects of the tools. Benefits of stacking tools remained over varying conditions weed size, soil moisture and tractor speed, but crop mortality was also greater than measured with individual tools. Individual tools, averaged over 247 observations, had a mean efficacy of 28% with 3% crop mortality. In comparison, stacked tools, averaged over 61 observations, had a mean efficacy of 76%, but with 16% crop mortality. We estimated that individual tools would require 7.2 passes, on average, to achieve 90% weed control, but only 1.6 passes with the stacked tools; crop mortality, however, would jump from 17% to 25%.

For more information on this, and our other weed management research, see: https://gallandt.wordpress.com.

How I Learned to Use a Kress Cultivator

Andre Cantelmo

Heron Pond Farm
299 Main Ave
South Hampton NH 03827

My partner Greg Balog has a saying, “we need butts in tractor seats.” You can have the best cultivator in the world but if you don’t go out there and use it, in a timely fashion, then it won’t help you solve your weed problem. However, the right set of tools can help get more complete weed control with fewer passes. This save time, money, and opportunity cost. Of course, the increased yields with better weed control are the goal.

We bought our Kress cultivator in 2013 with the hope that it would be the magic bullet, the missing link in our weed management program. We found that the learning curve was steep and had much frustration with the set up of the unit. The folks from Kress seemed to set it up and have it working fine in minutes. After they left we found frustration getting the weed control we wanted at each stage of crop development. This talk outlines our journey if not to complete success, then to a better understanding of the tool we own and how to best make use of it for successful weed management. We also recommend the use of stacked (multiple) cultivation implements. That topic covered by another speaker at this conference.

Problems out of the gate.

What did not go wrong? We would have a few amazing successes followed by hours or a full day of frustrations. Most common problems we have had? Wiping out a crop for stretches, burring crop, not touching the in row, getting no weed control, plowing, not being able to steer, and undercutting but replanting weeds. This leads to the feeling that we should leave this thing parked, “quick get the old D-12 and get rid of these weeds.” Thus, we would park the better tool in favor of the one we knew. We really needed to take the time learn how to use this tool.

Set up.

Out of the box the Kress set up is straight forward. Where you get into trouble is working with the proper down angle and pressure. Because of the unique steerable cultivation bar, you set the sweeps much closer to the in row then you might with a traditional cultivator. Sweep selection also is a bit different. With the shallow action of this cultivator the mix of knives changes. You can make this as simple or as precise as you want with this unit. You can use a general set up that can be used in almost every crop, or you can use the most appropriate sweep for that crop type and planting system for maximum weed control. For instance, two side sweeps look very alike. One is for direct seeded crops and one is for transplants. The direct seeded sweep pulls soil away from the in row, the one used for transplants pulls soil into the in row. Sweep choice is key in getting the result you want.

Bed prep.

Our bed prep is standard across the farm. With the beds laid out we need to do some stale seed bedding. Rocks are plentiful on Heron Pond Farm. We clear what we can in any given year. The tight action of the Kress cultivator will grab rocks and cause much crop damage. Our weed pressure is so high some inherited but mostly from our own creation. Use of a tine cultivator has been very helpful. Our best beds lay for about two weeks, then are flame weeded. Planting happens right behind the flaming. This buys us at least two weeks before we have to start cultivating. In wet years this has saved our butts. We sometime are kept off the fields for to long to catch up had we not done the flame weeding first.

Travel speed.

With the tool bar set up for the crop we are doing the nest step is to get the correct speed of travel. It seems that the correct speed is always faster then I think it should be. What we are doing is disturbing a small slice of soil hopefully no deeper than two inches. Within that two inches we want maximum soil disturbance. The speed helps create greater action in this soil column. Speed matching to tools use is key.

Tool action.

Many times, sweeps are enough. The high dome of the shallow sweep will roll the soil in the best cultivating conditions. We almost never have the best conditions when we have time to cultivate. It is either to wet, cloudy, dead calm, all conditions that lead to weeds surviving the cultivation process. This is where the tool stacking mention in the previous talk is key. Sweeps combined with small tine rakes are most helpful in less then prime cultivation conditions. The finger Weeders do an excellent job of stirring the soil in row. The drive wheels for the fingers make the soil beside the plants very friable. This sets the soil up for the sweeps and rakes, exposing the weed roots to the air and sun resulting in better kill. The videos of this action will be posted along with the power point. Getting them to play may be changing. Email me for the mp4 if you have trouble.

Maintenance.

We have rock. Lots of rocks. Our tines get beat pretty good. It is possible to have new sweeps put on your mounts. You don't need to buy all sweeps and mounts. The finger weeder arms are subject to side to side forces. This presses the mount arm against the bracket. It is necessary over time to press the mounts back in place. This will remove the play in the finger arms. Rake tines can move over time. Keeping an eye on this will stop them from either wiping out a crop or not getting the weeds turned over. One solution is to weld these in place once you have them where you want. Keeping a 13-millimeter wrench with you is another. Finger weeders should be flipped at least once a year. These will warp over time and start hilling the in row and push weeds into the in row instead of pulling them away. We keep a 19, 22, 24, and 13 millimeters with us at all times for in field adjustments.

Conclusions

The steep learning curve will scare folks away from this weeding system. Spending some time wiping out crops is no fun. Taking the time to learn and invest in this system can pay off in better all around weed control. The adaptability of this tool will allow for reduction in the need for other weeding equipment. Nothing will replace or change the fact that timely cultivation is our best tool in the tool box. We have found that when we do make the effort to get out there when we can, it is nice to have the most effect tool for the job and get the best bang for our buck.

Weed Mats, Living Mulches and Cultivation

David Marchant

River Berry Farm
191 Goose Pond Rd., Fairfax VT, 05454

We began working with living mulches to manage alleyways between plastic mulch and bare ground plantings approximately 7 years ago.

We have developed several systems that work for us on our farm in Fairfax, VT. After trial and error these are the systems that we continue to use.

System 1 –

Planting annual ryegrass between black plastic in winter squash. Plastic is laid then direct seeded with winter squash. After seeding we plant annual ryegrass in the aisles with a walk behind Scotts seeder. Then the planning is covered with row cover. This works especially well Cucurbita maxima group as it prevents any early feeding from striped cucumber beetle. The row cover is removed once plants are to full size. After removal mow the aisles with a weed trimmer. After harvest the plastic is left with the vegetated mulch ways and is removed the following spring. We like to use this where we have fields prone to erosion, as it can be difficult to get a solid cover crop established after harvest.

System 2

Use of Agryl weed mat, purchased from Brookdale Fruit Farm. It is a spun bonded mat similar to row cover with a lifespan of 4 to 5 years. We purchase 3 ft wide mat that is laid between the plastic to provide yearlong weed control with no maintenance during the growing year. Crops that we have used this on with success are peppers and kale. These are crops that are picked for the full season. The mat is laid after transplanting and stapled every 3 ft. with ground staples. It is important to staple at 3 ft especially in windy locations and if you plan to drive a tractor on the weed mat for spraying or harvesting. The advantages of the weed mat is no mowing during the season which is an issue in terms of getting clipping debris on pepper fruits and kale leaves.

Other crops we have used annual ryegrass or weed mat on with various success

Weed mat

Peas – weed mat worked well this year placed right tight to the row of peas after a first in row cultivation.

Long season greens - weeed mat worked well on dandelion greens planted on plastic.

Eggplant – provided season long weed control
Zucchini – too much labor in application and removal of mat for short season crop
Onions – provided excellent control of weeds between plastic

Annual ryegrass –

Kales – provides nice groundcover but mowing is an issue
Zucchini – covers ground quickly and provides a nice clean area for picking baskets
Peppers – mowing is an issue

Costs –

Weed mat - $180 for 820 ft. with a box of staples $.22/ft. Lifespan is 4 to 5 years approx. $.05 per ft per year. Main drawback is labor for laying and removal

Annual rye grass - .60/lb cost per foot between plastic is approx. $.012.
Takes approx. 1 hour labor to seed ½ acre of plasticulture.

While no system is perfect, we have determined that the use of annual ryegrass and weed mat is advantageous for crop quality in many crops and will continue to use these systems in the future.

Strategies for Canopy Management for Optimal Juice Quality

Alex Bienvenue, Jonathan Raber, Connor Sullivan, Sonia Schloeman, Elsa Petit

University of Massachusetts, Amherst
epetit@umass.edu

Facing unpredictable climate changes, maintaining a sustainable agriculture depends on the availability of genetically diverse cultivars. The traditional European grapes (e.g. Pinot Noir) are cultivars of a single species. In contrast, emerging grape cultivars (European-American hybrids) take advantage of the tremendous genetic diversity of the native American grape species (about 30 species). In the traditional European grape varieties, shoot and fruit thinning is known to influence fruit juice quality (ripening time, sugar, acidity) and help reduce pesticide usage. Little is known regarding these effects on emerging European-American grape hybrids. Our multiyear project, started in 2015, quantifies the effect of thinning practices and their cost on these emerging hybrids. Here we ask: Would the resulting increase in wine and grape quality and decrease in disease pressure be worth the added labor cost?

Most of the previous research on the effect of shoot thinning is focused on the grape juice and wine quality and is a little unclear maybe because it is highly depend on variety and year (1). Yet in most varieties (Marechal Foch (2), Corot Noir (3) and Chancellor (4)), shoot thinning consistently increased total soluble solids (Brix). The benefit of shoot thinning on the decreasing incidence of the disease Botrytis has been shown in Seyval Blanc (5) and Vignoles (6).

We started this research in 2015 at Cold Spring Orchard in Belchertown, MA, USA on the red wine grape Frontenac grown on a Double Geneva Curtain training system. We carried out three shoot thinning treatments (4, 6 shoots/foot and control) with each vine being a different treatment. Around harvest time, we sampled one cluster per treatment. We measured pH and Brix. In 2015 and 2016, as shoot thinning increased, pH and Brix increased (Figure 1).

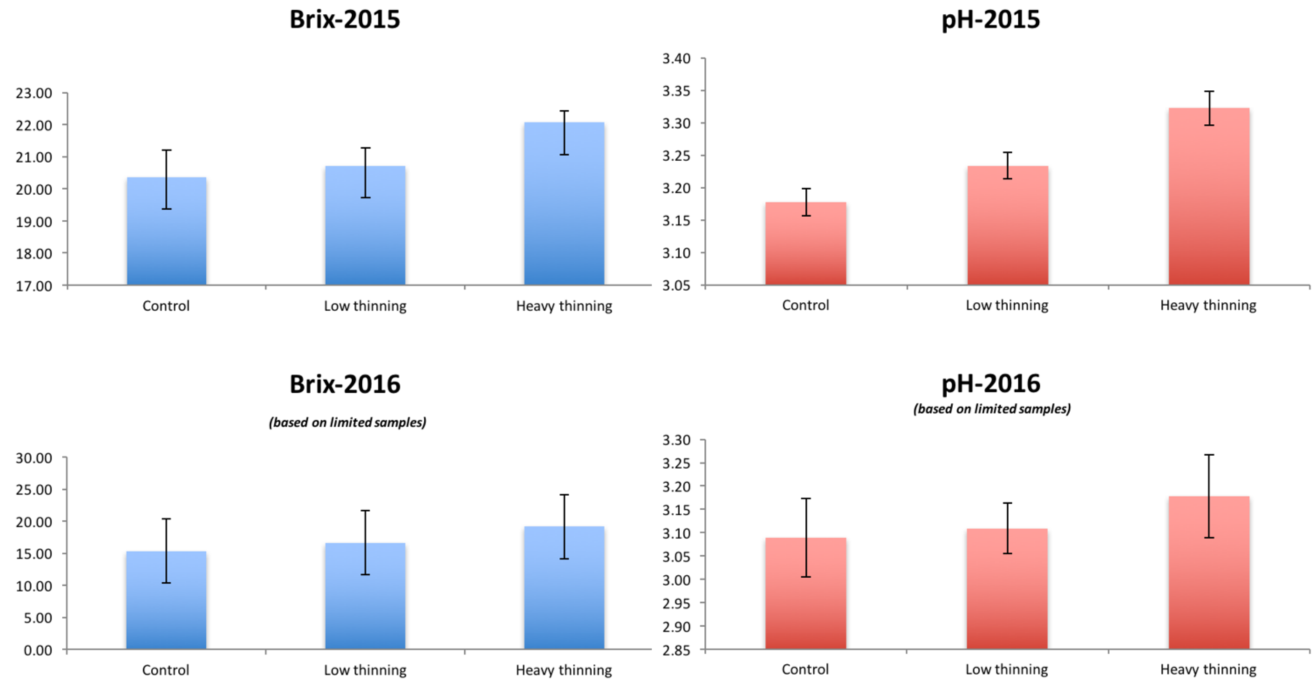


Figure 1: Effect of level of shoot thinning (Control, low thinning (6 shoots/foot) and heavy thinning (4 shoots/ft)) on Brix and pH on the red wine grape cultivar Frontenac in 2015 and 2016.

In the past two years (2016 and 2017), we have included more cultivars (Corot Noir, Chambourcin, Chardonel, La Crescent, Marquette, Noiret, St. Croix, Vidal) and a cluster thinning treatment (1 cluster/shoot versus control). In the long term, we hope to answer the following questions: (1) What is the effect of shoot and/or cluster thinning on grape quality? (2) How does it vary across grape varieties and years? (3) How does it compare between table and wine grapes? (4) How much is gained in terms of disease control and quality and does it outweigh the labor cost of thinning?

References cited:

1. https://psuwineandgrapes.wordpress.com/2017/05/19/early-season-grapevine-canopy-management-part-i-shoot-thinning/

2. Sun Q., et al. 2011. Impact of shoot thinning and harvest date on yield components, fruit composition, and wine quality of Marechal Foch. AJEV. 62:1, 32-41.

3. Sun Q., et al. 2012. Impact of shoot and cluster thinning on yield, fruit composition, and wine quality of Corot noir. AJEV. 63:1, 49-56.

4. Morris, JR. et al. 2004. Flower cluster and shoot thinning for crop control in French-American hybrid grapes. AJEV. 55:4, 423-426.

5. Reynolds, AG et al. 1986. Effect of shoot density and crop control on growth, yield, fruit composition, and wine quality of ‘Seyval blanc’. J. Amer. Soc. Hort. Sci. 111, 55-63.

6. Walter-Peterson, H. 2013. Shoot thinning: Good for the vines, but good for the wines? Finger Lakes Vineyard Notes.

Cold Climate Wine Grapes for New England: Focus on Reds

Andy Farmer

Northeastern Vine Supply, Inc.
1428 River Rd. West Pawlet, VT 05775
andy@nevinesupply.com 802-287-9311 www.nevinesupply.com

New England and northeastern New York offer a great diversity of climate, soil and topography to support commercial wine growing. While 20 years ago, wine growing would have been limited to only the mildest locations in southern and coastal areas, we are now seeing viticulture thrive throughout the region thanks to improved grape varieties and increasing expertise. The expansion of vineyards and local wine production has arrived at a time when consumers are increasingly interested in exploring new wines from new winegrowing regions.

Before the mid 1990's, wine grape options for our area included vitis vinifera (chardonnay, cabernet franc, pinot noir, etc.) and French hybrids (Marechal Foch, Baco Noir, Vidal blanc, Vignole, etc.). There are many growing sites in our region that may support SOME vinifera and hybrids in SOME years, or even most years. However most parts of New England and northeastern NY, even the mildest coastal areas, will experience seasons that could bring substantial crop loss, decreased quality, or even outright vineyard losses from midwinter cold, late spring frost, or cool to cold growing seasons.

Dozens of new wine grape varieties have been introduced since the mid 1990's that are well adapted to the climate of the Northeast and northern Midwest. Several breeding programs are working to improve grape selections for our specific needs. The University of Minnesota, Cornell, and private breeders Elmer Swenson, Tom Plocher, and Mark Hart are at the forefront of this effort. Grape varieties from these programs are now planted around the country and we have seen how most of them perform in the Northeast.

In an effort to identify and mitigate production risks for growers, this presentation will provide information about cold hardy selections of wine grapes. These grapes offer a greater possibility of producing consistent, high quality crops every year that produce wines which are enthusiastically received by the local market.

The discussion will first address some of the strengths and challenges of winegrowing in our area. This will include a look at general and micro climate characteristics throughout the region, geology and soils, access to educational opportunities, access to skilled labor, and markets.

As a cool/cold climate grape growing region, some consumers might think that white wines and sweeter wines would dominate our production. Many producers have shown that we are not this limited in what we can do well here. Indeed there are lots of fresh, aromatic whites and delicious dessert wines being made from northeastern grown grapes, but countless other wine styles are possible too. As one very accomplished local winegrower recently said, "… we have just scratched the surface." Among other pleasant surprises over the last decade, locally grown red wine has become the standout wine from some wineries. These wines are being made from varieties that combine cold hardiness and early ripening with good chemistry and flavors. Most importantly, these wines can be made every year in our climate, not just in the best one or two years out of ten.

I will present an honest look at what several newer red wine varieties have to offer cold climate grape growers. Specifically, we will look at Marquette, Petite Pearl, Frontenac and St. Croix, as well as a few up and coming selections. I'll cover their individual characteristics in the vineyard and describe some of the ways commercial wine is being produced from them. None of these are "silver bullets" to produce excellent wines. Winegrowing takes a great deal of investment, planning, strength, and expertise. With the right tools and the right place, some great things are possible. The spread of viticulture in New England adds another layer to our local food landscape. It also takes advantage of outstanding fruit growing locations, keeps farm land in production, and it opens up skilled agricultural and ancillary jobs that provide livable wages in rural communities.

Integrated Disease Management of Cold Climate Grapes based on Cultivar Susceptibility and Fungicide Sensitivity

Patricia McManus

Professor and Chair, University of Wisconsin-Madison, Department of Plant Pathology
pmcmanus@wisc.edu

The lack of cold tolerance in *Vitis vinifera* grapes has been a limiting factor in wine grape production in the northern U.S. Over the past 20 years several "cold-climate cultivars" that are crosses of cold-hardy native American grape species (e.g., *Vitis riparia, Vitis aestivalis, Vitis cinerea, Vitis labrusca*) with *Vitis vinifera* have been released. These cultivars can tolerate winter temperatures of -16 ˚C to -37 ˚C and have been key in the rapid expansion of the wine grape industry in the Upper Midwest, Great Plains, and Northeast U.S.

Cultivar susceptibility. Plant resistance is the cornerstone of integrated disease management in most cropping systems. While we might expect that hybrid grape cultivars, including the cold-hardy cultivars, have acquired some disease resistance from their American lineage, reports of resistance/susceptibility to three major diseases—black rot, downy mildew, and powdery mildew—are inconsistent. Without know which cultivars are susceptible to which diseases, we are treating them as though they are susceptible to everything, and this might be resulting in over spraying. This problem prompted us to conduct controlled research trials on the relative resistance of several cold-climate cultivars.

We conducted trials at two locations in Wisconsin in 2015 and 2016. Throughout the growing season we evaluated black rot, downy mildew, and powdery mildew on leaves and fruit clusters of vines that had not been sprayed with fungicides. In both years and at both locations there was regular rainfall that promoted disease development. The relative susceptibility of cultivars is reported in Table 1. While there was no "silver bullet" cultivar that was resistant to all three diseases, most cultivars were fairly resistant to at least one disease, which might allow us to tailor spray programs.

Table 1. Relative susceptibility of cold-climate grape cultivars to diseases

	Black Rot	Downy Mildew	Powdery Mildew
Most susceptible	Marquette, Valiant	La Crosse, Valiant	Brianna, Frontenac, Frontenac gris
|	Frontenac, Frontenac gris	La Crescent	Marquette
Moderately susceptible	La Crosse	St. Croix	La Crosse
|	Brianna, St. Croix	Brianna	St. Croix
|	La Crescent	Frontenac, Frontenac gris	La Crescent, Valiant
| Most resistant		Marquette	

In general, cultivars that were most susceptible to black rot on leaves were also most susceptible to black rot on berries. Likewise, patterns of susceptibility to powdery mildew were similar on leaves and fruit. Rachises (fruit stems) were susceptible to powdery mildew on most cultivars. Regarding downy mildew, however, only Valiant developed symptoms on fruit. Berries of other cultivars remained free of downy mildew even when adjacent to sporulating lesions on Valiant leaves and berries.

Our study had a few caveats and limitations. First, we collected data over just two years at two locations. While the trends were generally consistent among trials, results might be different in regions with warmer temperatures that favor black rot and powdery mildew. Another possibility is that development of one disease might have interfered with development of another. For example, severe downy mildew on La Crescent early in the season might have made the leaves less susceptible to powdery mildew, because the powdery mildew pathogen prefers to infect healthy leaves. Growers should take into account these limitations when thinking about using plant resistance to management disease.

Sensitivity to fungicides. While many synthetic fungicides are failing owing to the emergence of fungicide-resistant pathogen populations, copper- and sulfur-based fungicides remain effective despite decades of use in vineyards. In grape production, sulfur is used primary to control powdery mildew, whereas copper is used primarily to control downy mildew. Some copper- and sulfur-based products are allowed for use in organic production, and many formulations are relatively inexpensive. Thus, copper and sulfur continue to have an important place in modern grape production. Unfortunately, some grape cultivars are sensitive to injury from copper and/or sulfur. Likewise, possible injury to hybrid grape cultivars from the fungicide difenoconazole has prompted the manufacturer to post warnings on product labels. Information on the sensitivity of cold-climate wine grape cultivars to copper, sulfur, and difenoconazole is limited because many of the cultivars have only recently been widely planted. Therefore, we conducted trials to test the sensitivity of northern grape cultivars to these fungicides.

We conducted trials at two locations in Wisconsin in 2012, 2013, 2014, and 2015, for a total of 11 trials, although not every trial included every cultivar (see Table 2 for cultivars tested). Copper (either Cuprofix Ultra 40 or Champ WG), sulfur (Microthiol Disperss), and difenoconazole (Inspire Super) were applied three to six times at 2- to 3-week intervals in the various trials. We assessed injury to leaves throughout the season. Results are summarized in Table 2.

Brianna was highly susceptible to copper, often showing injury (leaf bronzing and/or yellowing) after just one or two sprays. Several other cultivars are rated “moderately sensitive” to copper, because injury was not severe and it developed only after five or six sprays of copper. Brianna, Leon Millot, and Marechal Foch were highly susceptible to sulfur, with leaf browning, especially at the margins, after just two or three sprays. La Crescent and St. Croix developing less severe symptoms after five or six sprays of sulfur. The only cultivar that developed injury from difenoconazole was Noiret.

Table 2. Sensitivity of cold-climate grape cultivars to fungicides

Treatment	Highly sensitive	Moderately sensitive	Not sensitive
Copper	Brianna	Frontenac, Frontenac gris, La Crescent, Leon Millot, Marechal Foch, Marquette, St. Croix	La Crosse, MN1220, Noiret, NY76, Petite Pearl, Valiant
Sulfur	Brianna, Leon Millot, Marechal Foch	La Crescent, St. Croix	Frontenac, Frontenac gris, La Crosse, Marquette, MN1220, Noiret, NY76, Petite Pearl, Valiant
Difenoconazole	Noiret	--	Brianna, Frontenac, Frontenac gris, La Crescent, La Crosse, Leon Millot, Marechal Foch, Marquette, NY76, Petite Pearl, St. Croix, Valiant

Putting it all together. Before using copper and/or sulfur in a spray program, you must weigh the risks and benefits. Keep in mind also that copper is strictly a protective fungicide with no post-infection activity. Applied protectively, copper is a good downy mildew fungicide. Sulfur is primarily protective, but it can inhibit powdery mildew after infection but before symptoms are apparent. Neither copper nor sulfur is highly effective on black rot.

Potential advantages of copper and sulfur are that certain formulations are permitted in organic production; copper and sulfur are not prone to pathogens becoming resistant to them; and some forms of copper and especially sulfur are relatively inexpensive. But there are risks that need to be considered as well. In our trials, we applied copper, sulfur, and difenoconazole alone—no tank mixes and no spreaders/stickers. The risk of crop injury generally increases when products are mixed or applied within a few days of each other. Copper fungicides should not be used if you are also using phosphorous acid products or if water pH is less than about 6.5. At lower pH, copper ions are released into solution rapidly, and this can increase the risk of injury to plants. You also need to consider weather conditions, since this can influence crop injury by copper and sulfur. Copper injury to plants is usually worse under cool, slow-drying conditions, whereas sulfur injury is enhanced by high temperatures (above about 85 degrees F). In our trials, conditions were often cool and damp and therefore favorable for copper injury to develop. However, we did not often have temperatures greater than 90 degrees F, and the temperatures within a day of spraying sulfur were never more than 85 degrees F. It’s very likely that more sulfur injury would develop under warmer conditions.

Grape Weed Management Update

Hilary Sandler

UMass Cranberry Station
PO Box 569
East Wareham, MA 02538
hsandler@umass.edu

Managing weeds in perennial fruit systems brings its own set of challenges especially in comparison to issues seen and tactics typically employed in annual systems (e.g., lack of perennial weeds, crop rotation, ease of mechanical cultivation, etc.). In many cases, perennial weeds will predominate in crop systems that are also perennial, such as apples, cranberries and grapes. Decisions and choices made early in the establishment of a perennial crop can have long-lasting impacts (either positive or negative) on the growth, health, and productivity of the crop. With high-value crops, such as grapes, the importance of selecting appropriate weed management practices cannot be understated.

Weeds will compete with young and established vines for air, space, nutrients, and water. Perennial weeds are biologically "built" to be able to withstand harsh or unfavorable environmental conditions (e.g., by producing underground storage structures such as corms, rhizomes or tubers). New plantings typically have fewer perennial weeds than established vineyards but annual and biennial weeds can be present in either or both situations.

Importance of Correct ID and Descriptions of Plant Life Cycles. Correct weed identification is key to maximizing weed management options, whether employing chemical, mechanical, mulches, or biological controls. It is wasteful both economically and environmentally to apply inappropriate control measures to any pest problem. In many cases, it is not necessary to know the exact genus and species; often being able to identify the type of weed you are trying to control can substantially increase your chances of applying the appropriate control option(s). Keep in mind that the following, while very useful, are arbitrary categories that people use to group plants. Nature does not always observe the groups that we create and some plants may have characteristics of more than one group; significant influences that can affect the traits of plant life cycles include environment and climate.

Annual plants complete their life cycle in one year. They typically have little or no woody tissue, usually grow rapidly and produce numerous seeds. The keys to control are to substantially interrupt their germination and/or initial growth, followed by tactics that minimize or eliminate the production and/or dispersal of viable seeds of any individuals that escaped the initial control measure. Weeds can be winter annuals, which flower in the late winter/early spring (e.g., henbit, annual bluegrass, or rabbitfoot clover) or summer annuals, which flower in the summer/early fall (many grasses including large crabgrass, foxtail, and fall panicum as well as broadleaves such as chickweed and lambsquarters). Biennial plants complete their life cycle (germination, flowering, seed production and death) over 2 years (e.g., wild carrot, hairy bittercress, sand spurry, sweetclover). Plants that produce rosettes are usually biennial. Perennial plants are usually mostly woody (but can be herbaceous as well), develop and flower over the course of many years (e.g., goldenrod, Canada thistle, yellow nutsedge). They can produce seeds in any given year as well as make structures that can overwinter (and produce new plants).

Identification Resources. Many excellent resources exist on-line and as books for doings IDs. For some great pictures of common grape weeds, download the pdf of the New England Vegetable Management Guide Pest Identification Supplement (http://nevegetable.org/about-guide/ordering-and-downloads) at the New England Vegetable Management Guide website. The New England Wildflower Society supports a great web site where you can ID plants (using a key), become aware of distinctive traits to discern between similar plants, and learn more about life cycles and common habitat of many plants found in New England (https://gobotany.newenglandwild.org).

Caution for New Vines. Weed control is essential in vineyard establishment. If you opt for chemicals, bear in mind that several herbicides should not be used on newly planted vines as young vines can be very susceptible to herbicide injury. These include the pre-emergence use of Chateau, Karmex, Princep, Matrix, and Goal as well as the postemergence use of Rely. Some herbicides can only be used on nonbearing vines including the grass herbicides Select and Fusilade. The use of grow tubes (see below) can provide a physical barrier against herbicide injury. The use and availability of herbicides can vary from state to state in New England, so if you have any questions, contact your state’s Extension office.

Grow Tubes. The use of grow tubes can be beneficial for promoting upright growth with no training as well as protect the vines from herbicide damage. However, they should not be left on too long; the vines need time to harden off before cold temperatures arrive. Grow tubes can accelerate growth of the vine, protect against small animal predation, and improve survival in windy and/or drought conditions. Use large-diameter, good quality grow tubes. Skimping on quality may save money up front but is usually more costly in the long run. Do not use tubes that are too small; do not use green tubes. The vine gets the same sensory feedback as if it was surrounded by weed competition. In other words, the vine responds as though it is surrounded by other plants (either physically pressing against it as with small diameter tubes, or reflecting green light as with green tubes). Circular white tubes that open from the side seems to provide the best results for most grape growers who choose to use grow tubes. Growers in other perennial systems sometimes also employ a weed barrier “apron” that goes around the grow tube to cut down weed competition even more.

To allow for adequate hardening off, tubes should be removed by ca. mid-September in Year 1. Should grow tubes be used (re-applied) in Year 2? If your extension agent or viticultural expert recommends re-applying grow tubes the following spring, follow their recommendation. The horticultural benefits may still be under discussion, but grow tubes will provide protection from herbicide spray, reducing labors costs associated with weed management. The cost:benefit should be carefully considered before employing tubes after the first year.

Weed Control in New and Established Vineyards. A combination of mechanical, nonchemical, and chemical controls is the best approach for most weed management programs. Using an integrated program has many benefits including helping to forestall herbicide resistance. Even so, each control option comes with its own pros and cons. The weed species present can greatly drive the initial choice of control. Bear in mind that some research has shown the weed communities can change based on control method(s). It is possible that an early control decision/choice can lead to the predominance of a weed that is more difficult to control. Unfortunately, it is not always possible to predict the outbreak of a secondary and/or more problematic pest. But knowing what weeds are present in your vineyard and going through the process to assess the biology and impact of weeds in your vineyard (see weed priorities below) can help you make more informed decisions.

Mechanical options include the use of tools that can be tractor-mounted (e.g., Grape Hoe, Weed Badger). Thermal weeding is also an option that can be utilized during and after vine establishment. A video showing multiple farming implements for mechanical weed control can be found at: https://www.youtube.com/watch?v=2o4ej2AZwBE. Nonchemical options would include the use of mulches, ground covers or fabrics to suppress weeds.

Herbicide options include preemergence (PRE) and postemergence (POST) chemicals.

Herbicides registered for use in the New England Small Fruit Management Guide 2017-2018 are listed below and are grouped by mode of action (group number as determined by the Weed Science Society of America). Herbicides are applied PRE unless otherwise noted.

Group 1: Fusilade, Select, Poast (all POST)
Group 2: Matrix
Group 3: Kerb, Prowl, Surflan
Group 5: Princep
Group 7: Karmex
Group 9: Roundup (POST)
Group 10: Rely (POST)
Group 12: Solicam
Group 14: Chateau, Goal (PRE/POST), Aim (POST), Venue (POST)
Group 15: Devrinol
Group 20: Casoron
Group 21: Gallery
Group 22: Paraquats (POST)
Group 29: Alion
Fatty Acid Group: Scythe (POST)

Weed Priorities. Weeds present a unique problem for decision making for many farms. Unlike insects, which typically have action thresholds based on numbers that are scouted and counted in the field, weeds are typically not viewed as discrete individuals and have few, in any, science-based action thresholds. In cranberries, we have developed a way to prioritize weeds, so when time and/or resources are limiting, this prioritization aids in decision-making. This priority concept could certainly work in grapes, if and where it could be useful. It is a framework that lends itself to be modified according to specific commodity and growers’ needs.

For each weed, a weighted score of 8, 4, 2, or 1 is given to each criterion (4 criteria are used for cranberry). The score is based on the grower's experience of the weed on their farm as well as the accepted scientific knowledge of the weed's biology. The points are then totaled to determine the priority ranking: 4 to 7 points is considered low priority, 8 to 15 points, 16 to 23 points, and 24 to 32 points are considered medium, high, and very high priority, respectively. The four criteria are: 1) Impact of the weed on the crop itself; 2) Biological form or type of the weed; 3) Invasive/reproductive capacity of the weed; and 4) Adaptation to the crop habitat. Again, these criteria could be modified to better fit the grape production system, but they have provided a reasonable assessment framework for cranberry growers.

Chili Pepper Production for our Sriracha Products

Tim Wilcox

Kitchen Garden Farm, 131 S. Silver Lane, Sunderland, MA 01375
info@kitchengardenfarm.com

We started our vegetable farm in 2006 and have been making Sriracha since 2013. We now have 50 acres in production (2 acres in peppers). We are certified organic and sell our fresh produce and line of sriracha and salsa products wholesale to stores, restaurants and distributors throughout the Pioneer Valley, Boston, NYC, Berkshires, and Rhode Island.

Peppers are just one of dozens of crops we grow – but we specialize in 45+ varieties of exotic chili peppers and host an annual hot pepper festival, Chilifest, the second week of September. When we first started making sriracha we had a limited market for selling fresh hot peppers but wanted to grow more so we developed a value-added product to turn peppers into hot sauce.

As our farm has become recognized for our sriracha we have connected with new buyers and found increasing demand for fresh peppers. In 2017 fresh pepper sales made up 10% of total revenue from vegetables (just 2 out of 50 acres). Sriracha peppers accounted for a mere 2/3 of an acre section of that same 2 acre pepper block and sriracha sales made up 22% of the farm's total annual revenue (as of Nov. 15, 2017).

Seeding

Start *chinense* varieties mid-March. Start *annum* varieties end of march. Seed a second succession 3 weeks later for continuous harvest August-October. In 2017 we installed a BioTherm radiant bench heat system on our propagation house tables which has improved germination rates now that benches are heated to 80 degrees, while allowing us to heat the air temp in the greenhouse to 50 instead of 70 degrees.

Planting

Planting begins third week of May. We plant 2 rows to the bed, 18" between plants with a water wheel transplanter. Apply foliar fertilizer (mix of fish and kelp) twice during bloom.

Disease

Hot peppers have relatively few enemies besides moisture-related diseases. Hot peppers are more resilient than sweet types. Our main disease concern for pepper production is Phytopthora capcasci, which we combat through subsoiling to improve drainage and prevent standing water and crop rotation.

Harvest

Green harvest begins mid-July (varieties we grow and harvest green include Shishito, Padron, Jalapeno, Serrano, Anaheim, Poblano, Hungarian Wax). Red harvest begins early August. Red pepper varieties we grow for sriracha production include Cherry Bomb, Fresno, Paprika, Cayenne, Calabrian, Red Jalapeno. We also include sweet orange and yellow bull's horn peppers Oranos and Escamillo in our Habanero Sriracha. *Chinense* harvest begins early September. *Chinense* varieties we grow for sriracha production include Habanero, Fatali, and Superhots like Ghost (Bhut Jolokia), Trinidad Scorpion, and Carolina Reaper.

Yield

We harvest all peppers by hand. Over the course of the harvest period, commercially grown pepper plants will yield around 3-5 lbs. per plant or 20,000-40,000 lbs. per acre. Yield varies by type and cultivar. From 2/3 acre of sriracha peppers we processed 20,000 lbs. into sriracha, plus we also sold thousands more pounds of fresh peppers from that same field.

Seed Companies:

Johnny's Selected Seeds

Seedway

High Mowing Organic Seeds

Baker Creek Heirloom Seeds

Seed Savers Exchange

Adaptive Seeds

Refining Fire Chilies (super hot peppers)

Totally Tomatoes

Tomato Growers Supply

Pepper Growing Equipment & Supplies:

Rain Flo Irrigation: Bed maker, water wheel transplanter, drip tape, plastic mulch

Nolt's Produce Supplies: seedling trays, greenhouse supplies, various packaging, bulk bins

PCA: waxed boxes

Inter Crate: reusable stack & nest harvest/shipping crates

Peaceful Valley Grower Supply: Soluble Organic Fertilizers

I & J Cultivator: Row-crop cultivation equipment

Boosting Production of Asian Eggplant Varieties

Dr. Viliam Zvalo

Vineland Research and Innovation Centre, Vineland, Ontario, Canada

Changing demographics and evolving culinary preferences of Canadians have created growing demand for new vegetables such as Oriental long eggplant. In order for Canadian vegetable growers to capture the full value of these emerging markets, domestic production of these vegetables must increase.

Methodology

In the 2015 and 2016 growing season, four varieties of eggplant were trialed (three Asian long and one Indian round) for yield and quality on the research farm at the Vineland Research and Innovation Centre.

Soil-borne diseases such as *Fusarium* and *Verticilium* can significantly reduce yields in okra and eggplant. Fumigation is currently the only mean of controlling these diseases. Since soil fumigants may not be available in the future due to environmental concerns, grafting onto disease-resistant rootstock was investigated as a tool to mitigate losses to soil-borne pathogens in field production. In addition to soil pathogen tolerance, rootstocks in general can enhance crop performance by increasing plant vigor and tolerance to environmental stress, leading to higher yield and quality. Building on research from the 2015 season, in 2016 eggplant (Asian Long) was grafted on to four tomato roots stocks: DR0138TX, DR0141TX, Kaiser and Maxifort. These rootstocks are tolerant to some soil-borne pathogens, and were tested alongside non-grafted plants in non-fumigated plots to assess field compatibility, effectiveness against *Verticilium* and *Fusarium* wilts, and effects on yield potential.

In another part of the research trial, soil was fumigated to control soil-borne pathogens and crop performance was evaluated. Busan 1236 at 570 L/ha was applied in the fall of 2016.

Asian eggplant is highly susceptible to damage caused by wind. To prevent wind damage and scratching of fruits, which may become unmarketable, it is essential to trellis plants to minimize plant movement and achieve high quality marketable fruit. Two different staking systems were evaluated: “Florida Weaving” and “Trellising” around the perimeter of the raised bed. Trellising is especially important on grafted plants, when plant vigour is strong and chances for plant breakage and/or uprooting are very high.

Nitrogen is one of the key elements that plays a major role in determining yield and health of the plants. Six rates of nitrogen (treatments) - 25, 50, 75, 100, 125 and 150 kg N/ha plus a no fertilizer control - were evaluated for effects on yield. Except for the 25 kg rate, 50 kg N was applied prior to planting and the remainder was applied through the drip irrigation system. Phosphorus and potassium were applied based on soil test results and fertility recommendations for okra and eggplant.

Clear, perforated plastic low tunnels (TUAEPCL 7230105) and floating row covers (AGRY2; Dubois Agrinovation) were tested in early planting trials of eggplant to assess effects on yield performance and potential for early harvest. The trial was established 7 days earlier than normal planting without cover using three types of plants: Long Purple grafted on DR0138TX and Kaiser root stocks, and non-grafted plants.

Results and Discussion

Chu-Chu F1, round Indian eggplant produced the highest marketable yield (72.7 t/ha) among the four varieties studied. This was followed by Orient Express at 60.3 t/ha, Long purple (42.5 t/ha) and Asia beauty (30.4 t/ha).

While grafting is an effective tool for controlling soil-borne diseases, in 2015 grafting on Maxifort rootstock delayed flowering, fruit set and maturity. In 2016 plants were grafted on 4 different rootstocks; plant performance of grafted plants was superior to the non-grafted plants. Similar to the previous trial Chu-Chu grafted on various root stocks produced the highest yield (67.5 t/ha with DR0138TX to 77.2 t/ha with DR0141TX). This was followed by Orient Express (46.5 t/ha with Kaiser to 54.8 t/ha with DR0141TX) and closely followed by Asia Beauty (42.7 t/ha on DR0141TX to 51.1 t/ha with Maxifort). Long Purple is the lowest yielding variety among the four studied (37.3 t/ha with DR0141Tx to 47.8 t/ha with Maxifort).

Non-grafted Asia Beauty and Long Purple plants were used to compare with the grafted plants. Yield in the non-grafted plants in non-fumigated plots is approx. 35 % lower (Asia Beauty 31.3 t/ha and Long Purple 27.7 t/ha). When the soil was not fumigated, yield of both Orient Express and Long Purple suffered significantly. Total yield from Orient Express reduced by almost half whereas in the case of Long Purple, the reduction was little over 50 %. This is not surprising given the fact that non-grafted Orient Express plants suffered more damage from *Fusarium* and *Verticilium* wilt in the non-fumigated plots. Planting Long Purple grafted on Maxifort in fumigated plots produced 40 % more yield than non-grafted plants. Results from 2016 showed that grafting eggplant on to disease tolerant rootstock can significantly enhance plant performance and yield.

Overall, either fumigating the field or grafting the plants is essential for high yield if soil-borne pathogens are present above a defined threshold level. Choosing either of these methods will depend on the disease presence in the soil, grafting plant availability, consideration for the environment, access to soil fumigants and the cost involved.

Staking of eggplant reduced plant damage and prevented bruising of the fruit, improving overall yield and enhancing the proportion of marketable fruit. On average, staking increased marketable yield from 28.9 t/ha (without staking) to 35.6 t/ha (with staking). Similar to the results from 2015, there was no statistical difference between the two systems of staking (“Florida weaving” vs “Post and twine”) tested.

Nitrogen: A response curve was established from data collected in the 2016 growing season. The highest marketable yield of non-grafted Chinese long eggplant was 45.2 t/ha and was achieved at 125 kg N/ha. Plants that received 75 kg N/ha produced 37.7 t/ha. No additional benefits were derived when higher nitrogen levels were used; grafted Chinese long eggplant achieved a maximum yield of 47.1 t/ha at 150 kg N/ha and the yield was 42.2 t/ha when the plants were fertilized with 75 kg N/ha. The higher nitrogen demand and increased yield response can be attributed to healthier and more vigorous plants. There were no significant differences between different N regimes for both grafted and non-grafted plants. This results contradict data obtained in the 2015 season, where 90-100 kg N/ha produced the highest yield. More work is needed to optimize N-levels to obtain the best yield and quality of eggplant in the most cost-efficient manner.

Use of clear, perforated plastic low tunnels and floating row covers in grafted plants slightly reduced eggplant yield; however, the reduction was not statistically significant. Use of row covers in non-grafted plants, however, increased yield by 20 %, although differences in yield from control plants and those covered with perforated plastic or row covers were not statistically significant. When conditions are favourable for early planting, there is no need to use low tunnels. However, in cooler climates, use of row covers can provide benefits by creating a more favourable micro-climate that promotes early plant growth leading to increased (and earlier) yield.

Lessons Learned:

1. Orient Express performed the best out of all Asian Long eggplant varieties tested in the field with a yield of 60.3 t/ha.
2. Chu-Chu round eggplant was, overall, the best performing variety in the field out of the four varieties studied, yielding as much as 72.7 t/ha
3. Grafting improved the overall yield in all varieties in both fumigated and non-fumigated plots. DR0141TX and Maxifort root stocks were superior in terms of yield/growth response compared to DR0138TX and Kaiser.
4. Soil borne diseases such *Verticillium* spp. and *Fusarium* spp. have a significant effect on yield and infected soil has to be fumigated; if fumigation is not an option, though, grafting of eggplant on to disease-resistant root stocks is a viable option.
5. Trellising and staking eggplants, particularly grafted plants, prevented damage caused by wind, improving overall quality and yield.
6. Non-grafted plants had a nitrogen requirement of 125 kg N/ha whereas the grafted plants had a slightly higher N requirement (150kg N/ha)

Acknowledgments:

I would like to express my sincere gratitude and appreciation to my research technicians, namely Derek Pearson, Gillian Limebeer and Ramesh Eerpina for their hard work and dedication on this project.

I would like to acknowledge Agriculture and AgriFood Canada for funding this project through Growing Forward 2, A Federal- provincial- territorial initiative.

Cultural Management Techniques for Avoiding Light and Heat Induced Fruit Damage

Fumiomi Takeda[1] & Gina E. Fernandez[2]

[1]Appalachian Fruit Research Station, USDA-ARS, Kearneysville, WV
Fumi.Takeda@ars.usda.gov
[2]Department of Horticultural Sciences, North Carolina State University, Raleigh, NC
GEFernan@ncsu.edu

Raspberry and blackberry production is increasing worldwide into nontraditional climates. In the case of raspberry, their production has expanded from cool Mediterranean-type climates into locations regions with warmer dryer temperatures. Until the 2000's, the commercial fresh market blackberry was nonexistent, but now blackberries are produced in hot and dry regions of Mexico as well as in the Ohio River Valley region where several winter temperatures are common.. With the increasing production footprint of both cultivated raspberry and blackberry, plants are being exposed to a wider range of climate extremes, including heat stress. It is well known that high temperatures during the vegetative and reproductive periods and extreme cold conditions in the winter can impact raspberry and blackberry production. Understanding the effects of heat on plant growth and development will be key to the continued success and further expansion of these crops to new regions.

In plants, heat stress occurs when temperatures exceed an optimal value for a period of time and the result is irreversible damage to plant growth and development can be short-term (transitory) and cause leaves to wilt during part of the day or damage floral development, often resulting in the failure of the crop to produce fruit. Heat stress can also occur at night and can result in significant yield losses. In other situations, season long periods of heat stress can inhibit photosynthesis, and as a result plants will have very limited growth and eventually die. In cultivated raspberry production heat stress in one of the most often cited factors that limit productivity.. High heat and solar radiation have been attributed to fruit quality losses in blackberries.

The optimal rate of photosynthetic capacity of 'Titan' red raspberry appears to be between 59 and 68 F, and as temperatures increase from 68 to 104 F the rate rapidly decline. In case of 'Heritage' red raspberry, the photosynthetic capacity declines when temperatures were above 68F. In contrast, blackberries tend to have higher photosynthetic capacity even at temperatures exceeding 104 F.

High temperatures during summer months is attributable to increased levels of solar radiation, which is the major contributor to berry head load. Higher levels solar radiation account for as much as 0.15 MJ/m^2 of cumulative daily UV-A + UV-B radiation. High temperatures have been shown to impact fruit set. In *Rubus*, air temperatures impact floral initiation and development in peak summer months on primocane-fruiting raspberry cultivars and primocane-fruiting blackberry. Although breeders were excited to develop primocane-fruiting blackberries in the 2000's, initial attempts to produce fruit in the southern U.S. in primocane fruiting types was limited. This was due to the inability of the plants to set flowers in the summer, although in

Oregon’s milder summer temperatures they would thrive and produce much more fruit on the primocanes in the late summer fall.

Researchers found that under high heat treatments of 95 F/75 F day/night temperatures resulted in injury to both stamens and pistils of blackberry. However, they suggested that the damage to the stamens was of major concern as the pollen from anthers is needed to stimulate the development of and the fertilization of ovaries. Conversely, low temperatures of 27 F have been implicated in the injury of the female part of the plant, the gynoecium (pistils) in blackberries during spring freezes.

In red raspberries, heat stress, or exposure to temperatures > 107 F cause sun scald, or more specifically photo-bleaching of maturing fruit that have developed red pigmentation turning white). Both high temperatures and ultraviolet (UV) light have been attributed to occurrence of white drupelet disorder in both raspberries and blackberries. Even under temperate-zone growing conditions, the fruit of some cultivars become susceptible to solar injury when fruit is exposed to intense sunlight and high temperatures. In particular, the white drupelet disorder in ‘Apache’ blackberry can cause as much as a 30% reduction in fresh-market quality pack-out. Shading red raspberry and blackberry plants for just a few days prior to fruit ripening was as effective as season-long shading for reducing white drupelet formation. Early studies with plastics and filters which absorb nearly all UV radiation was as effective as aluminum foil cover at preventing injury.

In blackberry, red drupelet disorder, also called reversion, reddening or red cell disorder, occurs after fruit is harvested and previously black drupelets turn red. It is still unclear as to what exactly is the cause of this disorder. However, physical damage during harvest to the drupelets has been implicated, as have rapid changes in temperature from the extreme hot field conditions to the sudden cold temperature of the refrigeration and nitrogen levels.

Researchers have found that the Rotatable Cross Arm (RCA) trellis system provides some relief from heat stress. The unique canopy configuration of the RCA trellis and cane training system has provided benefits on fruit quality. The RCA trellis technology allows fruit to be positioned on one side of the row. If the rows are oriented east-west, fruit can be positioned on the north side of the row and not exposed to direct sunlight in the morning or afternoon. If the rows are oriented north-south, the fruit would be exposed either to morning or afternoon sun depending on which side the fruit is positioned. A study showed that with ‘Apache’ blackberry the incidence of white drupe formation was similar whether fruit was on east or west side of the row. However, direct exposure to sunlight either in the morning or afternoon significantly increased the number and severity of white drupe formation compared to the fruit in the shade. The skin temperature was as much as 14 F higher in berries exposed to sun than those in the shade. In the Central Valley of California the RCA trellis and cane training system increased harvest efficiency 30% and, more significantly, fruit cull (berries with white drupes) was eliminated when the fruit was positioned on the north side of rows that were oriented east-west.

Similar reduction in white drupelet disorder can be achieved by decreasing solar light transmission with a placement of a shade fabric over the plants. A large grower in the Central Valley of California has been able to grow ‘Ouachita’, ‘Natchez’, and ‘Prime-Ark 45’ blackberries without any signs of white drupe formation by growing them under high tunnels clad with a 50% shade cloth. A study initiated at North Carolina State University’s Piedmont Agricultural Research Station to evaluate the fruit quality of ‘Natchez’, ‘Ouachita’, and ‘Von’ blackberries trained on the RCA trellis in rows oriented north-south and east-west with fruit positioned on east, north, west, or south side of plant canopy also confirmed production system that by changing row direction and positioning the fruit away from sunlight can be useful in reducing fruit quality loss and white drupe disorder in blackberry attributable to high light intensity.

Summary:

According to the National Oceanic and Atmospheric Administration the year 2016, marked the third straight year in a row that there were record warm temperatures on the globe. Heat tolerance will be an increasingly important factor for all plant species, including raspberries and blackberries. With increasing focus on local fruit production, raspberry and blackberry production can increase in areas located at high elevations (>3,000 feet) where high solar radiance, temperatures, and ultraviolet radiation during the growing season. With increasing episodes of extreme heat during the summer and longer duration of growing seasons, raspberry and blackberry will both be impacted. However, we suggest that the emerging technologies both in the lab will be used to develop more heat tolerant raspberries and blackberries. In the field, superior production practices will become available to mitigate adverse environmental factors such as high heat and solar radiation levels.

Choosing the Best Raspberry Cultivars for High Tunnels

Eric Hanson

Department of Horticulture, Michigan State University
hansone@msu.edu (517) 353-0386

High tunnels allow raspberry growing in a warmer, drier and less windy environment. Harvest can begin earlier and continue later than in the open field. Yields and fruit quality are increased and most fungal diseases are suppressed. However, tunnels can increase some diseases (powdery milder) and pests (spider mites, white flies). Since tunnels substantially increase production costs, benefits need to be maximized. This means variety choices are very important.

We have observed different raspberry varieties in Haygrove interconnected tunnels for over 10 years. The tunnels are left uncovered each winter. Some varieties have been grown in-ground and others in 3-gallon pots with bark/peat media. Most varieties have been grown for primocane fruit, but some have been pruned for primocane plus floricane fruiting, and some floricane fruiting types have been included for comparisons. Although our observations below were made in high tunnels, varietal differences seem to be similar to those in open fields, so growers considering field production can use this information as a general guide as well.

SUGGESTED TYPES FOR TUNNELS (earliest to latest primocane fruit)

JOAN J is a very early variety with darker red fruit and thornless canes. Fruit are medium to large and firm with an excellent flavor. The only drawbacks we have seen is lower vigor cane growth the dark color that does not appeal to some customers.

POLKA has been perhaps the best early season variety for us. It is just a day or two later than Joan J. Primocane fruit are medium to large, firm, medium red and glossy, and have an excellent flavor. Yields are moderate to high. Plants are very susceptible to leafhopper damage but may have resistance to tomato ringspot virus or the dagger nematode vector.

HIMBO TOP is extremely productive with tall, open canes. Primocane fruit mature in the early mid-season and are large, somewhat soft, with a bright light red color and only average flavor. Shelf-life is somewhat limited by lack of firmness.

CAROLINE matures in the early mid-season and has been a useful open field variety in many short season areas. Strengths are very high yields, excellent flavor, and some gray mold tolerance. Fruit have only medium firmness though, and plants have a tendency to produce too many canes, which is a drawback in pot culture.

JOSEPHINE has been a good mid- to late season variety in open fields. It is very productive with tall canes and very large, firm, tasty berries. A drawback is that the very dark red color is not appealing to some consumers.

NOVA is a floricane fruiting variety that can yields a small, late primocane crop. Floricane yields are very high. Fruit are large, firm, and glossy red in color, but only have average flavor. Primocane fruit are similar to floricane fruit.

ENCORE is a late floricane fruiting variety. Yields are very high and fruit size, firmness and flavor are very good.

NEWER PRIMOCANE TYPES

ADDISON (MD, 2016). We planted this variety in pots in 2017. On first observation of primocane fruit are impressive; large, very firm with a very good flavor. Fruit are conical in shape and very dark red with a slight gloss. Canes are sturdy and upright with prominent thorns.

BP-1 (Italy, 2012) is a very early maturing type that has not performed well for us. Berries have a nice flavor but are somewhat dark and soft, with a tendency to crumble. Canes were short and branched so the potential for floricane production seems low.

CRIMSON NIGHT (NY 2012) was developed as a specialty berry due to its very dark red color. Berries have a very good flavor. Yields in pots have been moderate. Harvest time appears similar to Heritage or later. Berries have an attractive uniform color and shape, and glossy surface.

DOUBLE GOLD (NY 2012) has unusual golden champagne color berries and is suggested for farm marketers and homeowners looking for a unique color. Potted plants produced moderate yields. Berries were medium in size, with an attractive, uniform shape and pleasant flavor, but somewhat soft. Primocane harvest is late.

IMARA (The Netherlands) has very high quality fruit that appear to ripen in the mid-season. Berries are very firm with a uniform medium red color, glossy surface and excellent flavor. Primocane and floricane yields were very high and berries from both seasons had excellent shelf life.

KOKANEE (OR, 2017). We just potted this variety in 2017. On first observation, primocane fruit appear to ripen in mid-season, and are large, flavorful, medium firmness, and a lighter red, somewhat glossy surface.

KWELI (The Netherlands) is a mid-season type that has stood out in pot culture. Berries were very firm with a uniform medium red color, excellent flavor, and very good shelf life. Kweli produced high yields of both floricane and primocane fruit, and has promise for double cropping.

KWANZA (The Nethlands) is a late season type that has been very vigorous and productive in pots. Berries were very large, round, and lighter red with a glossy surface. Drupelets are large giving berries a coarse appearance. Flavor and firmness are exceptional and berries had an excellent shelf-life. Since the primocane crop is late, Kwanza may have limited value in short season areas except under tunnels or perhaps for floricane cropping (hardiness is not known).

NANTAHALA (NC 2010). Nantahala is late season type with large, light to medium red berries with a dull finish and excellent flavor. In pot culture, yields were modest and berries were relatively susceptible to gray mold and powdery mildew, and some double fruit occurred. Primocane fruit mature too late for good yields in short season areas.

VINTAGE (OR 2013). This new type appears to mature in the late mid-season. Yields from potted plants have only been low to average. Berries are a very attractive bright, medium red color, with excellent flavor and uniform shape. Firmness was only average and berries appeared somewhat susceptible to gray mold.

High Tunnel Raspberry Production

Adam Hausmann

Adam’s Berry Farm
985 Bingham Brook Rd
Charlotte, Vermont
adam@adamsberryfarm.com

Adam’s Berry Farm is a certified organic berry farm located in Northern Vermont growing strawberries, blueberries and raspberries. Our sales focus on regional restaurants and markets through our wholesale accounts, we attend local farmers markets and operate an on farm pick your own and farm-stand. Five years ago we made the decision to shift the majority of our summer and fall raspberry crop under cover for season extension and crop stability purposes (pest and disease management, increased yields, fruit quality). In this talk we will discuss the reasoning for growing in high tunnels, pro and cons of this transition and tips and techniques for successful fruit production.

The talk will cover:

-Why high tunnel raspberries vs. other small fruits?
-Our systems
- Varieties
- Trellising
-Pruning methods
-Pest and Disease management
-SWD control
-Nutrient and water management
-Pollination
- Harvest and yields
-Labor requirements
-Additional resources

If you have further questions please feel free to email Adam Hausmann at adam@adamsberryfarm.com

A Behaviorally-Based Attract and Kill System for Spotted Wing Drosophila

Tracy C. Leskey, Sharon K. Jones, Brent D. Short, & Kevin B. Rice

USDA-ARS, Appalachian Fruit Research Station, 2217 Wiltshire Road, Kearneysville, WV 25430-2771 USA

Spotted wing drosophila (SWD) is an invasive fruit fly that attacks soft-skinned fruits. Originally from Asia, SWD has successfully invaded the United States as well as European and South American countries. Currently, calendar-based insecticide applications are used to combat SWD. Based on SWD attraction to visual stimuli, we evaluated a behaviorally based attract-and-kill management technique originally developed for apple maggot fly, red attracticidal spheres. In laboratory bioassays aimed at identifying effective toxicants for spheres, dinotefuran, spinetoram, spinosad, permethrin, lambda-cyhalothrin (CS) and lambda-cyhalothrin (WG) all performed well. In field trials, statistically equivalent infestations rates were recorded in raspberry plots protected by attracticidal spheres containing 1.0% a.i. spinetoram compared with standard weekly insecticide applications. In field trials using 1.0% a.i. dinotefuran, attracticidal spheres decreased SWD infestations compared with control plots but insecticide applications were more effective at reducing infestations, though differences in harvesting practices used for the two studies likely affected fly population densities and infestations. Future work includes identifying optimal deployment locations for attracticidal spheres in small fruit plantings and the replacement of insecticides with non-nutritive sugars as toxicants.

Alternative Method of Primocane Management for Primocane-fruiting Blackberry and Raspberry

Fumiomi Takeda & Ann Rose

Appalachian Fruit Research Station, USDA-ARS, Kearneysville, WV 25430
Fumu.Takeda@ars.usda.gov

In most northern areas blackberries cannot be commercially grown unless the canes are protected from severe winter conditions (Takeda et al., 2008). This limitation can be overcome by: 1) protecting floricane-fruiting varieties from winter conditions in heated tunnels; 2) growing plants on the Rotating Cross-Arm (RCA) trellis and covering them with heavy rowcover in winter (Takeda et al., 2008), or 3) growing new primocane-fruiting (PF) blackberries. To date, pruning and tipping practices have been used to increase yield in PF blackberries (Drake and Clark, 2003; Strik et al., 2008; Thompson et al., 2009). Typically, unpruned or untipped primocanes produce a single inflorescence (flower cluster). Growers have used a combination of pruning back the primocanes and then tipping the lateral shoots prior to bloom to increase branching and plant yield (Thompson et al., 2009). We thought that primocane-fruiting (PF) blackberries can be manipulated by other means to enhance their cropping potential, thus eliminating the need for hard pruning and soft tipping. Lateral shoot numbers can be increased by bending the primocane as previously shown with floricane-fruiting blackberries (Takeda and Peterson, 1999).

The objectives of this study were: 1) Study the effects of bending primocanes, forcing them to grow horizontally on a static post with two cross arms, and soft-tipping primocanes when they have grown horizontally for 1 to 1.5 m; 2) Study the effects of removing leaves from horizontally-oriented primocanes on side shoot emergence; and 3) Compare yield and harvest time of blackberries grown using different primocane management methods.

A patent method was used to train the primocanes of 'Prime-Ark 45' and 'Prime-Ark Traveler' blackberry (Fig. 1).

Fig. 1. Illustrations showing the process of primocane manipulation and the potential change in the development of fruiting shoots on bent primocanes (U.S. Patent No. 9,357,716 B1).

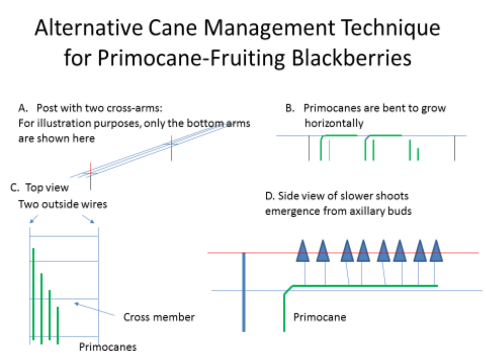


Fig. 2. This photograph shows bent primocanes with most of their leaves removed. Many of the buds at the leaf axil broke within several weeks.

In addition, to bending the primocanes, the leaves were taken off from the bent primocanes (Fig. 2). Our findings indicated that leaf removal stimulated more of the buds to push. The shoots that developed on bent primocanes were reproductive and produced a cluster of flowers in one month after bending and defoliation. An increase in flower shoot numbers on bent and defoliated primocanes was also observed in primocane-fruiting red raspberry (Fig. 3).

The study conducted in 2016 indicated that ‘Prime-Ark Traveler’ responded more favorably to the alternative primocane management by developing more fruiting shoots on bent primocanes. We also observed that the initial flush of spring-emerging primocanes responded quite differently to cane bending then the primocanes from the second flush. The primocanes from the first flush usually terminated in a large inflorescence upon reaching a height of no more than 1.5-m-tall whereas the primocanes from the second flush grew 2-m tall or more before an inflorescence developed terminally. When the primocanes from the second flush growth were bent and defoliated once they had grown to 2 m or more, many flower shoots developed (Fig. 2). In the case of primocane-fruiting red raspberry, cane bending and defoliation stimulated flower shoots along the entire length of 2.5-m-long bent primocanes. As many as 25 flower shoots were observed.

Fig. 3. Effect of primocane training on growth and flower location. a: Note the untipped primocane can grow as much as 10 feet tall and produce flowers only at the tip. b: Tipped primocanes with several lateral shoots. c: Bent primocanes with many flower shoots. d: Bent primocanes of primocane-fruiting raspberry showing the development of flower shoots from near the soil-line to the distal end of 8-ft long bent primocanes.

a b c

d

The findings from this research represents an important step towards the development of horticultural practices for primocane-fruiting blackberries. These horticultural tools will enable growers to advance or delay harvest time and potentially help in increasing yields. Our research has also provided new information to assist research activities geared towards canopy management strategies for berry crops that improve production efficiency, quality, and tolerance of abiotic stresses. Products that will be derived from this project include lower risk of crop loss through a better understanding of the biology underlying plant response to cane manipulation. Findings could lead to increasing blackberry production in non-traditional production areas.

Summary: In 2016 and 2017, we conducted a study on 'Prime-Ark 45' and 'Prime-Ark Traveler' to determine the effects of primocane bending and defoliation on subsequent flowering and fruit development. Our findings indicated that leaf removal stimulated more of the buds to push. The shoots that developed on bent primocanes were reproductive and produced a cluster of flowers in one month after bending and defoliation. An increase in flower shoot numbers on bent and defoliated primocanes was also observed in primocane-fruiting red raspberry. Of the two cultivars evaluated in this study, 'Prime-Ark Traveler' responded more favorably to the alternative primocane management by developing more fruiting shoots on bent primocanes. We also observed that the initial flush of spring-emerging primocanes responded quite differently to cane bending then the primocanes from the second flush.

Literature cited:

Drake, C.A. and J.R. Clark. 2003. Effects of pruning and cropping on field-grown primocane-fruiting blackberries. HortScience 38:260-262.

Strik, B., et. al. 2008. Management of primo-cane-fruiting blackberry to maximize yield and extend the fruiting season. Acta Horticulturae 777:423-428.

Takeda, F., et. al. 2008. Row covers improve winter survival and production of western trailing 'Siskiyou' blackberry in the Eastern United States. HortTechnology 18:575-582.

Takeda, F. 2016. Method and apparatus for primocane management. US Patent No. 9,357,716 (issued June 7, 2016)

Thompson, E., et. al. 2009. High tunnel versus open field: Management of primocane-fruiting blackberry using pruning and tipping to increase yield and extend the fruiting season. HortScience 44:1581-1587.

Here Today and Gone Tomorrow: Understanding the Dynamic Nature of Nitrogen.

Heather Darby

University of Vermont Extension

278 S. Main Street, St. Albans, VT 05478, 802-524-6501, heather.darby@uvm.edu

Nitrogen is a nutrient that is most often limiting in agricultural soils. It is a dynamic nutrient that changes from one form to another depending on a wide variety of environmental and biological factors. It is truly one of the most difficult nutrients to manage in our agricultural systems. Having a good understanding of how nitrogen functions on your farm can help you manage this nutrient to improve crop yields and minimize losses into the environment.

There are several types of nitrogen in the soil:

Organic Nitrogen. Organic matter contains carbon. Aside from mineral forms such as calcium carbonate (lime), anything with carbon is either living or was once living. For instance, a field of grass plowed into the soil is considered organic fertilizer because it was once a living organism. Any nitrogen bound to the carbon in the dead grass would be considered, by association, organic nitrogen. This kind of nitrogen is not readily available to the plants. It takes microbes to break down the organic matter into inorganic-N forms that plants can use.

Inorganic Nitrogen. Inorganic or mineral nitrogen is present in the soil in many forms:

- *Nitrate-N (NO_3^-).* Plants prefer this type of nitrogen, and almost all N taken up by plants is in this form.
- *Ammonium-N (NH_4^+).* This is the first form of N produced when soil microorganisms convert organic N into mineral N. Usually it is rapidly changed into nitrate.
- *Nitrogen Gas (N_2).* This is the type of nitrogen in the air and is the most abundant form in the world (the air you breathe is 78% N_2). The only plants that can extract N from the air are legumes (such as clover, alfalfa, and birdsfoot trefoil). If you plant legumes, you can make your own nitrogen!

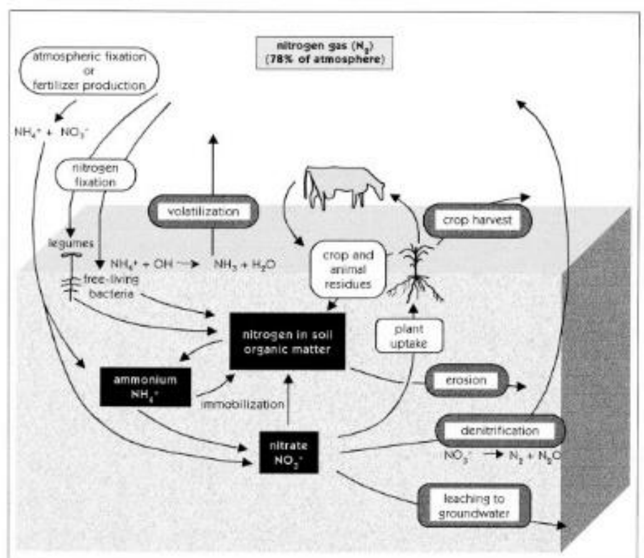


Figure1. The nitrogen cycle.

- *Nitric and Nitrous Oxides (NO and N_2O).* These are forms of nitrogen that are not utilized by plants but can be utilized by some microbes.

The pathway that N follows in and out of the soil system is collectively called the "nitrogen cycle" (Figure 1). The nitrogen cycle is biologically influenced. Biological processes are influenced by climate as well as physical and chemical properties of the soil.

Nitrogen Cycle

1. Nitrogen Fixation. Nitrogen gas from the atmosphere is converted to ammonium-N. This is done by the bacteria living in the nodules on legume roots. Remember the rhizobium? If you inoculate your legume seed with the rhizobium bacteria it will help ensure that atmospheric nitrogen gas is converted into a form that the plant can use. In turn, the plant will pass on some sugar to the bacteria and give the bacteria a place to live. This is how N is "fixed." It becomes available in the soil for other crops after these legumes or their roots die.

2. Nitrogen Uptake. This is the process of your plants taking up ammonium-N or, more commonly, nitrate-N. They then use these forms to make amino acids and then proteins or other essential chemicals.

3. Nitrogen Mineralization. Organic N is converted to ammonium-N. In most soils it is converted to nitrate almost immediately. These forms can then be used by plants or other organisms in the soil.

4. Denitrification. Nitrate-N is converted to gas — N_2 or nitrous oxide — which then go into the atmosphere. This happens when the soil is saturated with water or really compacted. The nitrogen will volatilize into the air and your soil loses valuable nitrogen.

5. Ammonia Volatilization. When urea is applied to the soil surface and not quickly incorporated, a significant amount of N may be changed into the form of ammonia-N gas and is lost into the atmosphere.

The excessive application or misapplication of nitrogen can have a negative impact on the environment. Nitrogen can be lost to the environment in the following ways:

6. Leaching. Nitrate-N can leach easily as excess rainwater moves through soil to groundwater. It leaches because it has a negative charge that will repel, rather than bind to, the negative charge of the soil particles. Ammonium-N, on the other hand, has a positive charge so it binds to the soil particles.

7. Runoff and Erosion. When the surface of the soil, fertilizer, and manure erode in a rain storm, they can carry ammonium-N and organic forms of nitrogen into the water.

8. Volatilization. Ammonium-N can volatilize through the air if it is on the surface of the soil, especially in warm weather. If possible, incorporate fertilizer and manure to avoid these types of losses.

The need for N fertility is commonly based on soil type, field history, yield goals, and measurement of organic matter. On an organic farm where the crop's N supply comes primarily from sources such as soil organic matter, cover crops, manure, and composts, a thorough understanding of mineralization is essential to avoid a deficiency. Mineralization is faster when pH is near neutral, moisture is adequate, and the soil temperature is above 60 degrees. Failure to synchronize N mineralization with crop uptake can lead to plant nutrient deficiencies and the potential for excessive NO_3^- leaching.

Hence many farmers lean towards incorporating purchased organic fertility sources to supplement the N they get from soil organic matter, manure, compost, and cover crops. These purchased organic fertilizers should not be thought of as quick release fertility sources. Organic purchased fertilizers include examples like fish emulsions, blood meal, and soybean meal. These fertility sources commonly take 30 to 60 days to mineralize 60% or more of its N.

Therefore the timing of fertilizer application is critical for meeting the N needs of a crop. As an example, the rapid N uptake stages of corn begin at the 6th leaf stage. If the majority of N is required by the crop 50 days after planting than the timing of purchased N-source would need to occur at planting. If the N-source was applied at the 6th leaf stage the corn would not receive the required amount of N at the critical stages.

Essentially the more you know about the mineralization potential of the organic fertility source the better equipped you will be to the meet the N-requirements of your crop.

Developing a fertility and soil management plan that combines a wide variety of organic approved nitrogen sources will likely lead to the best yield and quality. Each source of organic-N has positive and negatives associated with its use. However a combination of materials can hopefully meet the needs of the crop being grown.

How to Market Organic Vegetables Now that it is Competitive

Kate Donald

Stout Oak Farm
83 Middle Rd, Brentwood, NH
www.stoutoakfarm.com
kate@stoutoakfarm.com

Stout Oak Farm grows five acres of Certified Organic vegetables in Brentwood, New Hampshire. When we landed at our permanent farming location, and purchased our land in 2012 we dove into a diversified marketing plan that we've been refining ever since. The NH Seacoast area is home to a vibrant community of farmers, and an abundance of CSAs, farmers' markets, and farm stands, so we are embracing the challenge of carving out a place for ourselves in a competitive marketplace. "Organic" is not always our most important marketing term but it has played an important part in distinguishing our farm, and building a loyal customer base.

Our marketing decisions have led us to three strategies: finding and filling a niche in each of our marketing channels, adding new enterprises that play to our farm's particular strengths, and collaborating with other farmers to increase visibility and build more consumer demand. We've also been looking closely at costs associated with each of our marketing channels, tracking market-related costs, and keeping records specifically to inform marketing decisions.

We've added two enterprises that complement our vegetable field production and fit well into our farming systems: seedlings for sale to home gardeners and microgreens for both retail and restaurant sales. Both enterprises are growing steadily, and while they require separate and significant management, supplies, and labor, we're finding that offering these distinct products helps to set us apart, and attract new categories of customers.

We bookend our main marketing season with two events held at our farm – a Spring Plant Sale in May and a Fall Harvest Weekend in November. These events provide us with a significant influx of cash at crucial times of year, during months when other direct marketing outlets are weak. We use an online storefront to take pre-orders for both of these events – seedlings in the spring and bulk vegetables and Thanksgiving Shares in the fall.

Farming in an area with healthy competition among local farms, also means we have ample opportunity to collaborate with each other and work together to build consumer demand, and create new outlets and access points for local food. We've been involved in the development of a series of Winter Farmers' Markets run by the non-profit Seacoast Eat Local, now in their 11th year. In 2014, we teamed up with Heron Pond Farm and Meadow's Mirth Farm to establish Three River Farmers' Alliance, a marketing collective and local food distribution business that has helped us all reach new restaurant and wholesale accounts, while keeping our distribution costs low. Finding farmer-driven solutions, and collaborating with other local farmers is helping to creating new marketing opportunities for all of us.

To Grow, or Not to Grow? Scaling Up, and Down, at Blue Ox Farm. Enfield NH

Steve Fulton

steve@blueoxfarm.com

- Introduction to the farm

Several points / thoughts

Decision making on the farm:

- What crops to grow, or eliminate?
- Should the farm expand or contract?

1. If you want to manage effectively, one needs to know what to manage for. So, what do you want personally? And for the business?
   a. Farming and a farm business are difficult enough, **make the farm / business meet your goals**
   b. Most of the hard decisions are non-technical.
   c. Holistic Farm Management
   d. Example(s)
      i. Scaling up
      ii. 2016, ½ day off every other week
      iii. 2017, a summer vacation!

2. The farm is a small business
   a. Production and being in the field is why I got into farming, but running the business well is what allows me to keep farming.
      i. Farming is different, but there are a lot of commonalities with other businesses. GFM has had many articles around this such as 'triage on the farm'. Learning what other types of businesses do can help solve problems / resolve issues on the farm.

3. **Make your business visible to yourself**. Learn and use tools that help you manage information. (Communication, documentation, data collection, and analysis).
   a. Farming gives feedback visually and quickly (in the field), set up your systems and methods to make your business visible to you 'in the office'. Decisions are better based on fact / actual experience.
      i. Plans
      ii. Data
      iii. Analysis
      iv. Tools, EXCEL, WORD, QUICKBOOKS, or of course, paper and pencil
   b. Written plans (seeding schedule)

        i. Seeding schedule
            1. Enables the years seeding to be planned in the off season, then able to be handed off to someone else for the season.
            2. Track what information that you want / need.
        ii. Tomato house planting map
            1. Plan in advance, then you do not need to be there, and there is a reference to remind what you what the plan is in detail.

    c. Getting the information / data
        i. Find ways to use the same information in multiple ways
            1. Daily harvest sheet
            2. Labels
            3. Invoices
        ii. Make data collection part of the job
            1. Tomato production
        iii. Where time is spent still a struggle

    d. Analysis and reports
        i. What are you managing for?
        ii. What is important to know?
        iii. Having the data will give you a better understanding of the business.

4. Numbers and Plans and analysis make the farm a better place, but you don’t need to be a slave to them.

Post Harvest Cooling and Curing

Christopher W. Callahan[1], Robert G. Hadad[2], & Andrew Chamberlin[1]

[1]UVM Extension, Agricultural Engineering
310 Main St, Bennington, VT 05201
chris.callahan@uvm.edu

[2]Cornell Cooperative Extension, Vegetable Team

The preservation and delivery of quality in fresh market and storage crops on small and medium sized farms in the Northeast depends on two primary, crop-specific, pre-storage and re-distribution practices; 1) **curing** or controlled drying to provide a protective outside "coat of armor" and 2) **precooling** that provides a rapid reduction in pulp temperature and maintenance of relatively low temperatures to retard metabolic respiration. In addition to storage systems, these practices are essential to post harvest quality.

There is strong foundational work correlating both controlled curing and early, rapidly depressed temperature at the start of the cold chain with product quality when delivered to the consumer. Postharvest handling is critical for fresh produce farmers and the markets they sell to. Effort and expense invested in growing fruits and vegetables can be wasted without good handling practices at and following harvest time (Gross 2014). Consumers expect the best from fresh produce. Quality and freshness are ranked with high importance among consumers. Farmers market respondents respectively rank quality (63%) and freshness (59%), as highly important factors in their buying decisions. Nearly 87% of the respondents indicated that availability and quality of fresh produce affected their decision about where to purchase (Gorindasamy 2002).

Still, many of the farms in the Northeast are seeking guidance in improved post-harvest handling infrastructure and processes. A 2012 survey by the principal investigator of Vermont fruit and vegetable growers with 69 responses, resulted in 82% of respondents indicating interest in formalized workshop courses on post-harvest storage systems and practices. Despite many having plans to expand post-harvest infrastructure, only 30% rated their knowledge of storage systems and practices as less than good (poor, fair or not sure). Similarly, 69% self-rated knowledge of equipment as low and 43% indicated difficulty obtaining information on the topic (NE-SARE ONE13-179

Key Points

Precooling

- Starts the cold chain by rapidly reducing respiration.
- Improved with the combination of active cooling and forced flow of air (forced air cooling) or water (hydrocooling) or immersion in water.
- 1-3 CFM of air flow at 0.5 IWC static pressure per pound of product.
- Ventilated containers (e.g. holes or slats).
- Be careful to avoid infiltration.

Curing

- Provides a protective "coat of armor" for certain storage crops.
- Requires controlled temperature and relative humidity (RH) specific to each crop.
- Air flow is important for circulation and mixing to ensure consistent distributed conditions.
- Watch for chilling injury.

Callahan 2015). Most of the guidance and systems available is geared toward larger-scale, less diversified farm operations than we have in the Northeast.

This period “in between” production and distribution is the focus of a NE-SARE supported research and education project led by the author which is reported here.

Precooling involves flowing a controlled, chilled fluid (air or water) over the product to augment heat transfer for removal of field heat to depress respiration and initiate the cold chain. **Curing** also involves the flow of air with specific temperature and humidity over a product for a period to dry the outer layer in a controlled fashion to establish a “coat of armor” that minimizes water loss and physical damage from postharvest handling. The specific infrastructure required to do either process can be simple, but there are not many offerings that are scale appropriate for the types of farms in the Northeast.

PRECOOLING - One of the most important postharvest factors influencing quality is temperature. Temperature directly impacts the rate of metabolic respiration and associated decay. Produce which is not cooled quickly degrades in quality (Sargeant 1991). **Table grapes, for example, deteriorate more in 1 hour at 90 °F then in one day at 39 °F or one week at 32 °F** (Thomson et al 2008). Lower quality leads to a decrease in sales, inefficient use of storage space, wasted labor due to time taken to grow, clean, and store product that doesn’t sell. Coolers are a good addition to most farms, but fall short of meeting optimal precooling needs. **When produce is packed in boxes, stacked on a pallet and directly placed into a cooler, cooling time will be a minimum of 24 hours and may take many days**. (Thompson et al 2008).

One method to reduce cooling time is through **forced air cooling (FAC)**. In FAC systems, refrigeration cools a space and fans are set in position to actively draw the cold air through the produce. The cooling time drops from 24 hours to 10 hours when using a static cold rooms due to the increased air flow (increased convective heat transfer) (Thompson et al 2008, Boyette 1989).

Attempts have been made at smaller scale pre-coolers to reduce field heat at harvest in absence of coolers (Thompson and Spinoglio 1996). Retrofitting a cargo container with insulation and cooling with a large capacity air conditioner was also explored (Boyette & Rohrbach 1990). This forced-air cold room offered space for many pallets of produce but it still took many hours to reduce the temperature internally, especially for the boxes on pallets in the center of the container. **The key is integrating both cooling and air flow effectively (see figure 1).** We have built a prototype FAC for a single, fully or partially loaded pallet (figure 2) and are also planning to build a smaller multi carton cooler with a CoolBot™.

A mobile forced air cold box mounted on a trailer was constructed and demonstrated in Florida (Talbot and Fletcher 1993) aimed at farms growing produce on 5-50 acres. This unit could be self-built. Experiments showed that grapes could be cooled by 15 °F per hour. For denser produce like melons and tomatoes, the cooling times were longer. The construction cost at that time was close to $5,000.

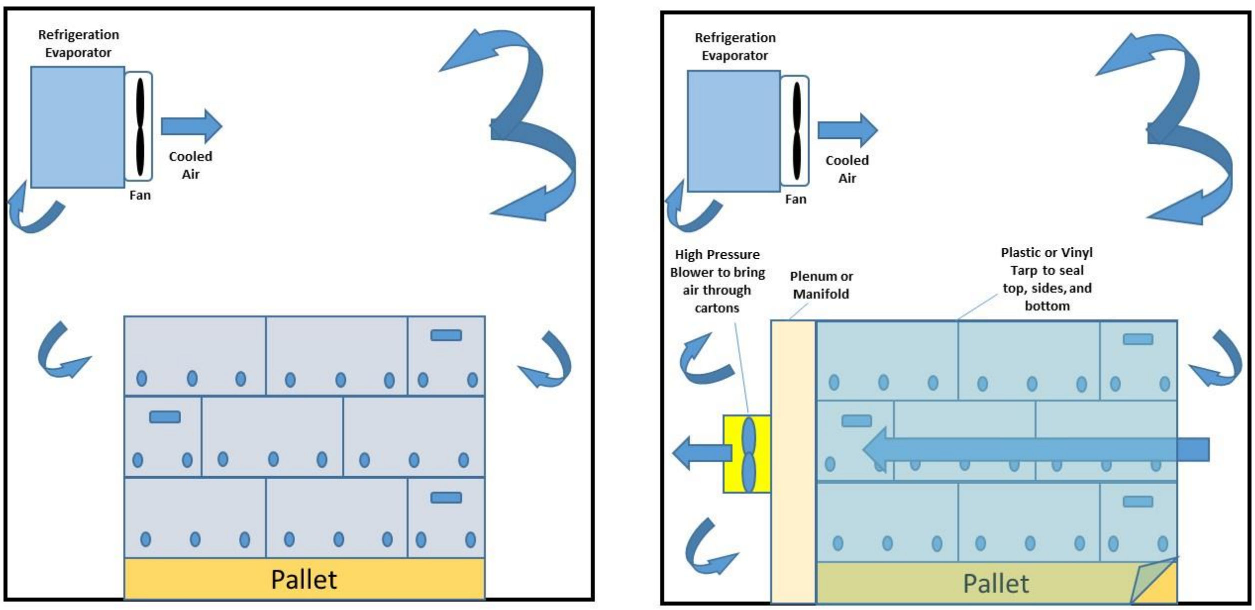
Gast and Flores (1991) also explored the concept of precooling produce to allow for rapid removal of field heat before moving fresh cut produce into cold storage. **Kitinoja et al. (2010) noted in a study with strawberries that pre-cooling decreased losses from 30% to 5%.**

Hydrocooling is another type of precooling method that has been employed by larger-sized farming operations and can take several forms. Certain crops can be dipped into very cold water to quickly reduce the temperature. Not all agricultural products can stand up to hydro-cooling.

Grapes, berries, and cut flowers are never hydro-cooled due to accelerated decay associated with direct water contact (Thompson et al 2008). Sweet corn, asparagus, greens, cabbage and melons are often hydro-cooled. A spray type hydrocooler uses nozzles to direct water over produce. The cold water and evaporation lowers the temperature of the produce. An immersion hydrocooler accepts crates of fruits and vegetables which are dunked in circulating cold water.

Hydro-cooling can reduce temperature faster than forced air cooling due to improved convective heat transfer from the product surface. For small diameter produce like radishes and asparagus it would take less than 10 minutes. Medium sized fruit like apples and peaches can take up to 25 minutes. Larger and denser produce like melons could take an hour (Kitinoja and Gorny 1999).

Thompson et al (2008) state hydro-coolers can be energy efficient and are one of the least expensive cooling methods to operate. However, a review of cooling practices for small farmers by Kitinoja et al (2010), showed that hydro-cooling to be moderately expensive to run compared to forced air.



Produce packed in cartons, lugs, or other containers will not cool rapidly even when placed in a cooler. The cold air does not have sufficient velocity or pressure to pass into the center of the pallet or even to the center of a single carton, even when the containers have vented sides. Heat removal from the produce depends on conduction through produce and cartons which is slow.

Using a high pressure blower, cool air can be pulled through cartons of produce to remove field heat and reduce product temperature to storage temperature more quickly. The heat removal rate from the produce is enhanced due to increased convective cooling in addition to conduction. This lowers respiration and leads to improved quality.

Figure 5 - The difference between static cooling and forced air cooling (FAC).

Hydro-cooling for smaller scale produce farms seems, on face-value, to be capital intensive. Prices range from $6000 to over $100,000 for integrated systems. An attempt to build a smaller scale unit was made by the Univ. Hawaii (Tsang and Furutani 2014) with a cost of $1650. We believe small chillers used for aquarium tanks are suitable and cost effective for this task and will be exploring this.

Care must be taken with hydrocooling for food safety reasons. Water quality must be monitored to prevent contamination of product. Further, when there is a significant differential (>10F) in temperature between the wash water and pulp temperature of some vegetables and fruit a vacuum effect can occur resulting in infiltration of the wash water into the produce and potential bacterial contamination (Zagary 2013). We feel there may be potential to integrate forced air cooling as a precursor to hydrocooling or rinsing/washing to reduce the water temperature differential.

Based on review of pre-cooling literature the project team is confident smaller-scale, improved methods are feasible for small and medium sized growers in the Northeast.

Figure 6 - Prototype forced air cooler setup for a pallet of stacked cartons. The fan is rated for 2520-2931 CFM at 2.1 IWC static pressure (Global Industrial, Model#T9F246343, $130). Typical required air flow rates for forced air cooling are 1-3 CFM per pound of produce at a static pressure of at least 0.5 IWC (Boyette, 1989).

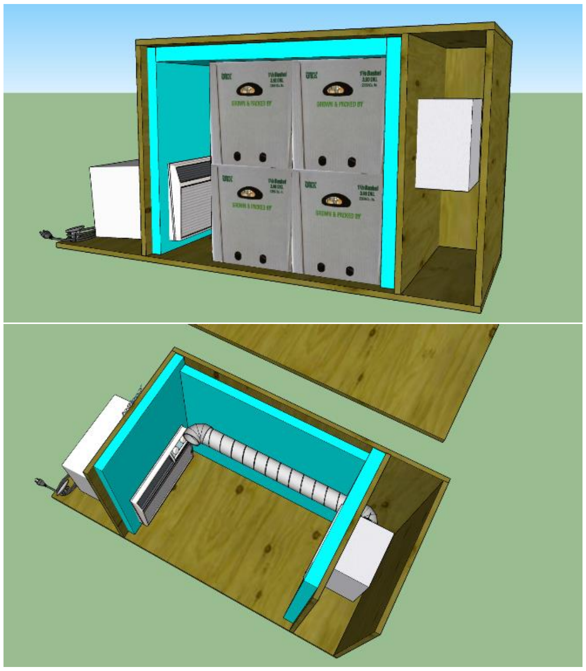


Figure 7 - A smaller precooling system for 1-4 cartons is being built as a prototype as well. The CoolBot™ (left) provides refrigeration of the air and a bathroom exhaust fan (right) provides the forced air circulation. Return air is ducted from the fan back to the left side of the chamber.

Hydro-cooling for smaller scale produce farms seems, on face-value, to be capital intensive. Prices range from $6000 to over $100,000 for integrated systems. An attempt to build a smaller scale unit was made by the Univ. Hawaii (Tsang and Furutani 2014) with a cost of $1650. We believe small chillers used for aquarium tanks are suitable and cost effective for this task and will be exploring this.

Care must be taken with hydrocooling for food safety reasons. Water quality must be monitored to prevent contamination of product. Further, when there is a significant differential (>10F) in temperature between the wash water and pulp temperature of some vegetables and fruit a vacuum effect can occur resulting in infiltration of the wash water into the produce and potential bacterial contamination (Zagary 2013). We feel there may be potential to integrate forced air cooling as a precursor to hydrocooling or rinsing/washing to reduce the water temperature differential.

Based on review of pre-cooling literature the project team is confident smaller-scale, improved methods are feasible for small and medium sized growers in the Northeast.

CURING - Certain crops (e.g. potatoes, sweet potatoes, onions, garlic, and winter squash) require a curing step prior to storage and distribution. This process is called “curing” because it is literally healing tissue wounds from production, harvest and handling with each crop requiring slightly different conditions (Gross 2014). Curing generally involves resting the product at specific, controlled temperature and humidity conditions to allow the outer layers to dry and heal. Often this will mean a dedicated infrastructure or a repurposed use of another space (Gross 2014).

Curing guidance can be broad and vague, often making it difficult to support adoption of ideal practice. For example, guidance on Irish potato curing is 68F and 80-100%RH for 1 to 2 weeks (Gross 2014). Aside from the fact that it is not variety specific, it is unclear if the curing process is equally effective over the entire RH range or if, e.g. 100%RH is better than 80%. There is also no guidance on measures of completion for the process. Is it 1 week or 2 weeks, and how does a grower know when they’re done? Another reference indicates 13-17C (55-63F) and “above 85%RH for a period of 7-15 days (FAO-UN 1989).

Curing guidance on onions is more specific with publications indicating 100F, 65%RH air, 3-5 CFM/bushel of air circulation and a typical product weight loss of 5-8% signaling completion of drying (Boyette, et al, 1992.) Guidance on achieving these conditions are geared toward larger scale operations and require some translation to be practical for farms in the Northeast. While there is limited guidance on design and construction of curing systems, one can use guidance available for both pre-cooling and storage spaces for this purpose while keeping in mind the specific air flow, temperature and humidity requirements of the curing process. Our project aims to clarify curing guidance for crops of interest to our region’s farms.

CITATIONS

Boyette, M. D., L. G. Wilson, E. Estes. Forced Air Cooling. 1989. Paper No. AG-414-03. Department of Biological and Agricultural Engineering, NC State University, Raleigh, NC. Accessed November 15, 2017 at https://content.ces.ncsu.edu/forced-air-cooling.

Boyette, M. D. and R. P. Rohrbach. A low-cost portable forced-air cooling system. 1990. Paper No. BAE 90-4 of the Journal Series of the Department of Biological and Agricultural Engineering, NC State University, Raleigh, NC.

Boyette, M. D., Sanders, D. C., & Estes, E. A. AG-413-6 Postharvest Cooling and Handling of Onions. 1992. NCSU BAE. North Carolina State University. Retrieved from http://www.bae.ncsu.edu/programs/extension/publicat/postharv/ag-413-6/

Callahan, C. Food Storage Curriculum for Farmers and Processors. 2013-2016. USDA NE-SARE #ONE13-179.

FAO - UN. Prevention of post-harvest food losses fruits, vegetables and root crops a training manual. 1989. Retrieved from http://www.fao.org/docrep/t0073e/t0073e00.HTM.

Gast K. L. B. and Flores R. Precooling produce. 1991. Kansas State University Cooperative Extension, Manhattan, Kansas.

Gorindasamy, R., Italia, J., and Adelaja, A. Farmers Markets: Consumer Trends, Preferences, and Characteristics. 2002. Journal of Extension v40 #1.

Gross, K. USDA Handbook 66: The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks. USDA ARS. 2014. Retrieved from http://usna.usda.gov/hb66/.

Kitinoja L. and Gorny J.R. Small-scale postharvest technology: economic opportunities, quality and food safety. 1999. Postharvest Horticulture Series No.21, Department of Pomology, University of California, Davis.

Sargent, S. A., Talbot, M. T. and Brecht, J. K. Evaluating precooling methods for vegetable packinghouse operations. 1991. Veg. Crop Department Special Series SSVEC-47, Inst. Food and Ag. Sci., University of Florida, Gainesville, FL.

Talbot, M.T. and Fletcher, J.H. Design and development of a portable forced-air cooler. 1993. Proceedings of the Florida State Horticultural Society 1993:106:249–255.

Thompson, J., and Spinoglio, M. Small scale cold room for perishable commodities. 1996. UC Davis publication 21449.

Thompson, J., Mitchell, F., Rumsey, T., Kasmire, R., and Crisosto, C. Commercial Cooling of Fruits, Vegetables, and Flowers. 2008. UC Davis.

Tsang, M. and Furutani, S.A. Low Cost Hydro-cooling Unit for Horticultural Commodities. 2014. University of Hawaii at Hilo, College of Agriculture, Forestry and Natural Resource Management.

Zagary, D. Wash water management: state of the art. 2013. Presentation made at the Wash Water Sanitation and Validation Conference 1/22/2013.

Lessons Learned Rebuilding Our Wash, Pack & Storage Facilities – December 2017
Paul Arnold

Pleasant Valley Farm, 118 South Valley Rd; Argyle, NY 12809
arnold.pvf@gmail.com 518-638-6501

Pleasant Valley Farm is located in a valley in a rural town 25 miles northeast of Saratoga Springs, New York (zone 4) and we have been operating it as an organic fruit and vegetable farm since 1988. We have two children, Robert (age 24) and Kim (age 21), who are an integral part of running our family farm. We own 60 acres and rent our neighbor’s 120-acre farm, both of which have somewhat limited tillable soil for good vegetable production. We use a total of about 5 acres for vegetable production, 1/2 acre for large fruits and 1/4 acre for small fruits, and keep another 3 acres in cover crops for rotation. We grow a diverse selection of more than 40 types of vegetables and fruits with organic methods (certified through Certified Naturally Grown www.naturallygrown.org) for retail sales at three area summer farmers' markets, two winter farmer’s markets, as well as a small amount to several local restaurants and a local natural food store.

Our farm started as just land in 1988, and over the 30 years, we have built and re-modeled our wash/pack and storage facilities to accommodate our growth, diversity, and seasons of marketing. The wash/pack area started out as a simple 20’x15’ lean-to off the end of a barn with benches, and we utilized a root cellar for cold storage, which matched what we could budget in our early years. Through constantly looking at efficiencies and crop quality, we expanded the washing station area in 1995 to be 20’x30’, adding a used 8x10 cooler, purchasing a barrel washer (from Dick DeGraff) and enclosing the washing station, and building in two overhead doors. These were important changes for season extension, which was very profitable, as well as the comfort and efficiency of the workers.

In 2006, a stainless-steel bubbler tank (old 180-gallon milk bulk tank we paid $300 for) was installed in the washing station, which was an amazing time-saver for our summer prep of all greens. Also in 2006, we started winter growing, which required we wash greens every week all winter. A smaller wash/pack area was created in another insulated building where we added a stainless steel table and utilized warm water from the greenhouse heat exchanger. Winter production increased rapidly and by 2010, we upgraded the original washing station with a concrete floor, washable walls/ceilings, insulation, and stainless-steel tables/benches. With food safety on the horizon, these upgrades were also considered necessary.

In 2015, it again became necessary to improve our wash/pack facility. Our family really wanted to bulldoze the whole barn and start over, but….adding an addition and many improvements would suffice till the next generation takes it over! The many improvements included: 14-foot addition off the end, 3 feet off the back side, insulated cement floor with radiant heat, new 12x14’ cooler with 2 slider doors, floor drains, crate storage area, barrel washer inside area, golf cart storage area, hand sink with hot water (electric instant on Stiebel water heater), 2 more overhead doors, and an increased wash/pack area. Since the washing station is only used 2 days per week in the winter, a propane-fired forced air heater has worked well for us (Reznor was best rated and is quiet). Our farm is fully solar powered, so efficiency of utilities was key, and the studies showing the insulation benefits for cooler floor (4”) and all walls, ceilings, etc. were key for us to reduce usage.

Many small technological gadgets help us to have efficient systems for washing/packing and monitoring. These include: electric switches for turning water on/off with a light switch, controls for water and washer on/off on both ends of the barrel washer, cameras, fluorescent lighting, the Nest to control heat, retractable hoses, IPad for record keeping, bubbler controls on a switch, 3 overhead automatic door openers, spinner (SS washing machine) on wheels with retractable ceiling cord, spinner with an on/off direct switch on the side, and dollies that can roll right into the cooler. Tsunami is used as our water-sanitizer, which not only keeps contaminates in check but also helps extend the life of produce. In 2017, we adopted a written safety plan.

Along with winter growing of greens in three unheated high tunnels, we utilize our 20-ft by 30-ft root cellar, buried on 2 ½ sides under our large barn, to store unwashed crops, which are sold all winter/spring. In the spring of 2007, a specialized cooling system was installed in the root cellar, which maintains a constant high humidity and cold condition, about 95% relative humidity and 34-37 degrees F. We increased production on crops that will store well for winter sales, and are learning more and more varieties of produce that lasts well under the right conditions. November harvested kale and swiss chard stored for over 6 weeks, and late November lettuce, cut and crated, will hold for 4-5 weeks in very good condition! Cabbage and leeks are lasting well into March, and the carrots, beets, and potatoes, will look near perfect in mid-summer when the new crops come in. Other crops we store are: radishes, celeriac, turnips, rutabagas, brussels sprouts, celery, kohlrabi, and cauliflower. Our root cellar holds about 24 tons of produce with a value of over $85,000. The $10,000 cooling system paid for itself in a matter of months!

Other crops that we store for winter sales are winter squash, sweet potatoes, onions, shallots, apples, and garlic, each in their own preferred environment. Winter squash and sweet potatoes are harvested in September, and then cured at 85-90 degrees for 4-6 days before cooling and storing for many months at 55-60 degrees and 60-70% humidity. We store these 2 crops together even though sweet potatoes prefer a higher humidity (70-80%). It is difficult to store each crop at their optimum conditions since we have over 20 varieties of produce for winter storage, so we compromise for what works satisfactorily.

Onions and shallots are cured in the field or on racks in our barns, and then moved to our walk-in cooler with conditions at about 33-34 degrees and 65% humidity. Garlic is racked and dried in our high tunnel before storing in ventilated crates in a cool area of the wash/pack shed. When the garlic starts to degrade, it can be dehydrated, ground and sold as dried garlic powder. Our apples, because they give off gases and should not be stored with vegetables, are kept in a local orchard’s cooler.

Storing crops and having them keep for long term with good quality, involves not only the correct environmental conditions, but also making sure that the crops we store are of good quality and few diseases when going into storage. Monitoring each crop, sorting out bad ones regularly, and maintaining optimum conditions are critical. Pre-cooling the crops or harvesting them for storage after the weather has cooled is important, and using varieties designed to store is helpful, especially for long term storage.

We have two favorite devices for helping to monitor all the different storage areas on our farm. One is our Davis Vantage Pro 2 (www.scientificsales.com), which has wireless temperature and humidity monitoring devices, each with the data transmitted back to the base unit in our house. We can constantly monitor any location with these portable devices: root cellar, warm storage, and cooler, as well as the high tunnel, and outside conditions; alarms can be set in case of malfunctioning equipment. The second device package is the Monnit system (www.monnit.com) which has wireless sensors for temperature, humidity, water, pressure, etc. and the data is not only transmitted to the base unit in the house, but all records are available to read on our cell phones or computers from anywhere, and we can get notifications to any phone (land or cell) or emails. Temperature monitoring devices/alarms should be a top priority because of the value of the stored crops, high tunnel crops, greenhouse crops, etc.; not spending this minor amount of money would be penny wise and pound-foolish! Cameras are also a favorite tool for monitoring efficiency in our wash/pack area as well as for security on the farm, with live feed available remotely. All of our systems are designed, installed and maintained by www.smartfarminnovations.com.

It's exciting to see the new technology available to assist farmers in creating an efficient, safe, and warm area for a wash/pack facility, as well as storage areas to meet the needs of individual crops to increase diversity of produce for customers and help the bottom line.

Cleaning Brushes and other Nasty Wash Line Parts

Kelsi Harper, Catherine Gensler, & Amanda J. Kinchla

University of Massachusetts
Food Science Department, 102 Holdsworth Way, Chenoweth Laboratory.
Ph: 413-545-2277; Email: kinchla@umass.edu

Project Summary:

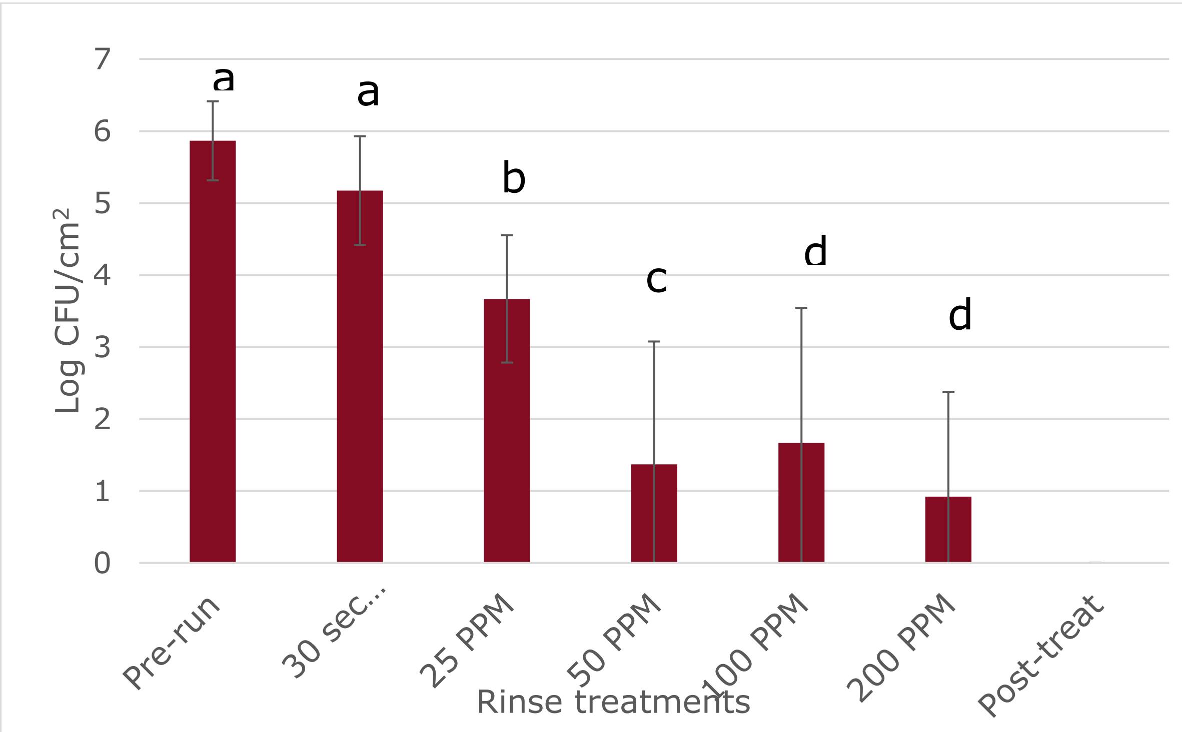


Figure 8. E.coli levels after a 30 second rinse with water and then a chlorine treatment using different concentrations (25, 50, 100 and 200ppm).

- Introduction: Produce brush washers are commonly used in small-produce production but are difficult to clean because of their mechanical design. This study investigated procedures to reduce microbial loads within this machine using approaches practical for small farms.

- Purpose: This work aimed at identifying an improved practice for rinsing and sanitizing a produce brush washer for the development of a standard operating procedure that would benefit growers through extension programming.

- Methods: Postharvest produce brush washing experiments were conducted by surface inoculating targeted zones on the equipment with nonpathogenic, streptomycin-resistant *E. coli* MC4100 to compare different washing times and concentrations of sodium hypochlorite. Sponge Swabs (3M, Minneapolis, MN) were used for sample collection, then serially diluted appropriately and plated on 3M® Aerobic Plate Count (APC) and E. coli/ Coliform Petrifilm™. Experiments were conducted in triplicate and statistical analysis of variance (ANOVA) was performed.

- Results: Results reported that up to 5 minutes of rinsing with a non-treated water in the brush washer yielded no statistical difference ($p= 0.707$) compared to the initial inoculation indicating that the use of water alone is not be sufficient to remove the inoculated surface of *E.coli* (control: 4.47 log CFU/96cm2; 300 second rinse: 3.56 log CFU/96cm2). Treatment with a 5 minute water rinse and then a treatment of 200ppm sodium hypochlorite resulted a reported value of <25 CFU/96cm^2 reduction. *E. coli* reductions after 200ppm, 100ppm, 50ppm, and 25ppm chlorine treatments were 4.31, 3.53, 2.68, and 1.78 log CFU96cm^2, respectively, showing that all chlorine concentration treatments were more effective at lowering *E. coli* levels than just a 30-second water rinse alone.

- Significance: This work helped to identify optimal sanitizing conditions for a produce brush washer to help develop a standard operating procedure for small-scale production to improve food safety practices.

This work was briefly summarized in the UMass Vegetable Notes Newsletter: https://ag.umass.edu/sites/ag.umass.edu/files/newsletters/september_1_2016_vegetable_notes_2.pdf

Managing E. coli in Vegetable Wash Water

Vern Grubinger[1] & Lynn Blevins[2]

[1]University of Vermont Extension, vernon.grubinger@uvm.edu
[2]University of Vermont College of Medicine, lynn.blevins@uvm.edu

Introduction. Growers of fresh produce have been adopting on-farm food safety practices in response to market demands and new regulations. Food safety risks posed by fresh produce are small, but practical steps should be taken to address them. One of these steps is to minimize the level of potentially harmful bacteria in vegetable wash water. This reduces the risk of cross-contamination whereby one contaminated item leads to the spread of bacteria to other items washed in the same water. Doing so is especially important for crops that will be consumed raw, such as leafy greens.

Key practices in wash water management. First, only potable sources of water should be used. Second, the wash vessel, whether a tub, a tank or a sink, should be free of cracks and thoroughly cleaned prior to use. Third, anyone engaged in washing produce must wash their hands thoroughly prior to handling product. Finally, our on-farm research found that using multiple washes (rinses) helps reduce the population of E. coli bacteria in wash water, as does the addition of an approved sanitizer containing peracetic acid (PAA).

Using E. coli levels to assess wash water risk. There are many types of E. coli present in the environment, and most do not make people sick. However, the presence of generic E. coli indicates the presence of fecal material and thus the possibility that human pathogens such as E. coli 0157:H7, Salmonella, or Campylobacter could be present. Testing for generic E. coli is an accepted practice for assessing the food safety risk of water that comes in contact with crops.

There is currently no widely-accepted standard for E. coli levels in water once the vegetable washing process is underway. Ideally the level would be zero, but that may not be practical to achieve for all farms with every wash. Thus, a reasonable goal is keep E. coli levels as low as possible to prevent cross contamination between produce items. For reference, the maximum generic E. coli level set for recreational water use in Vermont is 235 CFU/100 milliliters. (Note that E. coli levels can be measured as CFU, colony forming units, or estimated as MPN, most probable number, per 100 ml of water. The results of the two methods are similar.)

On-farm research 2012-2014. University of Vermont Extension personnel cooperated with commercial leafy green growers across Vermont and in nearby states to study the effect of different numbers of washes (rinses) and/or two sanitizer treatments on generic E. coli levels in wash water. The goal was to identify the practices which were most effective at reducing the risk of cross contamination.

Throughout the study, generic E. coli levels in on-farm wash water were measured after each wash (up to three) of leafy greens. We also measured E. coli levels after adding an organically-approved sanitizer (SaniDate®) containing PAA to the water after the first or second wash, at the full labeled rate and/or at half that rate.

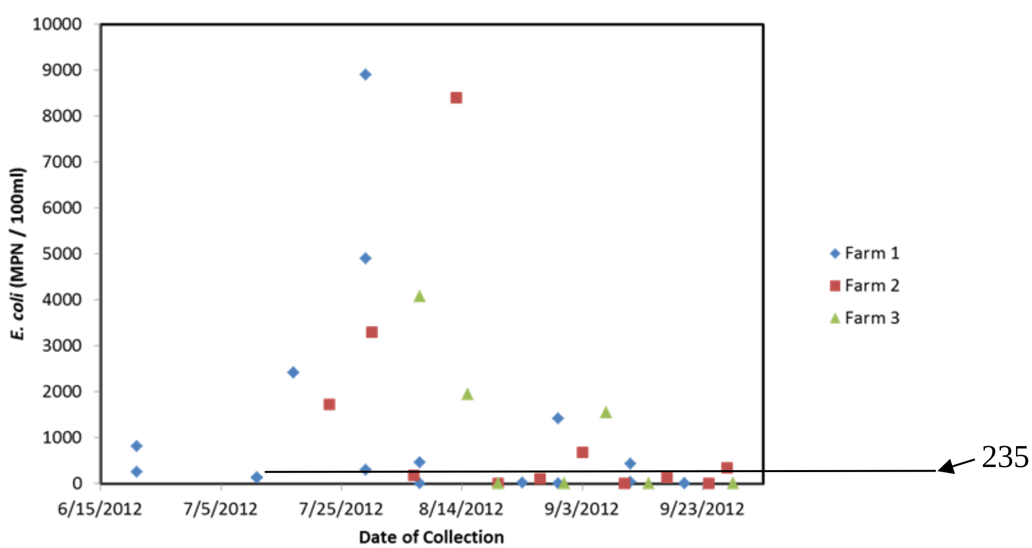
In 2012, with funding from the Vermont Agency of Agriculture, the research team collected bi-weekly water samples. Sampling took place from mid-June through mid-September on three commercial farms. In 2013, with funding from USDA Risk Management Education, the study team collected weekly samples, from mid-June through mid-October on four farms. Two of the farms had also participated in the 2012 sampling. In both years, all samples were taken from leafy greens washing systems. All farms had used composted manure to improve soil fertility, and all farms had an un-chlorinated but potable water supply for washing vegetables.

In 2014 growers were recruited to sample leafy greens wash water on their farms and submit samples for analysis using pre-paid mailers. Forty-three farms submitted a total of 80 paired water samples from a variety of leafy greens washing systems. The sample pairs represented a first wash and a 'final' wash that was the last in a series of multiple washes, a sanitized wash, or a combination. Twelve farms tested once (12 test pairs), 31 farms tested twice (62 test pairs) and 2 farms tested 3 times over the season (6 test pairs).

The Vermont Department of Health Laboratory performed the water analyses in all 3 years.

Results. In 2012 we found E. coli levels in the first wash on each farm varied greatly. High levels of E. coli were present in many of the samples, especially in mid- summer (Figure 1).

Figure 1. Level of generic E. coli in leafy greens in untreated wash water on three farms, after one wash in 2012. 235 MPN/100 ml represents the maximum E. coli level set by the State of Vermont for recreational water use.



Although E. coli was sometimes low or absent in the first wash water, in about half the samples the level of generic E. coli exceeded the recreational water standard of 235 MPN/100 ml. High E. coli levels were not predicted by appearance of the water. Whether water looked clean or dirty (turbid) did not appear to indicate how much E. coli it contained. On all three farms, the level of E. coli in water was greatly reduced by multiple washes and/or addition of sanitizer (Table 1.)

Table 1. Percent reduction of generic E. coli by number of washes and/or sanitizer treatment compared with a single wash on three farms in 2012.

	Double Wash n=18	Triple Wash n=18	Full Rate Sanitizer in First Wash n=18	Half Rate Sanitizer in First Wash n=8	Half Rate Sanitizer in Second Wash n=10
Minimum	73.9	94.9	96.9	79.9	96.3
Average (mean)	90.9	97.5	99.8	90.8	98.7
Maximum	98.8	100	100	99.8	99.9

In 2013, as in 2012, we found that either addition of sanitizer and/or triple washing proved effective in reducing E. coli levels in wash water. Double washing was not as effective as either of these treatments, but still reduced E. coli compared to an untreated single wash (Table 2.)

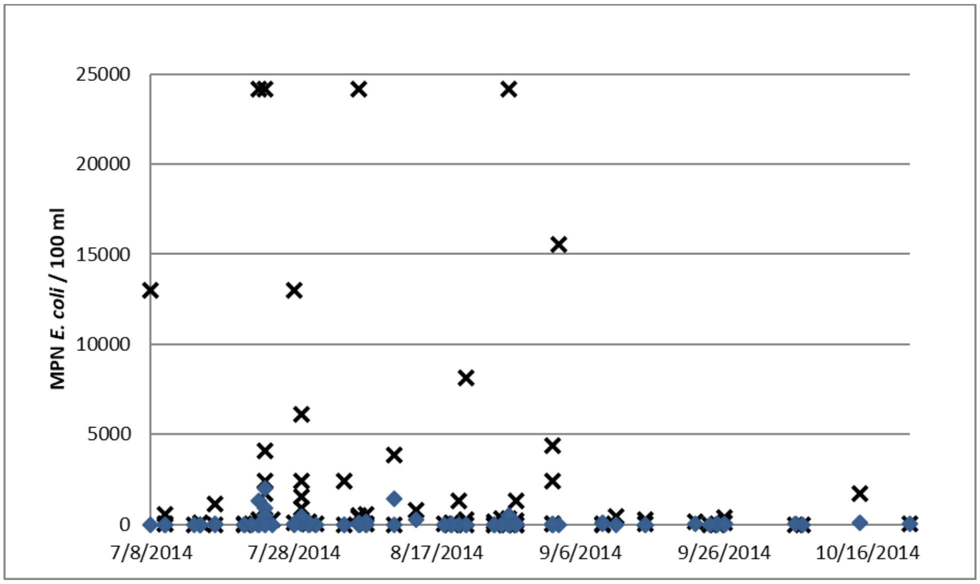
Table 2. Percent reduction of generic E. coli by number of washes and/or sanitizer treatment, compared with a single wash. Data combined from three farms in 2012 and four farms in 2013.

	Double Wash n=33	Triple Wash n=33	Full Rate Sanitizer in First Wash n=53	Full Rate Sanitizer in Second Wash n=9	Half Rate Sanitizer in Second Wash n=21
Minimum	56.6	89.6	55.3	98.1	94.6
Average (mean)	90.6	98.0	99.1	99.6	99.5
Maximum	100	100	100	100.0	100

In 2014 across all 43 farms with a variety of washing systems there was notable reduction in generic E. coli in wash water after multiple washing and/or use of sanitizer, compared to a single untreated wash (Figure 2.) There were some instances of very high levels of E. coli measured in the first wash on a few farms, over 20,000 MPN/100 ml. Conversations with growers from these farms about the high levels of E. coli in their wash water did not point to an obvious source for the contamination, such as wildlife observed on the farm or application of raw manure.

When farms with very high levels of E. coli in the first wash used a full rate of sanitizer, the levels were typically reduced to zero, but when a triple wash was used without sanitizer the E. coli levels were reduced, but not always to zero. This suggests that while triple washing can be effective at reducing E. coli in wash water with low incoming loads, it may not be sufficient for higher levels of incoming E. coli in wash water.

Figure 2. Incoming load of generic E. coli in first wash (X points) and the load of generic E. coli in the 'final' wash (diamond points) on 43 farms in 2014. Data combines all types of washing systems and treatments used.



Testing wash water for generic E. coli can help determine if a vegetable wash system is effectively reducing E. coli levels and thus the risk of cross contamination. Growers can obtain test kits from their state health departments or other accredited laboratories. In Vermont, the Department of Health offers an agricultural water test kit for $15. However, the water sample must arrive within 24 hours of collection so an overnight shipping cost may be incurred. Instructions provided by the lab should be followed to avoid contamination during handling.

In addition to testing the source of wash water at the beginning of each growing season, we recommend testing both the incoming load of E. coli in wash water (after the first, untreated wash) and the final load of E. coli in "used" wash water (after the last wash, and/or after addition of sanitizer). Testing is especially important in the summer months, when E. coli levels are most likely to be high. Testing multiple times each year, on a regular schedule, will provide a farm with information about the effectiveness of their wash system for avoiding cross contamination.

Good vegetable wash water management is one important part of an overall produce safety plan. For more information on brands, rates, and cost of wash water sanitizers, see this UMass fact sheet: https://ag.umass.edu/vegetable/fact-sheets/produce-wash-water-sanitizers-chlorine-paa

Constraints & Opportunities for Selling Apples to the Cider Market

Terence Bradshaw

University of Vermont Tree Fruit & Viticulture Specialist
tbradsha@uvm.edu
www.uvm.edu/~fruit

Fermented/hard cider (hereafter referred to, as it is in the rest of the world, simply as 'cider') has seen substantial growth as a commercial product in recent years. Between 2009 and 2014, cider sales saw average annual growth of 50% or more and revenues totaling $292.5 million (Petrillo 2014). Continued growth in the cider industry has been inconsistent- some large cideries have seen a slowing of growth in demand in recent years, while smaller producers of specialty ciders have generally been reporting strong growth in the sector. Regardless of the vagaries of specific aspects of the cider market, the breadth of ciders available and the ubiquity of cider as a product sold on-farms, in tasting rooms, at specialty shops, and even at supermarkets and grocery stores indicates that cider is here to stay. As fruit growers. It is critical to understand the cider industry so that we may take advantage of demand for fruit suited to various cider styles. Differences in cider styles provides opportunity for growers across scales and production systems, but understanding the economic and production constraints producing cider apples for different markets is critical to being successful.

U.S. cider production represents a 'bifurcated market', which means that two separate markets generally exist within virtually all cider and apple production regions. Most of the cider market is dominated by a small number of large to very large producers that produce ciders with, very generally speaking, lower price points, slimmer margins, and higher volume compared to the relatively larger number of smaller producers of higher priced, lower-volume ciders that tend to be sold in specialty markets. Both types of cider producers may purchase local apples from New England orchards, but the fruit sourcing models are different enough to consider both supply chains separately.

Dessert Cultivars as Cider Apples: Does the Market Make Sense?

Most cider made from New England apples uses traditional dessert cultivars, e.g., McIntosh, Empire, Cortland, etc. This is a natural fit, since those apple cultivars comprise the majority of commercial apples in the region. Prices paid for commodity fruit cultivars has increased substantially in recent years. As early as 2010, it was not uncommon to find cider-grade McIntosh and similar fruit sell for $3 per bushel; by 2014, such fruit were sold for an average of $5.75 per bushel (Becot, Bradshaw, and Conner 2016a). This effective doubling of the price for juice apples is welcomed by most growers, but the fact remains that it is far below the cost of production. The availability of such cider fruit is dependent on a strong wholesale or retail market for first-quality, high-value dessert fruit. If 80+% of a crop from commercial dessert cultivars may be sold for $20 or more per bushel, then the remaining fruit may be sold for substantially less. That amount may in fact represent substantial income from an orchard, and thus should not be discounted solely on the lower price received.

Sales of dessert cultivar fruit to cideries is becoming a common component of New England orchard businesses. However, the culture of producing high-quality dessert fruit has been counter to the idea of growing fruit for over 100 years in the region as we have all, as an industry, done our best to *not* grow cider apples. Until the mid-1990s when legitimate food safety concerns essentially shut down the practice, orchard drops were commonly purchased by cider mills. For nearly twenty years after that, drops were considered off-limits for virtually all market outlets due to safety concerns. However, because fermentation is a proven mechanism to eliminate microorganisms and their toxins implicated in food safety concerns (Burroughs 1977, Goverd et al. 2008, Moss and Long 2002, Semanchek and Golden 1996, Stinson et al. 1978), the use of drops for *fermented* cider has increased in recent years (Becot, Bradshaw, and Conner 2016a, b). Apples sold to cideries typically have included packing house culls and final 'strip-pick' cleanup harvests completed after the more valuable crop of higher-quality fruit is harvested. At this point, few New England growers are using mechanical harvesting equipment for cider apples, which is common in the cider production regions in Europe and facilitates the low prices paid by cideries for what would be considered premium, high-priced fruit in the U.S. Regardless of method of harvest, dessert fruit cultivars sold to cideries will only fetch a certain, lower price compared to fresh market fruit, so their production should either be minimized or costs and management carefully considered to meet lower price points. If possible, growers should negotiate pricing with cideries before harvest, and consider exploring contract agreements to establish pricing guidelines that are fair for both industries. In addition, growers may consider discussing the sale of

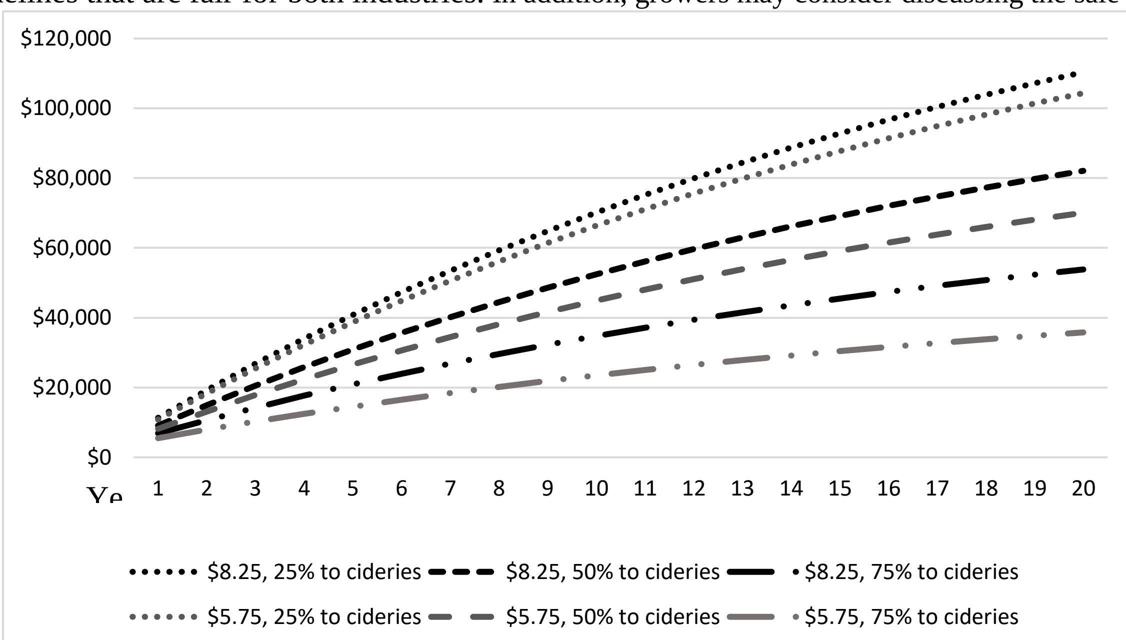


Figure 1. Net Present Value ($US per acre) for established, fully-depreciated orchards based on cider fruit sales price and % of fruit diverted to cider market. This assumes that a) the orchard is fully depreciated so no continued establishment costs are incurred, b) the fruit not sold to cideries is sold for $20 per bushel to fresh market outlets, and c) production costs are 'average' based on interviews with Vermont apple producers, 2015-2016.

drops to cideries, but, given the lower prices paid, shorter-storage life, limited markets (drops should not be sold to makers of fresh/sweet unfermented cider), and opportunity costs (e.g. putting a limited labor supply onto picking low-valued drops vs. higher-valued tree-picked fruit), this should only be considered a supplementary source of farm income for fresh market, dessert cultivar orchards.

When choosing whether to increase sales of fruit to cideries, a number of factors are important to consider. If an orchard has high establishment costs, like a recent tall spindle planting, then intentionally moving fruit to the cider market is likely not justified based on the need to recoup investment during the early production years. It is this early, and sustained high yields that make those expensive orchards make sense from a business standpoint (Robinson, DeMarree, and Hoying 2007). However, if an orchard has long-been established, and its costs have been fully depreciated, then growing that crop for sales to a cidery may make sense. However, consider the key business equation:

$$Profit = Income\ [(yield1\ x\ price1) + (yield2\ x\ price2)] - Expenses$$

It doesn't take an accountant to understand that increased yield and/or price are the primary determinants of profitability. To simplify, more fruit sold at a higher price vs.more fruit sold at a lower price will maximize profitability. In Figure 1, scenarios for shifting sales of fruit from fresh markets to cideries are examined, and profitability is most affected by a) the amount of fruit going to lower-valued markets and b) how much lower that price is compared to fresh markets. If labor and packing facilities allow, it is likely best to sell as much fruit to higher-valued markets before selling to cideries. However, cosmetic damage from hail, pest damage, or poor color or fruit size may preclude sales to fresh market outlets, or reductions in expenses through reduced pruning, harvest labor (e.g., strip-picking to speed harvest), or pesticide inputs may make growing a block of fruit specifically for sales to a cidery potentially profitable.

Adjusting Inputs to Meet Lower Price Points for Dessert-Cultivar Cider Apples

The following considerations pertain to producing fruit from already-planted, mature, productive orchards which have recouped establishment costs. As mentioned previously, the high costs of orchard establishment likely precludes planting new orchards of dessert cultivars with the intention of selling those fruit primarily to cideries as the prices just aren't there. Also, there are plenty of fruit on the commodity market that in any given year are available as utility/cider grade apples. However, consider a mature, 20 year-old 'McIntosh' block on M.26 rootstock that is still bearing 800 bushels per acre annually. If an agreement may be made with a cidery to purchase those fruit at $7.00 per bushel, then simple profitability given annual management costs of $4,750 per acre (Becot, Bradshaw, and Conner 2016b) would be $850 per acre. Because cosmetic blemishes are less of a concern; a single, more rapid harvest (ignoring fruit color, size, and, to some degree, bruising tolerance) is possible; and annual pruning may be reduced. Therefore opportunity exists to reduce input costs and improve orchard profitability. However, each of those factors must be carefully considered, and a decline in crop yield or tree health may occur which could threaten the productivity of the orchard for with fresh or cider apple markets. In the big picture, saving an occasional spray for cosmetic summer diseases may not greatly affect the overall management expense for an orchard. However, skipping apple scab protection in a wet primary infection season like was experienced in 2017, could lead to declines in overall tree health and crop yield.

Apple Cultivars for Cidermaking

We often hear the question of "what makes an apple a 'cider apple'?". The answer is simple, yet complicated. Whereas any apple that is made into cider has become a cider apple, certain apple cultivars more sought after for the unique characteristics they contribute to finished, fermented ciders. Cider apples are typically described by their acid and tannin levels, as 'sweets', ''sharps', 'bittersweets', and 'bittersharps' (Beech 1972, Williams 1988, Lea and Piggott 2012). While dessert and many dual-purpose cultivars may be classified as sweets of sharps, specific cider apple cultivars which contain relatively high tannin levels (bittersweets and bittersharps) are grown specifically for the characteristics they contribute to cidermaking, and thus are not also sold as fresh market fruit (Merwin, Valois, and Padilla-Zakour 2008, Merwin 2015, Lea 2010, Lea and Piggott 2012). Some relative juice chemistry characteristics of fruit evaluated in the UVM Apple Program juice lab are shown in Table 1.

Dual-Purpose Apple Cultivars

To complicate matters, some cultivars are dual-purpose, in that they have characteristics suitable for both fresh market and cider markets. Like many jacks-of-all-trades, they excel at neither, and a grower cannot likely expect to receive the highest prices for such fruit from cideries nor to have well-developed markets for them as fresh market/dessert fruit. Dual purpose fruit may include cultivars

Table 1. Mean Juice analysis values for cider apples evaluated in 2014 & 2015 at UVM juice analysis laboratory. Parameters include: soluble solids (SS), pH, titratable acidity (TA), total polyphenols (tannin). Values represent mean for multiple samples in limited seasons and are only a general representation for the cultivar.

			TA (g/l)[y]	Tannin (mg / l)[y]
Sharps[z]				
Ashmead's Kernel	17.6	3.3	10.4	489
Esopus Spitzenburg	15.3	3.5	7.1	486
Idared				
Jonagold	12.3	3.4	5.1	275
Liberty	11.5	3.5	5.7	369
McIntosh	11.7	3.3	5.5	408
Topaz	12.4	3.4	9.9	738
Wickson	13.9	3.4	11.9	147
Williams Pride	10.3	3.4	5.5	439
Winecrisp	16.2	3.6	6.1	595
Florina Querina	14.1	3.5	6.3	556
Crimson Gold	13.8	3.4	7.9	702
Crimson Crisp	14.2	3.4	8.3	1089
Liberty	13	3.2	8.5	1049
Galarina	14.9	3.5	8.7	668
Esopus Spitzenburg	15.8	3.1	9.3	633
Calville Blanc	15.3	3.1	10.0	728
Ashmead's Kernel	18	3.0	10.8	667
Crimson Topaz	14	3.2	12.1	617
Sweets[z]				
Cortland	11.2	3.4	4.7	459
Honeycrisp	12.6	3.5	5.0	254
Macoun	11.7	3.5	4.2	251
Paulared	11.0	3.4	4.5	747
Bittersweet[z]				
Dabinett	13.1	4.2	1.5	2442
Harry Master's Jersey	12.0	4.3	1.2	2120
Ellis Bitter	12.3	4.2	1.3	2625
Chisel Jersey	13.1	4.1	1.5	2408
Yarlington Mill	12.2	3.8	1.7	3538
Brown Snout	18.2	3.8	4.1	2148
Bittersharp[z]				
Kingston Black	13.7	3.3	5.4	1337
Redfield	13.6	3.2	6.5	3268
Franklin Cider Apple	16.9	2.8	7.8	3557

[z] Cider apple class based on Lea & Piggot (2012) classifications and measured parameters.

[y] Titratable acidity measured in malic acid equivalents, total polyphenols measures in gallic acid equivalents.

such as Baldwin, Idared, Northern Spy, Russets (Roxbury and Golden, as well as others), and other ‘heirloom’ cultivars. Growers with such cultivars in their orchards may wish to contact local cideries, as they may command higher prices than dessert fruit, although not necessarily as high as specialty, cider-specific cultivars.

If appropriate prices (at least $12 per bushel) can be secured and agreed upon with a cidery, then it may make sense to consider not only to manage existing plantings of such cultivars, but also to plant or replant new orchards. However, establishment costs and relative payback time need to be carefully considered. In addition, potential market channels should be explored so that fruit can be marketed when the orchard is in full production. While an orchard of heirloom cultivars that sell at presently high retail prices may seem like a great way to make money, it is important to consider potential for market saturation, and the willingness of markets to take multiple cultivars that do not have an established sales record. It is also important to consider that, like any cultivar, cultural needs vary among heirloom and other dual-purpose cultivars, and production models designed for high-yielding, standard cultivars for a particular region may not directly apply to different cultivars. For example, a model designed for evaluating long-term profitability of ‘McIntosh’ on tall spindle which may produce 800-1000 bushels by year four may not be accurate when maximum yield for another cultivar is only 500 bushels per acre. Also, recognize that not all ‘heirloom’ or other non-conventional dessert cultivars will be sought after by cideries.

Specialty Cider Cultivars

The area of greatest potential growth for orchards seeking to sell fruit to cideries is in the production of specific, specialty cider apple cultivars. Much has been discussed about these fruit in recent years, but many shortages in the production chain still limit the availability of replicated research on these cultivars and their applicability across diverse sites. Planting new orchards of specialty cider cultivars is a risky, but potentially rewarding endeavor. Because such fruit are in short supply but in high demand by cideries because of the unique characteristics they provide to ciders, the market price for such fruit is relatively high. However, many horticultural characteristics of such cultivars are not well-understood, especially across multiple sites and soils. There is considerable debate about the best method to grow specific cider cultivars, including rootstock (as basic as large semidwarf vs. dwarf/high density plantings); training system; groundcover management; cropload adjustment; and pest management. Many cider cultivars are known to be biennial in fruit production, and several are also known to be low-yielding. Careful consideration needs to be made when selecting systems in which to plant and manage cider cultivar orchards.

Resources

UVM Cider Resources. http://go.uvm.edu/cider

Cornell Hard Cider Resources http://hardcider.cals.cornell.edu/

Cidernomics: Life in the Underdog Economy https://cidernomics.com/

Growing Apples for Craft Ciders Merwin, I.A., 2015. NY Fruit Quarterly 23(1): 5-10. http://go.uvm.edu/15merwinciderapples

Hard Cider Production & Orchard Management in the Pacific Northwest Moulton, G. A., C. A. Miles, J. King and A. Zimmerman, 2010. Pacific Northwest Extension Bulletin PNW621. https://pubs.wsu.edu/ItemDetail.aspx?ReturnTo=0&ProductID=15402

Cider Apples and Cider-Making Techniques in Europe and North America Merwin, I. A., S. Valois and O. I. Padilla-Zakour, 2008. Horticultural Reviews, Volume 34: 365-415. http://go.uvm.edu/08merwinhortrvwcider

Northeastern U.S. Cider Varieties Good Fruit Grower, 2016. http://go.uvm.edu/16goodfruitnecidercvrs

Cited Literature

Becot, Florence A., Terence L. Bradshaw, and David S. Conner. 2016a. "Apple Market Optimization and Expansion through Value-Added Hard Cider Production " *HortTechnology* 26 (2):220-229.

Becot, Florence A., Terence L. Bradshaw, and David S. Conner. 2016b. "Growing apples for the cider industry in the U.S. Northern Climate of Vermont: Does the math add up?" *Acta Hort. Accepted Nov 2016, In press*

Beech, FW. 1972. "Cider making and cider research: A review." *Journal of the Institute of Brewing* 78 (6):477-491.

Burroughs, Leonard F. 1977. "Stability of patulin to sulfur dioxide and to yeast fermentation." *Journal-Association of Official Analytical Chemists* 60 (1):100-103.

Goverd, KA, FW Beech, RP Hobbs, and R Shannon. 2008. "The occurrence and survival of coliforms and salmonellas in apple juice and cider." *Journal of Applied Microbiology* 46 (3):521-530.

Lea, Andrew Geoffrey Howard. 2010. *Craft cider making*. Preston, U.K.: Good Life Press.

Lea, Andrew GH, and John Piggott. 2012. *Fermented beverage production*. Glasgow: Springer Science & Business Media.

Merwin, Ian A. 2015. "Growing apples for craft ciders." *NY Fruit Quart* 23 (1):5-10.

Merwin, Ian A, Sarah Valois, and Olga I Padilla-Zakour. 2008. "Cider Apples and Cider-Making Techniques in Europe and North America." *Horticultural Reviews, Volume 34*:365-415.

Moss, MO, and MT Long. 2002. "Fate of patulin in the presence of the yeast Saccharomyces cerevisiae." *Food Additives & Contaminants* 19 (4):387-399.

Petrillo, Nick. 2014. Cider Production in the US. In *IBISWorld Industry Report*, edited by IBISWorld. Melbourne, Australia.

Robinson, TL, AM DeMarree, and SA Hoying. 2007. "An economic comparison of five high density apple planting systems." *Acta Hort* 732:481-489.

Semanchek, JJ, and DA Golden. 1996. "Survival of Escherichia coli O157: H7 during fermentation of apple cider." *Journal of Food Protection* 59 (12):1256-1259.

Stinson, EE, SF Osman, CN Huhtanen, and DD Bills. 1978. "Disappearance of patulin during alcoholic fermentation of apple juice." *Applied and Environmental Microbiology* 36 (4):620-622.

Williams, Ray R. 1988. *Cider and juice apples: growing and processing*: University of Bristol Printing Unit. Bristol, England.

Cidernomics: Economic Considerations in Building a Successful Cider Business
Eleanor Leger

Eden Specialty Ciders
150 Main Street, Newport, Vermont 05855

Most start-up cideries do a pretty good job of estimating their productions costs and what they need to spend on plant and equipment. However, there are other critical choices that impact the economics of a cider business that should not be ignored. This presentation will highlight 5 key concepts – economies of scale, break-even points, sales channel economics, asset utilization, and working capital – and show how key choices in establishing a cider business will impact its economic performance. As artisan cider producers, we may want to focus on our passion for our craft, and sharing great ciders with others, but financial sustainability in the cider business can prove elusive. Cider makers should understand what the implications of their decisions will be on their ability to make a living and preserve their capital.

Economies of Scale – Exhibit 1

If you buy more things, the price per thing goes down. That's the obvious explanation of economies of scale. And there are plenty of examples of these in Cider – label printing, buying bottles by the case vs pallet vs trailerload, But there are other types of economies of scale too – like the fact that setting up a filter to run a 200 gallon batch takes about the same amount of time as it does to set up a filter to run a 2,000 gallon batch, and a 4,000 liter tank will cost less than twice the price of a 2,000 liter tank. It's important to understand how your unit production costs are going to change as your scale increases. You should be pricing your product on the basis of what the market will support, but you might be able to sustain lower margins in the first few seasons because you know your unit costs are going to decrease as you increase volume. There's a corollary to this, which is you will do better if you can consolidate / standardize your packaging across products, and minimize product proliferation.

Break Even Point – Exhibit 2

In its simplest form, break-even is the number of bottles/cans/kegs you need to sell in order to cover your costs and any volume above that amount will start generating profits. You need to know your variable gross margin per unit sold, and your total fixed costs. Then the break even amount is the total fixed costs divided by the gross margin per unit, which will give you the number of units you need to sell to break even. It is really important to understand how break even point changes as you grow. On the one hand, your gross margin may increase due to economies of scale. On the other hand, your fixed costs actually aren't fixed – every time you add a person, a tank, a vehicle, etc., you are increasing your fixed costs. You need to make sure that you can find a point where you actually will sell the units you need at a fixed cost base that will mean you make some money, otherwise you are just breaking bad!

Asset Utilization – Exhibit 3

Your ability to cover your fixed costs are in part a function of your asset utilization. concept refers to how much you can produce for a given investment in plant and equipment. Take, for example, a cider maker who produces one 'vintage' or 'ciderage' cider per year that ferments and ages in a 1,000 gallon tank for 8 months before bottling, and then the tank is empty until the following harvest. That cider maker produces 1,000 gallons per year from that tank. On the other hand, if you pressed apples out of cold storage every 5 – 6 weeks, fermented hot and fast, and packaged immediately, you could produce 5, 6 or even 8 thousand gallons of cider from the same 1,000 gallon tank. If you can spend less money for equipment per gallon of cider, you can invest more in your sales and marketing or package design.

Sales Channel Economics – Exhibit 4

Just as you spend time figuring out production economics, its arguably even more important to figure out your sales channel economics. The channels available to you to sell your cider are at your farmstand, at farmers markets and events, directly to stores and restaurants, directly to consumers online or through the phone, and through distributors. Each channel has three key characteristics – what level of price you will receive (retail, wholesale or manufacturing), what is the realistic volume potential of the channel, and what expenses will you incur selling through that channel. For example, at your farmstand or tasting room, you have staff labor, supplies, pos system / credit card processing fees, and possibly rent and utilities. If you work with a distributor, you will have sales people labor, travel costs, marketing materials costs, event costs, sample costs, pallet packing labor, invoicing and managing accounts receivable. It is crucially important to plan which channels you will use, how much volume you might be able to sell through them, and how much money those sales will ultimately provide to the overhead of running your cider business.

Working Capital – Exhibit 5

Working Capital is the money you need to pay for the things before you get money back in the form of sales. This concept is all about timing. If you have a vintage cider approach, you are going to pay for the entire cost of producing the cider during the course of the production year, and you won't start earning that back in the form of sales until the end of that year and it may take you all the next year to sell it through. Meanwhile, you need to put out for the costs of the next vintage of cider. What many people don't realize is that the faster you grow, the more working capital you need. Even though you may be technically making a profit on each vintage, you could be in a severely negative cash flow dynamic for quite a period of time. Planning for this, and ensuring you have the capital available to fund it, is critical.

Think of this as a 3-part puzzle that you need to solve: 1) what price point does your combination of liquid plus packaging justify in the mind of the consumer, 2) how much will your channels be likely to purchase at your price point, and 3) will the resulting gross margin and sales contribution give you a profitable business given how your production choices impact your fixed costs and working capital requirements? I hope I've convinced you that just looking at production costs and the cost of the shiny equipment you want to purchase is not sufficient to create a sustainable business. If you are not good friends with Excel, find someone who is, and make sure you are looking at all 5 of these concepts and doing so with realistic, fact-based evidence for your assumptions.

Questions?

EXHIBITS

Exhibit 1: Economies of Scale

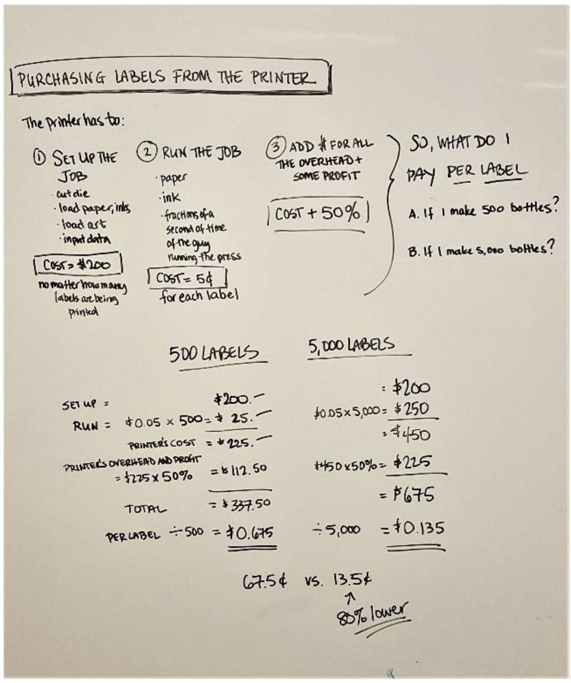
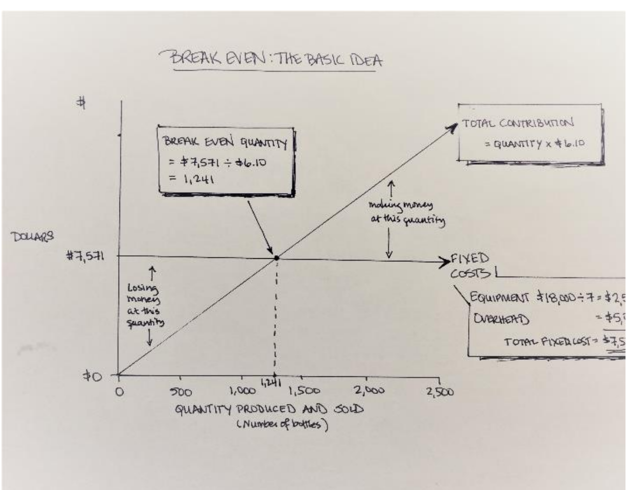


Exhibit 2: Break Even Point



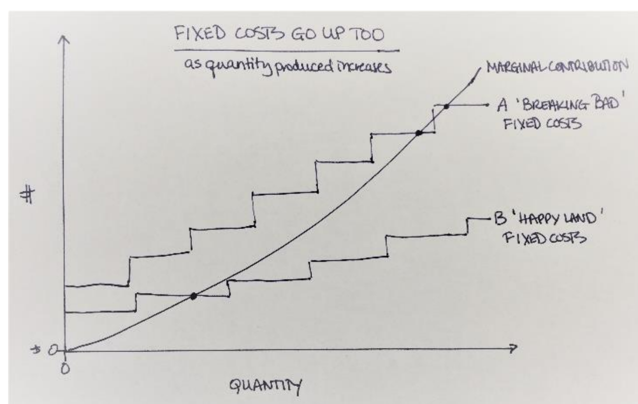


Exhibit 3: Asset Utilization

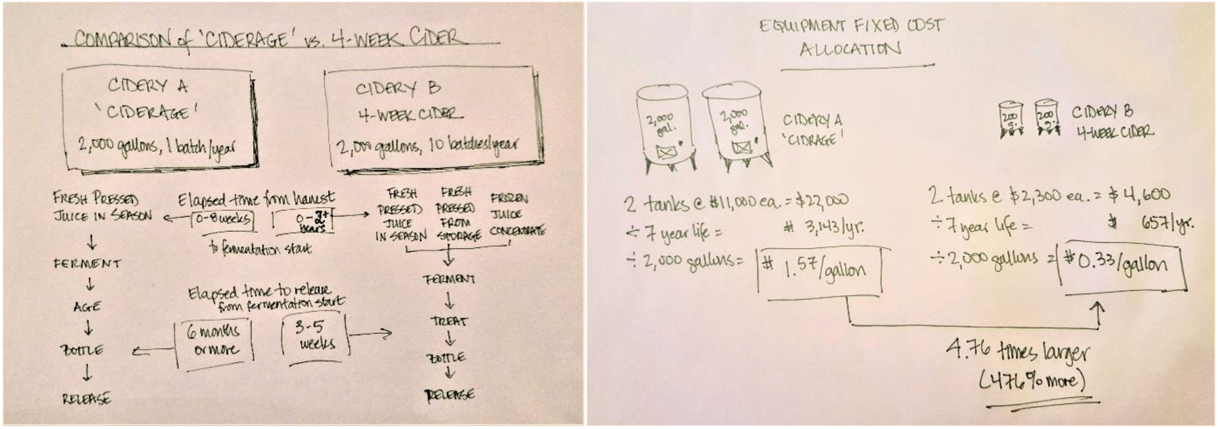


Exhibit 4: Sales Channel Economics

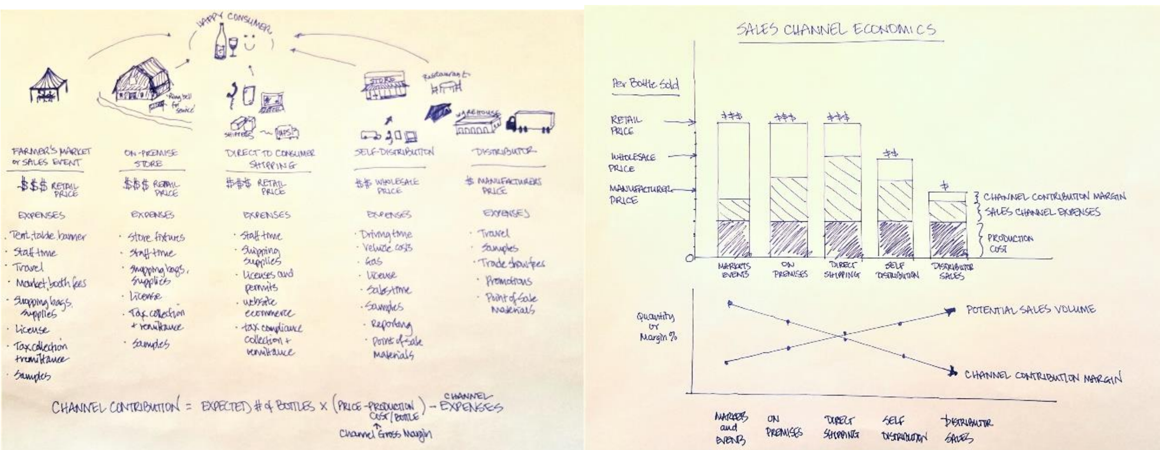
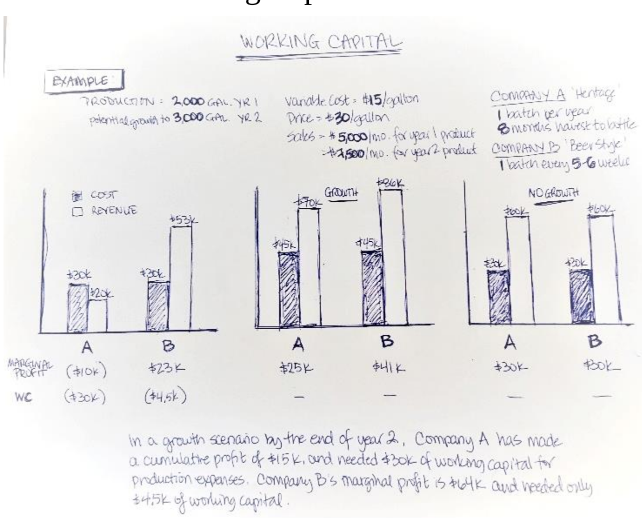


Exhibit 5: Working Capital



Basic Canopy and Cluster Management during Growing Season

[1]Sonia Schloemann & [2]George W. Hamilton

[1]UMass Extension Fruit Team, 100 French Hall/UMass
Amherst MA 01003, sgs@umext.umass.edu

[2]Extension Field Specialist, Food and Agriculture
UNH Cooperative Extension - Hillsborough County
329 Mast Road - Room 101, Goffstown, NH 03045
Phone: (603)641-6060 Fax: (603)645-5252
george.hamilton@unh.edu

Table Grape Session

The two areas of grape production management that can affect the grape quality in a growing season are proper canopy and fruit zone management. Proper canopy and fruit zone management are used to optimize yield, improve fruit quality, reduce the risk of disease, and improve spray penetration.

Canopy control is a vineyard practice that includes the physical adjustment of the vine as needed to balance the amount of fruit with the growth of foliage. This practice adjusts the crop level so there will be sufficient growth of shoots with leaves on each vine, and each shoot will be capable of maturing the fruit retained.

Canopy and fruit management includes shoot thinning, shoot positioning, cluster thinning, leaf removal, and hedging/skirting. These management practices can improve light interception that promotes sugar accumulation and improves development of aroma and flavor compounds. Light interception also affects bud development, fruit set, and berry growth. Remember shading can negatively affect crop levels. Open canopies tend to have reduced disease pressure, since improved airflow reduces humidity, which allows better penetration of fungicides and insecticides.

Shoot Thinning

The first of the canopy management practices to be utilized at the start of the season is shoot thinning. Shoot thinning can be used to help improve light penetration and air movement through a canopy, adjust crop load (by thinning fruitful shoots to reduce the crop), and increase the leaf-area-to-crop ratio (by thinning non-fruitful shoots). Shoots from the base of spurs, multiple shoots from the same node, shoots growing from non-spur positions or originating in the head region or on the trunk are all candidates for removal, unless needed to replace an old or poorly positioned spur or an old cordon.

Shoot Positioning

Shoot positioning is another important element of canopy management in the vineyard. Proper shoot positioning results in orienting shoots to create a uniform distribution of foliage that minimizes shading of fruit. An added benefit of shoot positioning is that it makes other canopy management chores, such as hedging and leaf removal, easier to accomplish. It also improves the efficiency of operations such as pruning. Not only is shoot positioning important for the current growing season, it also has an impact on productivity by encouraging the development of more fruitful buds for next year's crop.

Cluster Thinning

Cluster thinning is a practice used to adjust fruit yields to obtain balance between fruit and canopy to achieve optimum ripeness. Crop thinning can be used to remove undersized, poorly set or immature clusters. It can also be used to reduce bunch rot in tight-clustered varieties.

Leaf Removal

Leaf removal is typically conducted in and around the cluster zone to allow varying levels of sunlight exposure and airflow. The objective leaf removal is to have an average of one to two leaf layers remaining in the fruit zone after the leaves have been pulled. The goal is not to completely strip all the foliage from around the fruiting zone, but to provide between 40 and 60 percent exposure of the clusters. An adequate number of leaves must remain on the shoot to produce carbohydrates to support vine growth, fruit development and ripening. These leaves are needed to develop overwintering reserves and to allow vine shoot and bud winter hardiness. This can be accomplished by removing a relatively small number of leaves from the vine in the area around the fruit clusters. Restrict leaf removal to those leaves positioned at or below the cluster on the shoot since those above the shoot are the primary source of carbohydrates for the developing cluster.

Hedging

Shoot hedging consists of cutting shoots that grow beyond the allocated space in a given trellis system in order to control shoot length. It is called hedging for upward shoot training, such as on a VSP system. The goal of hedging is to remove excess primary and lateral shoot growth from the top and sides of the canopy. This is needed to prevent shading and entanglement of shoots between vine rows. Removal of these shoots will allow workers and tractor traffic through the vineyard. Although hedging decreases canopy by cutting primary and lateral shoots, it does not directly decrease the vine's inherent vigor. When conducted in early to midsummer, it can further promote growth by inducing lateral shoot growth in vigorous vines.

Skirting

Shoot hedging consists of cutting shoots that grow beyond the allocated space in a given trellis system in order to control shoot length. It is called skirting for downward shoot training, such as on a high cordon (HC) system.

Grape growers can indirectly controlled vine vigor by management techniques— training system used, dormant pruning, along with irrigation, fertilization, and floor management. These factors will affect canopy and fruit management practices.

While direct canopy management practices can be used to modify the canopy, indirect canopy management techniques are also used to alter vine growth and canopy size, thereby affecting vine balance. For example, vines with a weak canopy typically require methods such as irrigation and fertilization to increase vine size relative to fruit yield. Vineyard floor management practices can be used to control overly vigorous vines. Irrigation, fertilization, and floor management techniques can have strong impacts on canopy and overall vine growth and productivity over time.

Summary

Canopy and fruit zone management are two distinct concepts and practices that are intertwined and anything done to one will affect the other. Crop size can affect vigor of a vine and is sometimes used to slow down vegetative growth. Canopy and fruit zone management are vineyard practices that include the physical adjustment of the vine as needed to balance the amount of fruit with the growth of foliage. Proper canopy and fruit management is used to optimize yield, improve fruit quality, reduce the risk of disease, and improves spray penetration.

Protected Culture of Seedless Table Grapes

Andy Farmer

Northeastern Vine Supply, Inc.
1428 River Rd. West Pawlet, VT 05775
andy@nevinesupply.com 802-287-9311 www.nevinesupply.com

Seedless table grape production in the U.S. is largely located in warm to hot locations in the arid west. There are a lot of good reasons for the lack of a commercial table grape industry outside of the west coast, including climate, availability of suitable varieties, and market logistics. Nevertheless, demand and enthusiasm for locally grown table grapes has led to various attempts to grow them in New England.

Several varieties of seedless grapes are being grown around our region now. We have grown table grapes at our Vermont farm for over a decade on a very small scale as an off shoot of our cold hardy grapevine nursery. Specifically, I have pursued ways to grow table grapes in a protected environment. I will present what I have learned growing seedless grapes in a high tunnel for the last 6 years as well as some thoughts on other ways to produce high quality grapes for the fresh market.

Basic Grape Disease Identification and Management

Patricia McManus

Professor and Chair, University of Wisconsin-Madison, Department of Plant Pathology
pmcmanus@wisc.edu

Diseases are a limiting factor in production of table grapes and wine grapes. To manage diseases you must be able to identify and distinguish diseases from other disorders such as nutrient deficiencies or herbicide injury. You also need to understand disease life cycles so that you can reduce pathogen levels through practices such as pruning and applying fungicides at the appropriate times. Finally, you need to develop a proactive disease management program that starts at the time of vineyard establishment.

Start with clean plants. Purchase vines from a reputable nursery that sells certified virus-free plants. There are no treatments for virus infections in an established vineyard, so the only way to control viruses is to avoid them altogether. When choosing table grape cultivars, your primary concerns might be berry color, size, or flavor, but if you want to minimize fungicide inputs, then you should also consider disease susceptibility. Relatively little research has been conducted on table grapes, so much of the information on disease susceptibility is based on anecdotal reports. Therefore, you should not rely on a single source, but rather, check multiple sources (e.g., nursery catalogs, state Cooperative Extension web sites) to determine a variety's susceptibility to various diseases.

Identify the cause of the problem. Most diseases of grapes are caused by fungi. Major fungal diseases are black rot, anthracnose, powdery mildew, and Phomopsis leaf spot and cane blight. Another very common disease is downy mildew, caused by a water mold. You should familiarize yourself with the symptoms of these diseases so that if they do arise, you can act quickly to prevent them from developing further. Many states have a university-based plant disease diagnostic clinic that will provide diagnoses for a modest fee or free of charge. Positive diagnoses are not always possible, but the diagnostician can often narrow down the possible problems.

Know where pathogens overwinter. By knowing the initial source of fungal spores, you can act to prevent early infections. The fungi that cause anthracnose, Phomopsis leaf spot and cane blight, and powdery mildew all overwinter on bark. Black rot overwinters as mummified berries that are retained in the trellis or on the ground. In the spring, fungal spores are released when temperatures rise into the 50s and 60s degrees F and there is rain. The initial fungal spore loads can be minimized by pruning and then removing prunings from the vineyard and by applying dormant sprays of lime sulfur or liquid sulfur. For black rot, most mummies will be removed when pruning, but it is important to remove mummies that are still clinging to trellis wires. Research conducted at Cornell University on wine grapes showed that mummies retained in the trellis produced 10 to 20 times more spores of the black rot fungus than mummies that overwintered on the ground. Mummies in the trellis produced spores over a longer period (those on the ground decompose more quickly), and their close proximity to new leaves and young fruit make them a greater threat than mummies on the ground.

Unlike the fungal diseases mentioned above, downy mildew is caused by a water mold that overwinters in soil and/or leaf debris on the soil surface or in the top few centimeters of soil. In the spring, when shoots begin to grow and temperatures are about 50 degrees F or higher, the downy mildew pathogen becomes active. Spores are splashed by raindrops and become airborne. They land on young leaves and cause primary infections. Volunteer seedlings or sucker sprouts are sometimes the first leaves infected, because they are close to the ground. After about a week, infected leaves develop downy mildew lesions that are the source of millions of additional spores. Because downy mildew overwinters on the ground, and not in the canopy, it is not controlled by pruning or dormant sprays of fungicides. There are no fungicides that can legally be applied to the ground. Spraying the ground probably would not be effective anyway, because the downy mildew pathogen persists as thick-walled, chemical-resistant structures that are partially buried in leaf debris and soil.

Develop a disease scouting protocol. Because table grapes and wine grapes are susceptible to many diseases, you should have a proactive, preventative spray program rather than wait for diseases to appear and then act. Even if spraying preventatively, you should scout regularly in case additional control is needed. Walk through the vineyard at least once per week when the lighting is good. Observe lower as well as upper leaf surfaces, and pay special attention to shady or low lying areas of the vineyard that are slow to dry and therefore prone to diseases.

Develop a fungicide spray program. Even if you intend to be certified organic or "low input," fungicides will be needed to control diseases in most years. Most grape pathogens prefer soft, succulent tissues and immature berries. Therefore, diseases are controlled best by spraying preventatively in the early season rather than trying to eradicate a disease after it becomes widespread in July or August. Dormant (i.e., when buds are swollen but not yet broken) sprays of lime sulfur or liquid sulfur, applied in enough water to thoroughly soak spurs and cane, can reduce the number of spores of anthracnose, Phomopsis, and powdery mildew pathogens. Dormant sprays are not necessary if the vineyard had little disease the previous year, but they might be worthwhile if you are trying to "clean up" after a bad disease year or if you are an organic grower with limited spray options.

Consult a state or regional Cooperative Extension fruit pest management guide for a list of fungicides and information on which diseases they control. There are dozens of fungicides registered on grapes, but you need just a few to develop a robust spray program. Many growers choose protectant fungicides that are active against multiple diseases (e.g., mancozeb, captan) as the backbone of the spray program. It is also good to have at least two fungicides with post-infection activity that are from different fungicide classes in case you need to control disease after a rainy period. Narrow-spectrum fungicides that work on just one disease might be warranted in special cases (e.g., to knock back a bad case of Botrytis bunch rot).

Keep records. Even experienced growers have bad years when disease control fails. Knowing when, where, and on which varieties the problem arose will help you sort out what went wrong. Although pathogens persist from year to year in the vineyard, grapevines are quite resilient and generally will rebound after suffering significant disease, as long as they are cold hardy.

Basic Grape Insect Identification and Management

Dr. Alan T. Eaton

Extension Specialist, Pest Management, University of New Hampshire, Durham
alan.eaton@unh.edu

To cover this subject in the available time & space, I will put the insect pests into three groups:

1) those that can cause significant injury in New England
2) species that occasionally harm grapes, especially in backyard situations
3) species that can harm grapes, but rarely create significant injury in New England

Japanese beetle, **spotted wing drosophila**, **grape berry moth** and **yellow jackets** are in category 1. Japanese beetles attack the foliage, and sometimes cause serious injury. Their shiny bronze and green backs are distinctive. Since their larvae feed on roots of grasses, populations can be very high when there is a lot of grass in or near the vineyard. There's just one generation per year, and adults are present from about July 1st through early September. Rarely, we see significant grape defoliation from two close relatives: Oriental beetle and rose chafer. They have similar life cycles to JB, and the adults are similar in shape to JB. Rose chafers are light tan in color, with spindly, spiny legs. Oriental beetles have mottled dark gray and tan patches, and are highly variable in pattern. Control of all three is the same: IF THERE IS ENOUGH DEFOLIATION, it is worthwhile to apply an insecticide to control the adults. Mature vines can handle a lot of feeding, while young vines establishing themselves can handle less. For years we used 15% loss of leaf area (by all pests) as a threshold, but when I actually measure it (rather than guess), I rarely find that much. I suggest you scout vines for defoliation every 10 days or so from July 5 through Aug 30th. I recommend being cautious about using Danitol, Brigade or Sevin to control these insects. They are broad-spectrum insecticides. Using them can disrupt insect & mite predators and cause mite outbreaks. While there are insecticides to control the larvae feeding on grass roots, they are not labeled for use in the vineyard. By the way, I strongly urge you NOT to purchase or employ Japanese beetle traps. They attract more beetles than they catch, therefor making the problem worse.

Grape berry moth has two generations per year. The first (overwintered) generation moths fly in mid to late May. The females are tiny mottled brown moths, with about 10mm [3/8 inch] wingspan. They lay their eggs on newly-set berries. The caterpillars hatch and bore into the green berries. When the fruit are still green, the entrance marks are discolored. Later in the season, affected berries shrivel and often show an obvious entrance hole. In New Hampshire, I have a hard time finding first generation larvae or damage, even when I search unsprayed grapes. A second generation of these moths flies in August. This is the one that causes most damage for us in New Hampshire. Their larvae feed inside the berries. An August insecticide is useful to control this, and the NEWA website [www.newa.cornell.edu] can predict the generation timing (thus, spray timing) for your area. Varieties with tight fruit clusters seem to get more injury than those with loose, open clusters of fruit. Populations vary widely, so in some vineyards, it is worthwhile to treat those compact cluster varieties in the first generation as well (usually 7 to 14 days after mid-bloom).

Spotted wing drosophila is a recent invader that has now reached all areas where grapes are grown in New England. It is a light brown tiny fly, about 2mm long. The males have a single dark spot towards the tip of each wing. This species has multiple generations each year, probably 6 to 11 in New England. The pest becomes a problem after fruit reach verasion. The females saw tiny holes into the fruit and insert their eggs. The eggs hatch and the larvae (which may bring their own yeasts & breakdown organisms with them) feed on the berries, which quickly become mushy. Colored varieties with relatively thin skins are the most likely to suffer attack. Many wild plants have fruit that are important hosts for SWD. Controlling them is important if you wish to minimize attack in your vineyard: pokeweed, blueberries, brambles, glossy buckthorn. Monitoring the adults with traps is important, because populations vary widely site-to-site. Trece makes an excellent SWD trap and an excellent SWD lure that you can buy. All you have to provide is a drowning liquid to make it work. Cooperative Extension staff in each New England State have fact sheets, newsletters and photos on recipes (usually apple cider vinegar plus a little alcohol) and details on using traps. Set up traps when your first varieties reach verasion, and remove them when harvest is imminent. When you find more than one SWD fly in your vineyard and fruit have reached verasion, it is worthwhile to spray. Some sprays last for a week or more; others much less. My colleague Mary Concklin has produced and annually updated a chart with the characteristics of SWD insecticides. We post it on the SWD page of our website www.extension.unh.edu and my extension IPM colleagues have done the same on their websites and/or newsletters.

Yellow jackets and bald-faced hornets sometimes cause serious problems at harvest time. We have about a dozen species of them, and populations are the highest of the year at harvest time. Many yellow jackets nest in the ground, and we have more problems with them in dry years, compared to wet years. That might be because many ground nests fail in wet years. The adults have strong jaws, and can bite open fruit. Feeding can introduce unwanted rot organisms, and the wasps threaten workers. This can be a tough problem. I suggest monitoring for nests (spot them by seeing adults fly in & out) in and near the vineyard two or three weeks before harvest begins, and eliminating them. I have a publication that describes the treatment methods (references) but basically you mark the nest and return two hours after dark, and treat with a wasp & hornet JET spray (any brand). Some growers try to spray the crop at harvest time, to stop wasps & hornets, but I think this a difficult trick, both logistically and legally. There is one product that might (?) help, called evergreen 60-6. It can be used very close to harvest, but the label says it is for flies. In my state, that means that licensed private applicators are allowed to try it for another pest (like wasps), but I do not know about its effectiveness.

Group 2 pests: occasionally harm grapes, especially in backyard situations

Grape flea beetle occasionally is a problem, very early in the year. The shiny blue/black beetles are about 4mm long (1/6 inch). They chew on the swelling buds in early spring. In a few sites, they cause significant injury to the buds. It is worthwhile to scout for this, especially in perimeter rows, and see if you find a significant problem. If you do, consider immediate spot treatment of the affected rows/sections. Once buds have grown past about ½ inch, the danger period has passed, and scouting can stop for this insect.

Grape tumid gall a.k.a. **grape tomato gall** can look very bad, especially in some backyard vines, but it isn't an economic problem. In other words, you could spray, but the cost of the spray is MUCH greater than the value of the damage. My advice: ignore it. The cause is a tiny midge fly. It causes swollen reddish galls on stems and tendrils.

Grape plume moth: the small [15mm or 9/16inch wingspan] moths emerge in spring, and remind me of WWI airplanes, since they hold their long, narrow wings to the side when they rest. They lay eggs on the foliage, and the small caterpillars [up to ½ inch, 13mm] are very pale, with lots of short white spines. Using silk, the caterpillars fold a leaf into a protective shape and feed inside. They never occur in high enough numbers to warrant spraying.

Grape cane girdler is a small weevil that punctures the shoots while egg-laying. The shoots tend to break and dangle in such spots. If you search backyard vines, you might find some damage. Don't worry about it.

Group 3 insects: species that can harm grapes, but rarely create significant injury in New England: I put **grape phylloxera** into this category. It is an aphid relative, and most of the injury is to the roots, where you can't see it. The most visible evidence of this insect is the bumpy galls on the undersides of leaves. Control this insect by selecting the proper rootstocks: those derived from American grapes. They are highly resistant to the pest, thus you'll need no spraying.

Mites, **grape leafhopper** and **mealybugs** are almost never a problem in New Hampshire, Vermont and Maine vineyards, but occasionally appear farther south. **Grape mealybug** is an example of a pest that can build up if broad-spectrum insecticides are regularly used. Normally tiny native parasitic wasps and some insect predators hold mealybug numbers in check. Identification: Mealybugs are tiny, oval, almost flat, white insects that suck juices and produce white woolly wax secretions and sticky honeydew.

A final comment: many growers interpret ANY insect on their plants as a pest! To help reduce that tendency, I've recently completed a publication on beneficial insects. It has 72 color photos. Details are below, in the references section.

For More Information:

1) Eaton, A. T. Beneficial Insects in New Hampshire Farms and Gardens. 23pp UNH Cooperative Extension. March 2017. https://extension.unh.edu/resources/files/Resource000499_Rep521.pdf
2) Eaton, A. T. Controlling Wasps, Bees & Hornets Around Your Home. 7pp. UNH Coop. Extension. (re-formatted 2017) https://extension.unh.edu/resources/files/Resource000532_Rep554.pdf
3) To view labels of most crop pesticides registered in New England: www.cdms.net
4) Sonia Schloemann, ed. New England Small Fruit Management Guide. 2017-18. 142 pp.
5) Network for Environment and Weather Applications www.newa.cornell.edu
6) With so many acres of grapes in production in New York and Pennsylvania, Cooperative extension staff in both states have extensive pest management info for grape growers.
7) W.F. Wilcox et al, Eds. Compendium of Grape Diseases, Disorders and Pests. 2016. APS Press

Using Soil Testing and Tissue Analysis for Vineyard Nutrient Management

George W. Hamilton

Extension Field Specialist, Food and Agriculture
UNH Cooperative Extension - Hillsborough County
329 Mast Road - Room 101, Goffstown, NH 03045
Phone: (603) 641-6060 Fax: (603)645-5252
george.hamilton@unh.edu

Table Grape Session

The nutritional needs of grapevines are best assessed through a combination of soil testing, careful observations, and plant tissue analysis. Through soil testing, growers can monitor soil pH, organic matter, and nutrient levels of the vineyard. Soil testing, however, does not take into consideration site conditions and other cultural requirements of grapevines. To ensure that a grapevine is taking up sufficient essential nutrients, carefully observe foliage for nutrient deficiencies, and annual testing the mineral content of petioles through plant tissue analysis is recommended.

Plant tissue testing is the preferred method of monitoring the nutritional health of established vineyards. Tissue test results indicate the nutrient status of vines, and can be effective in identifying extremes, whether at levels of deficiency or toxicity. When samples are systematically collected during a period of years, tissue test results can be a valuable tool to manage the nutritional status of your vines to help identify problems. It is important to understand and correctly interpret tissue analysis data.

Many times plant nutrient imbalances (both toxicity and deficiencies) have been confused as disease problems. Therefore, by tissue testing, grape growers can determine if plant nutrients imbalances are causing problems in their vineyards.

The best times of the year to take plant tissue nutrient samples, are:

- 1st sample option: full bloom (May-June), collect leaves opposite the flower cluster
- 2nd sample option: Collect Most-recently-matured leaves and petioles in mid to late summer before verasion (fruit changes color). Separate the petioles from the leaves and submit the petioles.

Soil testing should be conducted on potential vineyard sites and corrections should be made prior to planting the grapevines. Soil test before planting and every 2 to 3 years thereafter, and whenever visual symptoms indicate a problem. Use the same soil testing laboratory for getting the soil analysis. Different soil testing laboratories use different test procedures and the result values may be different between laboratories and can be confusing.

Soil sampling provides an additional critical piece of information on soil pH. Soil pH determines the accessibility of nutrients in the soil for plants to utilize. Very often, if a nutrient imbalance is detected in the leaves of a plant, we will need to know what the soil pH is in order to determine if soil acidity is the root cause of the issue. Acidic soil pH is one of the biggest limiters to crop production throughout New England. Liming can help reduce this limitation to crop production, but lime takes several months to change the soil pH. Late summer or early fall is a good time to pull soil samples so you have time to put out lime if it is needed well in advance of the spring season.

Summary

- Soil test before planting and every 2 to 3 years thereafter, and whenever visual symptoms indicate a problem. Use the same laboratory.
- Perform plant tissue testing yearly in established producing vineyards at same time each year.
- Check test laboratory for specific collecting procedures.
- Comparing results from year to year will show a reliable trend.
- Map the vineyard - varieties/rootstock, age, topography changes, irrigated vs non-irrigated.

Blueberry Varieties I Like

Eric Hanson

Department of Horticulture, Michigan State University
hansone@msu.edu (517) 353-0386

Several new blueberry varieties have been released in the last decade and even more may become available in the next ten years. This is good news for growers because more choices are available, but choosing the best varieties for your location is challenging because available information on newer types is limited.

The primary need in New England is winter hardiness. New England ranges in USDA hardiness zones from 7a (0 to 5 ^{o}F minimum) along coastal regions in southern states to 3b (-35 to -30 ^{o}F) in the northern interior. Most northern highbush blueberries do best in USDA hardiness zones warmer than 5b. Zones 5a or colder may result in periodic winter injury so growers may have the most success with half-high blueberries. These are hybrids of highbush blueberries (*Vaccinium corymbosum*) and lowbush blueberries (*Vaccinium angustifolium*). Plants are shorter (2 to 5 feet tall) but more hardy than most highbush varieties. Hardiness zones are based on average winter minimum temperatures, but growing season length can also affect blueberry success. Blueberries do best with more than 160 frost free days and shorter growing seasons often do not allow bushes to fully acclimate for winter. Local topography also influences the likelihood of winter and spring cold damage. Once you have identified varieties that should tolerate your climate, you can begin to narrow your choices based on other traits, such as productivity, fruit quality, harvest season, and disease tolerance.

Varieties that should do well in much of New England are described in Table 1. To narrow your choices, consult your local Extension experts and also observed what has performed well for other growers in your area. Make sure to consider varieties that are adequately hardy for your location. We have also included descriptions of newer varieties. These are recent releases that have not been tested adequately to recommend, but should be trialed on a small scale.

Early-season

‘Duke’ is the best early variety for warmer areas, and has replaced older types such as ‘Earliblue’ and ‘Bluetta’ in most areas. It is high yielding and produces large firm fruit that store well, have a nice mild flavor and can be machine picked. It is less hardy so may not do well in zone 5 or colder. ‘Bluejay’ is another good choice for warmer areas, although yields can be inconsistent. Berries have excellent overall quality and bushes are upright growing and harvest well mechanically. ‘Northland’ and ‘Patriot’ are two older very hardy types for cold areas. They grow about 4 feet tall, and are very productive but berries are soft. ‘Northland’ is earlier than ‘Patriot’ but berries are small and darker. ‘Patriot’ produces larger berries with a nice flavor. ‘Polaris’ and ‘St Cloud’ are two other hardy half-high types that mature in the early season and produce firmer fruit than ‘Northland’ or ‘Patriot’. Polaris fruit are large and flavorful, and bushes grow to about 4 feet tall.

Newer early-season types that show promise include ‘Blueribbon’, which was released by Fall Creek Nursery in Oregon in 2012. Blueribbon matures between Duke and Draper and reportedly has high yields and exceptional flavor. Blueribbon is expected to be only as hardy as Legacy, which would be a problem in most of New England. ‘Sweetheart’ (New Jersey, 2011) is a very early type with good firmness and superior flavor, but fruit may be somewhat small, variable in color and soft. Huron (Michigan, 2009) as an early midseason type (between Duke and Draper) that appears hardier and a more consistent producer than Duke, with medium to large flavorful berries. Like ‘Duke’, ‘Huron’ blooms late to avoid spring frost damage.

Mid-season

‘Bluecrop’ is still worthy of planting in warmer locations for its high yields and large fruit. Fruit have good flavor, but they do not store for long. The bushes are moderately hardy, 4-6 feet tall and somewhat spreading. ‘Draper’ is a newer variety that ripens before ‘Bluecrop’. It often is not as high yielding, but berries have excellent flavor and firmness, and store for a long time. The bushes are somewhat slow growing and less vigorous than most varieties, but appear to be as hardy as ‘Bluecrop’. ‘Sierra’ and ‘Toro’ are good mid-season types for warmer New England locations.

Mid-season types to consider for cold locations include the highbush ‘Blueray’ and the half-high ‘Chippewa’. ‘Blueray’ is hardier than ‘Bluecrop’ and productive, but berry quality is not as high and the bushes produce many canes and take extra time to prune. ‘Chippewa’ is very hardy and grows to 4-5 feet. ‘Superior is a newer (2009) half-high from Minnesota that matures in the late mid-season. It is very hardy, with good fruit quality and grows to 5 feet tall.

New mid-season types include ‘Razz’ (New Jersey, 2011) and ‘Top Shelf’ and ‘Clockwork’ (Fall Creek Nursery, 2012). Reports indicate ‘Razz’ is a reliable producer with medium to large fruit. Berries have average firmness and may not store well. The name relates to the flavor, which has raspberry overtones. Hardiness of ‘Razz’ is not known. ‘Top Shelf’ and ‘Clockwork’ ripen with ‘Draper’. ‘Top Shelf’ is meant for hand picking and has excellent size and flavor (‘Draper’ is a parent). ‘Clockwork’ was developed for processing because berries are smaller and ripen all at once for machine picking. Hardiness of ‘Top Shelf’ and ‘Clockwork’ is not known but based on their parentage, they are expected to be similar to ‘Legacy’.

Late season

Some varieties to consider for the late season, in order of ripening. include ‘Nelson’, ‘Jersey’ ‘Legacy’, ‘Liberty’, ‘Elliott’ and ‘Aurora’. Nelson has excellent overall quality but is a little less hardy so yields have been site specific. Jersey is a reliable hardy producer but berries are small and soft. ‘Legacy’ is a very productive, high quality variety that matures with Nelson but has a long picking season. Hardiness is limited; ‘Legacy’ will do well only in the mildest New England locations. ‘Liberty’ is a newer type that ripens a little before ‘Elliott’ but has much better flavor and storability. ‘Liberty’ should do well in warmer locations. Elliott is very late maturing and extremely productive, and as hardy as Jersey, but berries have marginal flavor.

‘Aurora’ is the latest variety available. It is as hardy as the other late types and productive. Berries are somewhat tart.

Two new late-midseason types released by Michigan State University in 2013 are ‘Osorno’ and ‘Calypso’. ‘Osorno’ has yielded very well in various locations and has exceptional fruit quality. ‘Calypso’ also has shown high yields and quality in diverse test locations. ‘Osorno’ and ‘Calypso’ are hardier than ‘Legacy’, but may not do well in very cold sites. Two new types from Fall Creek Nursery are ‘Cargo’ and ‘Last Call’. ‘Cargo ripens a little before ‘Elliott’ and ‘LastCall’ comes in with Elliott. Keep in mind that very late ripening types may not do well where the growing season is short.

Blueberry Pruning and Rejuvenation

Marvin Pritts

Horticulture Section, School of Integrative Plant Science, Cornell University, Ithaca, NY
mpp3@cornell.edu

Regular pruning is an essential component of blueberry management, yet its importance is often misunderstood because the costs to the neglectful grower are not immediate. Yields may still be acceptable for a few years in plantings that have not been pruned, but eventually yields will decrease. Pruning is required to maintain the vigor and productivity of bushes, to aid in disease and insect management, to maintain large fruit size and quality, and to develop an appropriate growth habit for harvesting.

A young blueberry plant will produce many canes for the first several years. Cane production will gradually slow as bushes become tall and individual canes age. Yields will then decrease because of the absence of new growth on which flower buds will form. In older bushes, an increasing amount of leaf area is required to satisfy the respirational demands of both the fruit and wood. Furthermore, light penetration into the canopy will diminish with age, resulting in a shift of fruit production to the exterior of the bush, causing a decrease in bearing surface. Appropriate pruning practices can maintain a blueberry bush in an efficient and productive state, without the detrimental changes described.

Time of pruning

Early spring is the best time to prune blueberries. Although some growers begin pruning immediately after harvest, it is thought that this makes plants more susceptible to winter injury and reduces the long-term productivity of bushes. By pruning in early spring, one can identify winter-injured wood and remove it. Carbohydrates produced in autumn will also have had sufficient time to move into the roots and crown for storage.

Selecting canes for removal

When selecting canes for removal in older plants (e.g. eight years or older), first look for any winter-injured or broken canes, or canes with disease and insect damage. If injury is severe, remove that particular cane. Cankers and scales are common pests that can be partially controlled through pruning. Second, remove any cane that is rubbing against another to prevent canker infections. Third, remove those that are interfering with movement through the alley. Aim for a plant with an upright growth habit, yet with a sufficiently open canopy to allow for light penetration. Mechanically harvested bushes should be trained to a more upright habit and narrower crown than those that are hand harvested. Fourth, remove short, branched canes that never receive much light. If these canes produce fruit, it will ripen late and will rarely be harvested. Then, remove two or three of the oldest canes (those greater than 1.25 inches in diameter) if these were not removed using the previous criteria. Removing these older canes will stimulate new cane production and improve light penetration into the canopy.

Care should be taken to remove canes as close to the crown as possible. Do not leave 6 to 8 inch stubs. These will rot and act as a source of disease inoculum, but not stimulate new cane growth.

Pruning young bushes

Little pruning is required on young bushes. Remove flower buds for the first two years to promote vegetative growth. This can be achieved by rubbing off the fruit buds, or by pruning the tips of shoots where the flower buds are located. At the beginning of the third year, remove any twisted or low-growing canes to promote new cane production.

If more than two new canes were produced the previous year, remove all but the two healthiest at the crown level. In subsequent years, continue light pruning until the plants reach full size, removing all but 2 or 3 of last season's canes. When plants are about 8 years old, they should contain between 10 and 20 canes of many different ages. Some cultivars produce many more canes than others, so the amount of pruning that is required on young bushes will vary with cultivar.

Mature bushes

Eight year old canes start to lose their productivity as more leaves are required to support a given amount of fruit on those canes. In addition, canes have branched considerably, and the most recent growth on which flowers form is usually thin and weak. Removing one or two of the largest canes in a mature bush will promote new cane growth. If bushes contain a mixture of canes of different ages, then annual removal of canes that have reached 8 years of age will allow for a minimal reduction in productivity, as 7-year-old canes grow to replace those that were removed. Regular renewal will allow for consistent long-term productivity.

Canes larger than 1.25 inches in diameter are not as productive as younger canes, and eventually should be removed. If one or two of the largest canes in a mature bush are removed annually, and one or two new canes are permitted to grow, then an even age structure among canes can be maintained. In general, up to 20% of the older wood can be removed from a bush without adverse effects on yield. Although berry numbers will be reduced, larger fruit will compensate for this decrease.

Regularity of pruning

Annual pruning is essential for stable production and high productivity. When bushes are pruned irregularly, young canes are produced in great numbers the year after heavy pruning. These canes will age together, and become unproductive at the same time. If one then wants to prune out the unproductive canes, nearly the entire bush will have to be removed. Also, no young growth is present to make up for the loss of fruiting wood. Therefore, irregular pruning results in erratic yields from year to year, and tall bushes will develop as individual canes elongate to compete for light. Research has shown that annual, moderate pruning produces bushes with the fewest canes, but with the greatest yields.

Detailed pruning

Removing injured wood should be the primary objective of detailed branch pruning in the tops of the canes. Branch pruning can result in higher fruit quality because berry numbers are reduced. Also, branch pruning can help relieve drought stress in hot climates where plantings are unirrigated. However, if one has done a good job removing whole canes, then little detailed pruning will be required.

Weak bushes require more pruning than vigorous bushes because pruning stimulates vegetative growth. Also, special consideration must be given to varieties with spreading habits. Sprawling canes should be removed, but care should be taken to leave sufficient canes for fruiting.

Rejuvenation

When rejuventaing an old planting, remove one or two old canes for every five or six younger canes. In following years, remove up to 20% of the wood until new cane growth occurs. Keep only 2 or 3 new canes and continue to remove up to 20% of the oldest canes. Eventually, the bush will become more productive, cane numbers will decrease, and bush stature will decline.

In old, poorly maintained plantings, some growers have had success cutting all the canes to ground level; harvesting begins 3 years later. However, for this system to be most effective, emerging canes must be thinned to the most vigorous 6 - 10. Others find that summer hedging immediately after harvest, coupled with selective dormant cane removal, works well in old plantings.

Summary

Pruning is an investment in the future productivity of the blueberry planting. Regular annual pruning will spread costs throughout the life of the planting, ensure stable production from year to year, and serve as a useful tool for managing pests, fruit load, and quality. A properly pruned blueberry planting will looks 10 years old even though it is 50.

Proper Management of Blueberry Nutrition

Eric Hanson

Department of Horticulture, Michigan State University,
East Lansing, MI 48824 hansone@msu.edu

The nutrient requirements of blueberries are quite different from those of other fruit crops. One difference is that their nutrient needs tend to be relatively low, and excessive soil nutrient levels can hinder rather than help plants. Many growers get into trouble following the "if some is good, more is better" philosophy. Here are some basic concepts and thoughts on fertilizing blueberries.

Common Nutrient Problems. Soils vary by region and so do nutritional problems. Most Michigan blueberries are grown on naturally acidic sandy soil with a high organic content. The primary nutrient problem is lack of nitrogen (N) and high pH-induced iron chlorosis. Shortages of phosphorus (P), potassium (K), and magnesium (Mg) occur occasionally, and shortages of and most micronutrients are relatively rare. Other nutritional issues may occur on different soils. This is particularly true if heavier or more alkaline soils are used.

Soil pH. Many nutrition problems can be avoided by maintaining a proper soil pH. Optimum soil pH for blueberries is 4.5 to 5.0, but plants usually do fine a little above or below this range. If pH is above 5.5, leaves become chlorotic and plants lose vigor. Very acidic soils (pH < 4.0) can also reduce growth, particularly those with significant amounts of clay.

Measure soil pH before planting and every few years thereafter. Apply sulfur to reduce soil pH. Do not use aluminum sulfate; it is expensive and may injure bushes. Measure the pH to determine how much of a reduction is needed. As a guide, 300, 600 or 1,000 lb of S per acre are needed to reduce pH by one unit (e.g. 6.0 to 5.0) in a loamy sand, sandy loam, or loam, respectively. Apply sulfur a year before planting, since it takes a season to react in soils. Lime may help if pH is below 4.0, but we have not seen benefits from lime applications if pH is higher.

Soils that have been acidified tend to migrate back to their original pH, so additional sulfur may need over time. If irrigation water is high in alkalinity (dissolved lime), watering will tend to gradually increase soil pH. Alkalinity levels above 100 ppm are high enough to increase pH.

Nitrogen. Blueberries on most soils require annual N applications for good production. However, excessive rates can also reduce blueberry vigor, yields and hardiness, and also waste money and pollute water. Nitrogen management is even more important in very cold locations, since a slight reduction in hardiness can lead to winter damage. Use fertilizers containing ammonium (NH_4^+) nitrogen. Use urea if the soil pH is sufficiently low (below 5.0), and ammonium sulfate if the pH is slightly high (above 5.0). Ammonium sulfate is more acidifying (reduces pH) than urea. Mono-ammonium phosphate (MAP) and di-ammonium-phosphate are suitable N sources if P is also need. Blended fertilizers contain other nutrients may also be suitable if most of the N is in the form of urea or ammonium.

Start with low rates on young plants and increase amounts as the plants age, up to 60-70 lb N/acre on mature plants (Table 1). These rates may need to be adjusted by soil type. More N may be needed on very sandy soil with little organic matter, whereas plants on organic or fine-textures soils may require much less N.

Table 1. Blueberry nitrogen recommendations (lb/acre).

Years in field	N	Urea	Ammonium sulfate
2	15	35	75
4	30	70	150
6	45	100	215
8	65	150	300

Apply N during periods of peak demand by the plants. Our recommendation is to apply half of the annual amount prior to bloom and the second half at petal fall. If your site is very cold and winter injury is common, be particularly careful about the rate and application time. High rates tend to keep blueberries growing too late into the fall so the wood and buds will not have time to acclimate to the cold. Also avoid fertilizing after early July as this may also stimulate late growth and reduce hardiness.

Blueberries usually benefit from mulching with wood chips or bark. Mulch materials with high C:N ratios tie up N as they decompose, so more fertilizer may need to be applied to get enough N to the plants. Fresh sawdust and wood chips can have C:N rations of 500:1, so N rates may need to be doubled where these are applied. The C:N of bark and aged wood chips is usually lower, so N rates may not need to be increased quite as much.

Phosphorus. Many Michigan blueberries contain deficient leaf P levels even though soil test adequate for P. When plants are deficient, leaves develop a darker green, purplish color. We need to test some strategies for correcting P shortages. At this point, a reasonable program for P deficient plantings is annual applications of modest rates (25-50 lb P_2O_5 per acre). Two useful fertilizers are monoammonium phosphate or MAP (11-52-0) and diammonium phosphate or DAP (16-48-0).

Potassium. K applications are usually not needed each year unless the soil is very sandy. Acute deficiencies cause the margins of leaves to scorch and brown as if they are drying out. Rates of 50-75 lb K_2O per acre correct most deficiencies. Use potassium sulfate (0-0-50) or muriate of potash (0-0-60). Muriate is cheaper than potassium sulfate but the chloride in muriate can injure blueberries. Use some caution if you choose muriate. I would suggest applying this material in the fall so winter precipitation can remove chloride from the soil. Do not use muriate on young bushes or apply more than 100 lb K_2O per year.

Soil testing is best used in blueberries to monitor soil pH. Soil test nutrient levels only provide an estimate of nutrient supply and do not accurately describe whether bushes are getting enough nutrients. Sample all blueberry soils before planting, and sample established plantings every 2-4 years. One sample is usually need for every 10 acres. Soils can be sampled anytime. Collect soil with a soil probe or auger from at least 20 locations throughout the sampling unit. Sample from beneath the plants to a depth of 8 inches. Combine the soil in a bucket, mix, and submit a portion for analysis.

Leaf analysis is the best way to monitor the nutrition of blueberries. Sample from young plantings every 1-3 years and from mature plantings every 3-5 years. Sample leaves in late July to early August. Collect at least 50 leaves from different bushes throughout the sampling unit. Select healthy leaves from the middle of this year's shoots. Package leaves in clearly labeled paper bags, and send them to a reputable laboratory. Use Table 2 to interpret your leaf analysis results.

Table 2. Tissue Analysis Interpretation for Blueberries.

Nutrient	Deficient (<)	Normal	Excessive (>)
Macronutrients (%)			
Nitrogen (N)	1.7	1.7 to 2.1	2.3
Phosphorus (P)	0.08	0.1 to 0.4	0.6
Potassium (K)	0.35	0.35 to 0.65	0.8
Calcium (Ca)	0.13	0.2 to 0.6	0.8
Magnesium (Mg)	0.1	0.15 to 0.3	0.4
Micronutrients (ppm)			
Boron (B)	15	20-60	80
Copper (Cu)	?	5 to 20	?
Iron (Fe)	?	60 to 200	?
Manganese (Mn)	?	50 to 350	?
Zinc (Zn)	?	8 to 30	?

Growing Pesticide Free Blueberries in the Age of Spotted Wing Drosophila

Dale-Ila M. Riggs

The Berry Patch and Berry Protection Solutions
15370 State Route 22, Stephentown NY 12168
rberriesrgreat@fairpoint.net, berryprotection@fairpoint.net

The arrival of Spotted Wing Drosophila (SWD) has been a game changer for every berry grower in the United States. SWD arrived in our blueberries in Stephentown NY in 2012, and since we had always been a no-spray farm, this pest caused a 40% crop loss in our blueberries that year. Determined not to have such a loss in the future, we sprayed our blueberries for this pest in 2013. We have a half acre of blueberries, with mature, very healthy bushes, which meant that we could not use a tractor mounted sprayer to spray the planting. We also harvest 7 days a week during harvest season. The combination of pre-harvest intervals, weather events, battery-powered sprayer limitations, and physical limitations of carrying a 40-50 pound sprayer on my 120 pound body made me decide that another way had to be found to manage SWD.

In 2014, I received a Northeast SARE Farmer Grant to explore using exclusion netting for SWD management by adapting my existing bird netting support structure. In my first year, we compared 60 gram ExcludeNet netting to 80 gram ExcludeNet netting manufactured by TekKnit Industries in Montreal, Quebec. The netting was deployed on July 10-11, with the first of the Duke blueberries ripening. While the 60 gram netting delayed infestation by SWD, high levels of infestation occurred by the end of the season. The 80 gram netting had a total of **0.67 percent** infestation over the course of a 10 week harvest season. We had the highest yields **ever** that year. A key component of my netting system is having one defined entryway. We constructed a double-door entryway to minimize the ability of SWD from being introduced accidentally into the planting. I believe that having one defined entry, with an easy in/easy out system (a zippered doorway) is key to making an exclusion netting system work.

Seeing the potential of the system, and using the material for one year gave us ideas on how to change our attachment system for the netting in 2015. In 2015, we got the netting up one week earlier – on July 5-6. It was a smaller crop that year and a shorter harvest season. We had **0.37 percent** infestation over the course of a 6 week harvest season.

Two years in a row taught us that this material really works so our focus in 2016 was to get it up even earlier and to start to think about ways to make it easier to put up and ways to address the issue of "what do you do if you get an infestation inside the netting". We deployed the netting on June 29-30 in 2016. Over the course of a 9 week harvest season, we had **0.00 percent** infestation. Not one single berry out of over 2000 berries sampled had SWD larvae! We also had an observational trial, consisting of 2 replications, of an "attract and kill system". This system is made of red spheres, with an insecticidal cap comprised of spinosad insecticide and sugar in a slowly dissolvable material. Once the cap is "activated" with water (with a mist bottle in my case, or with rain in a standard summer), SWD are attracted to the red color, land on the red sphere, feed on the sugar/spinosad mixture, and hopefully, die. We also added an attractant lure to the sphere to further attract SWD. The spheres were hung in blueberry plants in small netted plots, but which we purposely set up to allow SWD to invade (entering to harvest by picking up the side of the netting, not attaching tightly at the bottom, not repairing small holes in the netting). Preliminary data from the spheres was very promising so we expanded the trial in 2017 to 4 replications.

In 2017, we deployed the netting later than we wanted (July 4th), thanks to being busy with the late strawberry harvest. We had ripe Duke blueberries when the netting went up. In 2017, the first SWD was caught in NYS in May, and the first SWD was caught at our farm in mid-June. On June 27th, there were three SWD caught in the ripening Dukes in the area that was eventually covered with netting. On July 5th, four SWD were caught in one trap inside the netting and on July 10th, 20 SWD (19 females) were caught in the ripe Dukes inside the netting. At that point we went on a sanitation blitz, making sure that no dropped fruit were left on the ground and our crew started harvesting bushes with sheets of plastic underneath so that all dropped berries were removed from the planting every day. We set up a systematic harvest schedule so that every bush was harvested twice a week and I deployed both red attractant spheres with insecticidal bait and six SWD traps to do some “mass trapping”.

Trap counts went down and we did not detect any larvae in fruit for several weeks. In late July, during an evening evaluation inside the planting, I observed one SWD on one berry. Two days later, two small larvae were detected in our weekly sample of 225 fruit. The larvae were from the area with the ripe Dukes and the trap that picked up the first adults. After consulting with Greg Loeb and Laura McDermott, I made the decision to make an application of spinosad insecticide and continue to monitor the fruit infestation results to decide if another application would be needed. So that we could continue to harvest, I sprayed one half of the front of the planting that had ripe and ripening fruit, focusing on the lower part of the bushes. Three days later, I sprayed the other half of the front of the planting. Infestation results went down to zero, and trap counts continued to be very low. Because of that, I did not make any more applications in 2017. I believe the combination of sanitation, mass trapping, and attract and kill spheres enabled me to manage the SWD population that had already established itself prior to deploying the netting. Only four larvae were detected in over 1200 berries sampled from netting deployment until August 21st, when there was an uptick in the number of larvae found. Most of the larvae were found in bushes that were no longer being harvested, later varieties that still had lots of fruit were still clean. We harvested fruit from July 7th to September 15th, a ten week harvest season. In 2017, my crop was the largest ever, exceeding my 2014 record by 19%.

I learned many things regarding the netting system. This system has worked far better than my greatest dreams for using the netting. Besides the obvious benefits of being able to again grow blueberries without having to spray for SWD, the netting provided other protection. Over the four years that I have used the netting, my crop has been protected from three hail storms; five severe thunderstorms with 30-60 mile per hour wind gusts; numerous hard rains, and of course, birds. The netting breaks the wind and diffuses heavy rains so that I no longer see ripe berries coating the ground after a heavy rain or thunderstorm. I don’t believe it is a coincidence that my top three production years have been during the four years that I have been using the netting.

My talk will focus on how we set up our system, aspects of the system that we have changed over time, the cost and payback time for the netting, and the results of the research that we have done over the last four years.

Future research needs to focus on structure design – what is the easiest, most economical way for growers to construct a support system for their planting. Should it be posts and wires? Should it be a hoop system like I adapted from old high tunnel parts? Should it be a modified shade structure? Should it be something that no one has yet envisioned? Every farm will be different based on their own knowledge and resources available.

In 2017, for the first time, I also used exclusion netting on my high tunnel raspberries, again using a double door entry system. It worked extremely well, despite my raspberries having 22 larvae **per berry** prior to setting up the netting. More information about the raspberry work is available by contacting me.

Netting can be obtained from Berry Protection Solutions. Contact information is: berryprotection@fairpoint.net or 413-329-5031.

Chemicals, Management and Equipment for Controlling Spotted Wing Drosophila

Dean Polk,

Rutgers Agricultural Research & Extension Center
121 Northville Rd, Bridgeton, NJ 08302
deanpolk@njaes.rutgers.edu

Background: The spotted wing drosophila, *Drosophila suzukii* (SWD) is native to southeast Asia, and had been found in Hawaii since the early 1980's. It was first discovered in the Pacific west in 2008, and by 2010-2012, it had spread though much of the eastern U.S. and upper Midwest. Also know in the common grouping of 'vinegar flies', SWD has specific characteristics that make it problematical to fruit growers. The female has a long pointed ovipositor with a double row of saw-like "teeth" which enables the fly to "saw through" the skin of small and thin-skinned fruits. Other vinegar flies are not capable of this behavior, so they can only lay eggs on already harvested, and over mature and rotting fruit.

Life History, Alternate Hosts and Their Relationship to Spraying: The ability for the female to oviposit and reproduce on otherwise healthy fruit has disrupted IPM programs, causing many fruit growers to change pest management and spraying practices. SWD is a pest of blueberries, raspberries, blackberries, strawberries, and cherries. It has been reported on tomatoes, grapes and peaches, but its pest status on these crops is not as critical. Females are usually attracted to ripening fruit as it starts to color. After mating, females cut a slit in healthy fruit and deposit an egg just under the skin. Multiple eggs may be laid on a single fruit, and females can average 7-16 eggs laid per day. The female may lay from 300 to 384 eggs in her lifetime of about 60 days. The larva or maggot hatches soon after the egg is deposited, and as it grows, the fruit softens and starts to collapse, often being invaded by fungi that hasten the decay process.

The insect goes through a complete metamorphosis, in that it has 4 distinct life stages: egg, larva, pupa, and adult. Its rate of development is dependent on temperature, with optimal development occurring between 68^0 to 86^0F. Lower temperatures slow down development, as will higher temperatures. The lengths of the various developmental stages can be: eggs – from 12 hr. to 3 days, larvae – from 3 to 13 days, pupae from 3 to 15 days. One generation can cycle completely through in as little as 8-10 days.

Where the various life stages are present is critical to understanding its management and achieving effective control. Adults are motile, and spend very little time on immature and ripening fruit, although adults will feed on dropped and softening fruit. Since the eggs are laid just under the skin, they are not accessible by most insecticides, except a few that may kill very young larvae. Neither is most of the larval stage, since it develops entirely inside the fruit. The pupae, which usually drop to the ground and incubate before the adults emerge, are also not accessible by insecticides, since their location is not targeted. They are protected by weeds, sticks and other ground "trash"; and they can't take up insecticide through feeding, since they don't feed. Therefore the principal target for SWD management is the adult stage, usually laying down a cover of insecticide to kill both males and females as they fly, and land on leaves and fruit, and females as they lay eggs.

SWD overwinters as adults in protected places and under snow cover. In New Jersey and many other states SWD adults can be captured all winter long. This means that even early maturing fruit like strawberries can be attacked. SWD will not just "hone in" on the crop that is ripening at the time. There are numerous non-crop hosts, which SWD will also use. These include wild *Vaccinium* spp. like wild blueberry and huckleberry, wild blackberry chokecherry and wild black cherry, dogwoods, elderberry, hawthorn, honey suckle, cherry laurel, mulberry, pokeweed, wild grape, and yews.

As your crop starts to ripen, remember that SWD prefers ripening fruit that is still on the plant. It will lay eggs on dropped fruit, but doesn't necessarily prefer them. However, if the amount of dropped fruit is large then it represents a greater number of host sites. Therefore every effort should be made to pick frequently and clean up or bury dropped fruit if possible.

SWD likes the shade, and during the growing season it is most active shortly after sunrise and again at dusk. This means you need good weed control, since many of the adults are often near the bottom and just under the plant. A raspberry or blueberry planting with heavy weeds is a difficult system in which to manage SWD. Sprays that are timed for early in the morning or at dusk will likely be more effective than insecticides applied during the heat of the day.

Make sure you use sufficient spray volume to cover the entire plant – top, bottom and undersides of the leaves. Remember that this is not spraying a two dimensional target. If you are used to covering 3-4 rows at a time, then maybe your equipment can only cover 2 rows at a time. If you are used to using 20 gal of volume per acre, maybe you need 40-50 gal per acre.

Spray frequently. Many state recommendations suggest a 7 day schedule, but as the season progresses even a 7 day interval might be marginal. I have seen growers stretch the interval to 2 weeks in mid July, and end up with 6 or more maggots per quart of fruit. I know one grower who sprayed through June and then stopped, and by mid July had over 600 maggots per quart of berries. The reason for the frequent application intervals revolves around the speed of the insect's development and the fact that the adult is the main target. SWD has a huge reproductive capacity. If a female lays 300 eggs in her lifetime and half of them develop into more females, and each one of those also lays 300 eggs, populations build fast, especially if the time from egg to adult is 10 days. As the growing season progresses and the population increases, generations tend to overlap. Using our example in mid July, we might have 5th generation females ovipositing on berries, which inside already have older 4th brood larvae, accompanied by some 5th brood larvae. Such a situation means that at any one time during the summer, only a very small percentage of the insects may be in the adult stage. The rest are inside the fruit as eggs and larvae or sitting on the ground as pupae. Therefore the target you are trying to reach may only consist of 8-10% of the entire population.

Monitoring: Male flies are easily recognized by the spot on the end of each wing and the 2 black bands on each of the front legs. Females have a long serrated ovipositor for which you usually need a hand lens or a small microscope to see. Traps are usually a hanging vessel, like a 1L plastic cup, and a fermenting bait or commercial bait hanging above a drowning solution. The commercial baits will last about 1 month before they have to be changed. We use either the Trécé Broad Spectrum Lure® or the Scentry SWD lure above 5-6 oz of apple cider vinegar with a drop of unscented dish soap. The dish soap breaks the surface tension of the drowning solution so all the captured flies sink. The traps should be set about 3 feet high well before your first susceptible crop starts to color. Traps should be set at the border of a wooded area near your crop, or in the first crop row by the woods. Traps should be checked once or twice per week by straining the contents into water or the old drowning solution, and spreading on a large petri dish or shallow glass bowl to count adult SWD. There is no trap count treatment threshold. If there are SWD adults in the trap, and you haven't started spraying, then start immediately.

Check the crop for any maggots that might get through your program. There are 2 methods outlined below: The first, "salt floatation method," is fast but will isolate only half grown or larger larvae. While the second method, the "filter method," takes a little more time, but will isolate even the smallest larvae. Both methods use a saturated salt solution made from 1 cup salt to 1 gal of warm water. We use a standard sample of 1qt of fruit per monitored field. You could use a pint if you have a small planting.

Flotation method: Place 1 qt of field run, unsorted fruit in a shallow 8x12 baking pan, and pour over 2 qt of warm salt water (1 cup of salt per gal). Place a ¼" mesh hardware cloth that has been cut to fit the pan, over the berries and press down to gently massage the fruit to break the skins, but not mashing them up. Place 2 pieces of round steel bars on top the hardware cloth to weight down the fruit, and then wait about 10 minutes for any maggots to float to the surface.

Filter method: Use the same amount of fruit as above and place in a 2 gal ziplock bag (or 2, 1 gal bags), and gently press the berries to break the skins. Fill the bag with the salt water, squeezing out the air to keep berries covered, and stand the bags for about an hour in a plastic tub so they are upright. Bend a piece of ¼" hardware cloth in a large funnel, and pour the contents of the bag through the funnel into a reusable stainless steel coffee filter. Then rinse the empty bag and berries with a sprayer to wash off any larvae sticking to the fruit or in the bag. Use a strong hand lens or a dissecting microscope to count any larvae in the coffee filter. This method is outlined in detail in: (Van Timmerman, S., Diepenbrock, L.M., Bertone, M.A., Burrack, H.J. Isaacs, R. 2017. A filter method for improved monitoring of *Drosophila suzukii* (Diptera: Drosophilidae) larvae in fruit. Jour. Integrated Pest Mang. 8(1):23; 1-7).

If no larvae are found you have a successful program. If you are packing with any kind of automated equipment, and a few larvae were found in the fruit, then do another sample with the packed fruit. Depending on your packing equipment, the sorting process may itself remove most of the infested fruit as long as your infestation level is low to begin with.

How to Choose Spray Materials: Most state cooperative extension services publish lists of effective materials similar to the list below.

Effective Materials for SWD Control

Pyrethroids	Neonicotinoids	Spinosyns	OP's	Carbamates	Combinations	Diamides
Asana	Assail (w/sugar)	Delegate	Imidan	Lannate	Endigo (Actara + Warrior)	Exirel
Brigade or Bifenture		Radiant	Diazinon		Leverage (Admire + Baythroid)	
Danitol		Entrust	Malathion			
Hero			Fyfanon			
Mustang Max						
Warrior						

A few notes on those materials should be considered when managing SWD during the growing season:

- Rotate chemistries.

- Observe other resistance management strategies, for example use no more that 2 consecutive applications of any one chemistry.
- If using Assail, use for the first spray only when populations are low, and consider sugar @ 1-2 lb/100 gal (Cowles et al, 2015; Knight et al, 2016).
- NuFilm-P can help increase efficacy when used with Delegate, Malathion and Pyrethroids (Fanning, MSU 2017).
- Weather makes a difference in the control you get. If it rains, especially over an inch, then reapply an insecticide.
- Malathion use requires the highest labeled rate of 2 to 2.5 lb a.i. per acre for effective control.
- Avoid the premix materials if your only target is SWD, since the pyrethroid portion is the only effective ingredient, and premixes are more costly.
- Exirel is a very good product, but expensive. Therefore use it if you have other pests that also need to be controlled (fruitworms, aphids, plum curculio, blueberry maggot, cherry fruit fly, thrips, Japanese beetle).
- Good weed control allows the insecticide to have good coverage. Prevent flowering weeds in the aisles since all of the insecticides are bee toxic.

What to Consider in a Sprayer: Sprayers need to be matched to the crop. If you have an airblast or canon sprayer, don't try to cover too many rows. Canon sprayers can do a great job, but if not adjusted properly can cover the first 1 – 2 rows of blueberries, but only the tops of the bushes 3-6 rows in. How far apart are your rows, and can you get between the rows without knocking fruit off when it starts to ripen? Should you consider an over the row sprayer that covers 5-6 rows; and if you use an over the row sprayer, should you consider drop nozzles on the boom. If you have a very small planting, then perhaps a backpack mister is more appropriate (Stihl, Solo, Beamnova, Hudson). If you have a planting that requires a mechanical sprayer, but you have narrow rows, then you may wish to consider narrow gauge sprayers that can be used on small tractors, such as a Jacto, Carrarospray, MM, Cifarelli, Cima, Berthoud, Hardi, FMC/John Bean, and Rears. Many of these can be run on as little as an 18 HP PTO. Whatever your choice, the insecticide needs to be delivered with complete coverage from the bottom to the top of the plant so that active material is always present throughout periods of SWD activity.

Citations

Cowles RS, Rodriguez-Saona C, Holdcraft R, Loeb GM, Elsensohn JE and Hesler SP. 2015. Sucrose improves insecticide activity against *Drosophila suzukii* (Diptera: Drosophilidae). J Econ. Entomol. 108(2):640-653.

Knight AL, Bosoalto E, Yee W, Hilton R, Kurtzman CP. 2016. Adding yeasts with sugar to increase the number of effective insecticide classes to manage Drosophila susukii (Matsumura) (Dipters: Drosophilidae) in cherry. Pest Manag. Sci. 72(8): 1482-1490.

Fanning, P. 2017. Making the most of your insecticide toolbox to manage SWD. Webinar from the Sustainable SWD Management SCRI Project, January 25, 2017. https://swdmanagement.org/wp-content/uploads/2017/02/Making-the-Most-of-Your-Insecticde-Toolbox-to-Manage-SWD-January-25-2017.pdf

Van Timmerman, S., Diepenbrock, L.M., Bertone, M.A., Burrack, H.J. Isaacs, R. 2017. A filter method for improved monitoring of *Drosophila suzukii* (Diptera: Drosophilidae) larvae in fruit. Jour. Integrated Pest Mang. 8(1):23; 1-7. https://doi.org/10.1093/jipm/pmx019

Reading Financial Statements

Julia Shanks

Julia Shanks Food Consulting, Cambridge MA
www.juliashanks.com Julia@juliashanks.com

Often times when I begin working with clients, their #1 question is: "How can I improve profitability? And right behind that is: how can I manage my debt? They are either trying to stabilize or grow their businesses. These questions and many more can be answered by reviewing their books (and financial statements).

If you don't have a good bookkeeping system, the first step in getting to answers is to get the books in order. We can't plan for growth, or trouble shoot challenges today without a solid understanding of where things are.

Most entrepreneurs (and let's be clear, if you have a farm business, you are an entrepreneurs) want to grow their businesses. To create a solid plan for growth, you need to know where you've been. And to understand where you've been, you need to be tracking your business financials. To effectively track, you need to have a basic understanding of accounting.

The Income Statement helps the business owner understand the profitability of her business, as well as the nuances of different product lines and revenue streams (historical)

Key Features

The income statement is a detail of the business activity over a period of time, usually a month, quarter or year.

The income statement details the activities directly related to the operation of your business (selling produce, paying employees), as well as indirect activities (money earned from renting land or interest income).

The income statement shows your total revenue, total expenses and net profit.

The income statement does not track cash flow. The income statement presents a summary of everything you earn through the course of your business. It includes selling products and/or services, as well as the cost associated with running your business: what you spent to purchase your seeds and soil amendments, to pay your employees, for advertising, rent, and so on. It does *not* include details of capital purchases (things like tractors, greenhouses or land) nor financing.

The "Schedule F Income Statement"

Perhaps the best way to understand my chosen format is to see the challenges with the more common format. Most people set up their accounting and tracking system to match with the Schedule F tax form. All the expense categories are in alphabetical order. This is great for tax filings; and for sure it's much more straightforward for tracking, but there is so much richness lost in the numbers.

If business is great, and you don't struggle with cash-flow, then this may be fine for you. But if you find yourself running short on cash, or not making as much money as you think you should, then reformatting your income statement can help you find the information you need to "trouble-shoot" your business.

Because the expenses are organized alphabetically, it's hard to quickly see where the money is going. If you want to understand what it costs to raise your pigs… the direct costs are in two different places – feed and veterinary. Just makes for extra work to pull out the numbers

Second, expenses get buried without any nuance. Is the insurance expense health, liability or workman's comp? If you're trying to manage costs, you want to know where to look. Similarly, taxes could be anything: payroll taxes, property tax or income tax.

Suggested Format for Your Income Statement

I suggest that you organize your income statement into categories that allow you to easily see where your money is coming from and where it's going. If you're using QuickBooks, this is how you'd set up your chart of accounts:

1. Revenue (top line) – just include the sale of products. Income from grants or off farm income should go in "other income."
2. COGS – any product you purchase for resale. If you have a farm store, you may buy jams and jellies to fill out your offerings. You may purchase eggs from another farm
3. Gross Profit – This revenue minus COGS
    a. Gross profit is important for farmers that resell a significant number of others' products. It can tell you if you're charging enough, if you're over-paying, or if something else is going wrong.
4. Operating expenses… and I like to divide them up into 5 major categories – This becomes important when you're trying to manage costs… if you find your expenses are out of line, you can more easily trouble shoot where the problems are.
    a. Direct Operating – anything related directly to the production of your goods – seeds, soil amendments, small tools, mulch, feed, packaging, and so on. This could also be "the cost of production"
    b. Labor – what does it cost to have employees – this includes the actual wages, as well as payroll taxes, workman's comp and health insurance
    c. Occupancy – what does it cost to be on the land – this can be rent, utilities, and property taxes.
    d. General and Administrative – These are the basic overhead expenses – your phone bill, your liability insurance, office supplies.
    e. Repairs and Maintenance – I like to call this one out specifically because this can be a cue as to when it's time to replace equipment or infrastructure. If you find your repair bills are getting out of control, it may be time to replace.

5. Operating Income – This tells you what your business does through its basic operations
6. The Line – You may hear people refer to “above the line” or “below the line”… this is where the imaginary line is drawn.
7. Other income and expenses (below the line)
    a. Depreciation , Taxes
    b. Off Farm Income – You may rent out a parcel of your land, but this is not money you earn farming. If it’s buried in your top line income, you can’t really tell. And as we discussed earlier, it can mask the profitability of your business
8. Net Income (Bottom Line)
    a. If the net income is negative, it may be because of depreciation.

Gaining Insights – Common-Size Numbers

The best way to compare expenses from one year to the next (how much money did I spend on orchard maintenance this year compared to last year, for example) is to look at the numbers as a percentage of revenue. By looking at the numbers as a percentage, you have context… if sales went up, then it’s reasonable to expect that orchard maintenance would go up to.

Troubleshooting Profitability

Too often, the only time farmers look at their income statement is when they don’t have enough money to pay themselves, and they’re trying to figure out why. The Income Statement Can help you figure out why your business is not more profitable. There are several different places where you can look:

I. Revenue – What Happened

You’ll want to look at revenue in several ways. First, look at revenue for different sales channels… is one category growing and another shrinking? Is that causing problems. Also, you can look at your sales mix and how it’s changed. Are you selling more berries than stone fruits? Is one more profitable than another?

II. Cost of Goods Sold – What Happened

If your COGS are going up, it could be one of a few things:

a. Your expenses are going up, but you didn’t increase your prices (or you didn’t increase them enough)
b. You have a lot of waste – you’re not selling everything you purchase or grow.
c. Someone is stealing from you

III. Other Expenses

a. You’ll want to go line by line through your income statement and look at each expense as a percentage of revenue. It helps to look at big categories first (repairs and maintenance, for example, or cost of production) and look for numbers that are unusually large. This is a good place to start digging for problems.

For more details on how to write a business plan or create financial projections, you can purchase my book, The Farmer’s Office or visit my website.

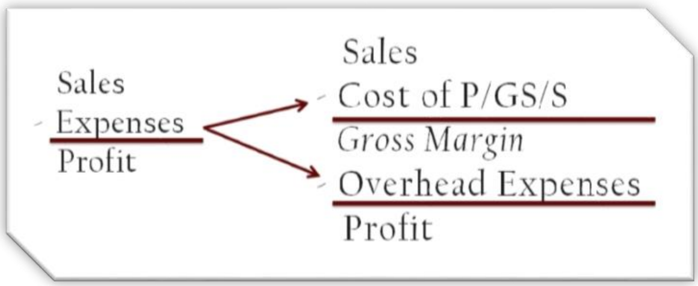
The Power of Margins

Erin S. Pirro

CAC, *Farm Business Consultant*
240 South Road, Enfield, CT 06082
(860) 377-0053
erin.pirro@farmcrediteast.com

Margin means space. It might be the space around this page so the text doesn't get caught in the binding, or it could extra beyond what's needed, or it could mean room for error. In your business, margin is room for you to be able to do things. Those may be the things you plan, things you want to do, thing you have to do, but also the unexpected or the plans that didn't turn out the way you wanted them to.

Financially, gross margin is a measure of how efficiently a business turns raw materials into sales dollars. If it costs $5.50 to grow a dozen ears of corn and you're selling them for $7.50, that's a 27% gross margin ($7.50 - $5.50= $2 / $7.5). "It can't possibly cost that much!" you say. But how do you know until you truly look?



In order to calculate your gross margin, you'll need to be able to separate your variable costs from your overhead costs. These costs, known as the *Cost of* ***P****roduction, Cost of* ***G****oods* ***S****old*, and *Cost of* ***S****ales* are collectively the ones that change with a change in the level of production and sales. That is, you'll use one more unit of input for every unit of output (think about one more vegetable seedling requiring one more pot to put it in, more soil, more fertilizer, more labor – and more inputs when it's transplanted into the field).

This calculation should first be done for the business as a whole to get a baseline. It's the weighted average of the whole business, and we know that averages can hide a lot of sins. So, when you're ready, move on to more specific units to get to know what's making you money and what's just taking up time and space and money. Start with higher levels rather than individual products (think groups of crops such as cucurbits or brassicas if you're in production or departments within your market if you're in a retail environment).

In order to calculate margins by crop or department, you'll need to know how much of something you sold (in dollars) and you'll need to know how much it cost to grow, buy, and sell that particular something. If you don't have the detail on this yet, make it a primary goal to collect this information for 2018. Set up a system (something done the same way each time) to collect the information, and think about the communication needed to get the information where it needs to go ever time. You'll be glad you did, because having department or crop group information helps make the best decision for the farm.

Say this is what your analysis reveals (see chart on the next page). If your weighted average gross margin (for the whole business) is 22%, which crops are bringing up the average and which ones are dragging it down?

Crop	Sales	CoP/GS/S	Gross Margin	Gross Margin % (GM ÷ Sales x 100)
Small Fruit	$190,000	$165,000	$25,000	13%
Tree Fruit	$175,000	$124,000	$51,000	29%
Vegetables	$310,000	$252,000	$58,000	19%
Pumpkins	$65,000	$38,000	$27,000	42%
TOTAL	$740,000	$579,000	$161,000	22%

What other things does this chart tell you about your business?

The danger in looking at sales alone is that there's temptation to grow the biggest department even further. Sure, vegetables gross the most money for the farm and even the most margin dollars. But if you were to expand the vegetable part of the operation, it will cost you 81₵ per dollar of sales. Expanding a higher-performing department such as pumpkins will only cost 58₵ per dollar of sales based on current performance. It may not seem like a lot, but 23 percentage points of return is a *huge*!

There are plenty of other questions that can be answered with this data, plus ones such as these that are prompted by looking at the margin information. For instance,

- What can you do to leverage those that are good margin-producers?
- What can you do to improve the margin on the ones that aren't at least average?
- How much additional business will we need to do to take on that hired manager?

These are just a few quick examples of a way to use gross margin information to make decisions within a business. In order to be able to make those decisions, owners and managers need to put systems in place to capture the information. There may be a learning curve in setting up the system, but that investment of time and energy is well worth it for you to have the information that will lead to more profitable decisions for the years to come.

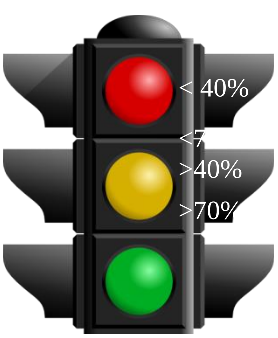
Ratios to Keep Your Business Running at Maximum Performance

Erin S. Pirro

CAC, *Farm Business Consultant*
240 South Road, Enfield, CT 06082
(860) 377-0053
erin.pirro@farmcrediteast.com

Anyone can keep records for their tax return, but a progressive manager keeps records for his or her own operation as the foundation of a toolbox that keeps the business running in top shape. If your business is an engine, then your good management records are the systems information for everything that's running under the hood. Ratios, also known as key performance indicators (KPI), are the gauges on the dashboard. Gauges give you the information you need to know right now, without getting you bogged down in the details that you don't. When your engine starts redlining, chances are you have another gauge that's pegged at the same time so you know you what you need to do next: look at oil pressure or back off the accelerator. Ratios do the same thing for the financial operations of your business.

Here are 5 basic ratios to keep your eye on:

Net Worth Percentage	
What:	This is the scoresheet of everything that you've accumulated from being in business, both assets (everything you own) and liabilities (everything you owe).
Why:	Your net worth percentage is a good indicator of when it's time to make the next investment move.
The math:	Total Assets – Total Liabilities = Net Worth ÷ Total Assets x 100 = Net Worth %
How to use this ratio: 	Calculate your net worth and compare the result to Virginia Tech Professor David Kohl's traffic lights to quickly get a sense of the direction you should go. > 70% - Green means go, < 70% but > 40% - Yellow means proceed with caution (notice it does *not* mean 'put the hammer down to get through this intersection'!), and < 40% - Red means stop. Imagine you want to take on an expansion, and the farmer next door is getting older and thinks he'll probably be looking to sell in 5 years. You'll need a green light for both projects! Calculate your current net worth, your projected post-expansion net-worth, and then what it will look like in 5 years when you want to buy the farm next door. If it's not a green light at any stage, you know now that you need to focus on earning profits to build your net worth. It's also likely that you'll need to make a decision about which is more important to you: expanding or buying land. Knowing that now allows you time to plan, because that farm next door only comes up once in a lifetime – if you're lucky.

Current Ratio

What:	The current ratio is a measure of liquidity.
Why:	Measuring your current ratio gives you a signal about your ability to meet your short-term obligations. If you don't like that signal, you have time to do something about it.
The math:	Current Assets ÷ Current Liabilities: 1
How to use this ratio:	A current ratio of 1:1 means you'll have just enough current assets to cover your current liabilities. That used to be good enough, but what have we come to expect input prices to do over the course of a few months? They can increase quite a bit, so if you've got *just enough* liquidity to cover the needs, you'll be hurting in the case of a price increase. Knowing that now means you can make a plan to increase your liquidity so that you can handle the unexpected.

Gross Margin %

What:	Gross Margin is a measure of how efficiently you're turning your inputs into sales dollars.
Why:	Each crop or product you sell has a different margin potential. Each of them need to carry their own weight to make the business successful. If you know your margins, you can make strategic, focused adjustments to optimize business earnings.
The math:	Sales - Cost of Goods Sold/Production/Selling = Gross Margin Gross Margin ÷ Sales x 100 = Gross Margin %
How to use this ratio:	Lots of different ways! Analyze your efficiency. A higher gross margin means you're getting more out of every input dollar when you sell the product. It's part of your budget goal to cover overhead and generate profit. Are you on target as you move through the year? Select areas of growth. All else being equal, those with a better margin will help you add to your bottom line faster.

Net Margin %

What:	Also known as profit.
Why:	Every farmer knows how much money they 'made' last year, but this is how much you 'keep!' You need profit to pay for living expenses, savings, equipment replacement and reinvestment, loan payments, and a whole host of other reasons – can you name two more?
The math:	Gross Margin – Overhead Expenses = Net Margin ÷ 100 = Net Margin %

How to use this ratio:	Set a goal that will cover your profit requirement. Monitor throughout the year to ensure you're on target. Make adjustments as needed.

Labor as a Percent of Sales

What:	How much of your sales dollar is spent on labor?
Why:	Labor is one a farm's biggest expenses – and it's the first one most business cut when they want to save money. But then how do you get the work done? Chances are, your analysis will reveal a different opportunity.
The Math:	TOTAL labor costs (not just wages) ÷ Sales x 100 = Labor as a % of Sales
How to use this ratio:	• Monitor how labor changes through the seasons in relation to sales growth or slowing • Set and monitor efficiency goals • As a marker for when it's time to invest

Faming Smarter, Not Harder: Discovering Your Profit Centers

Richard Wiswall

Cate Farm
135 Cate Farm Road, Plainfield, VT 05667
www.catefarm.com
www.richardwiswall.com
catefarm@gmail.com

Have an allergic reaction to business? Wonder where all the money comes and goes? Welcome to the most unglamorous, unfun, and most fiercely avoided topic in farming: the business end of farming. But oh, so important.

A farmer can be the best grower, innovator, marketer and mechanic, but all that goes out the window if the farm fails financially. Farmers can handle $100,000, $200.000, $500,000 in a year, but barely keep enough to survive. Discover your profit centers and make more money, and work less hours. Take time to work *ON* your business, not just *IN* your business.

This session will address the tools and concepts needed to shine a light on the inner workings of your farm business, in a farmer friendly way. A quick overview of macro and micro financial tools and how they interact will demonstrate how better to manage your business. For macro tools, an Income Statement paired with a Balance Sheet show how farm finances really work and how tax savings improve your bottom line. A lumpy Cash Flow typical of seasonal farm fluctuations is portrayed visually (no numbers!), with consequences explained.

Micro tools include Cost/Benefit Analysis when thinking about buying machinery, greenhouses or other capital purchases, and show their payback timeline. Another very important financial micro tool is a Crop Budget to determine the crop's profitability; on its own and in comparison to other crops or farm enterprises. Rate all the items your farm produces in terms of profitability, and use this critical information to make savvy business decisions.

Tips for making enterprise budgets will be highlighted. A goal for the workshop is that attendees will leave with ability to figure their farm's crop's costs of production.

High Tunnel Soil Management Update

Bruce Hoskins

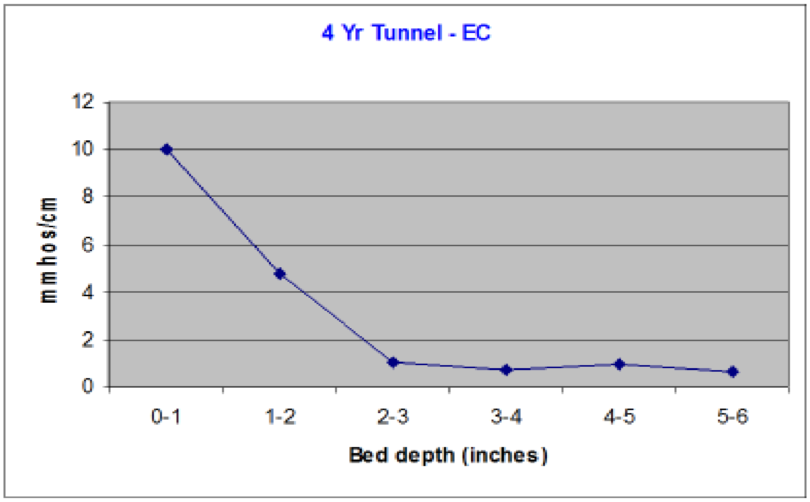
University of Maine, 5722 Deering Hall, Orono ME 04469
Hoskins@maine.edu

The High Tunnel Tomato Production Team is comprised of members from UMaine, UNH, and UVT. Our goal is to improve soil fertility and pest management practices in high tunnel production using organic practices, with an emphasis on tomato production. We are currently in the second year of a 3 year SARE funded project for that purpose, at 3 separate locations in NH and ME. Prior to this our team did a preliminary 2 year project looking at potassium (K) and nitrogen (N) fertility in high tunnel tomato production, using OMRI approved nutrient sources.

We have encountered a number of challenges within these projects that are both specific to high tunnel production and the byproduct of using natural and non-chemical nutrient sources. Many of these problems were unanticipated but also informative. Each of us has also worked with many high tunnel growers on specific problems in their operations. This talk is to share some of the insights gained in this process.

Salt buildup in high tunnel production is a well-known problem. Water is typically applied through drip irrigation only to satisfy immediate needs of the crop being grown. Transpiration of the crop plants plus surface evaporation cause a net upward wicking movement of soil water. Nutrient salts build up over time and eventually have to be flushed by uncovering to natural rainfall or by heavy irrigation. To document this salt buildup, several beds were excavated in one inch increments and measured for total salt content. We found that, regardless of the nutrient source (chemical fertilizers, natural fertilizers, or compost), all beds showed the same pattern of salt accumulation in the top 2 inches (figure 1). The top inch typically has 10 times the salt level and the second inch has 5 times the salt level of the remainder of the bed. This huge stratification of nutrients is best addressed by remixing the beds before each planting cycle.

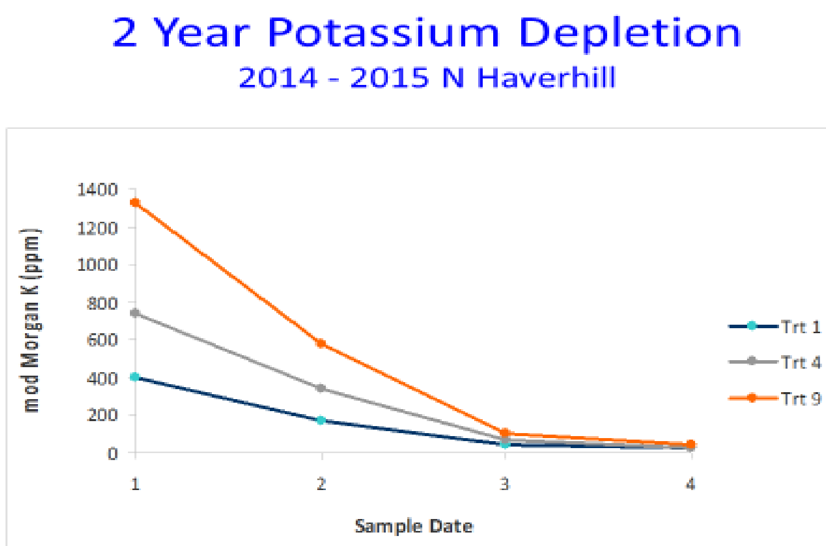
Figure 1.



High alkalinity (hard) irrigation water is a common problem in greenhouse bench crop production. When all water is supplied by irrigation, high alkalinity water can cause soil or media pH to rise over time, causing deficiencies of iron, manganese, or zinc in some crops. This pH "creep" has become an occasional problem for some high tunnel growers as well. Surface water from ponds or streams is the preferred source for irrigation, where available, since these sources typically have very low alkalinity. High pH soil can be (slowly) acidified organically by mixing in elemental sulfur at 15 lb/1000 sq ft of bed area for each 0.5 pH unit drop.

In our preliminary research project potassium (K) was applied the first year as natural potassium sulfate, with 2 successive crops grown with no further K application. Initial application rates ranged from 100 to over 900 lb/A of K. At all locations, soil K levels were "cropped down" by plant uptake to low test levels regardless of initial treatment level. In some cases this was an astounding amount of soil depletion in just 2 years (figure 2). Tomatoes and other solonaceous crops have a strong tendency to "luxury consume" K, whether or not it is needed for normal growth and yield. The high incidence of very low soil test K levels in tomato production high tunnels can be explained by this tendency. One of the goals of current research is to determine the minimum soil level of available K that will maintain maximum yield and quality of tomatoes.

Figure 2

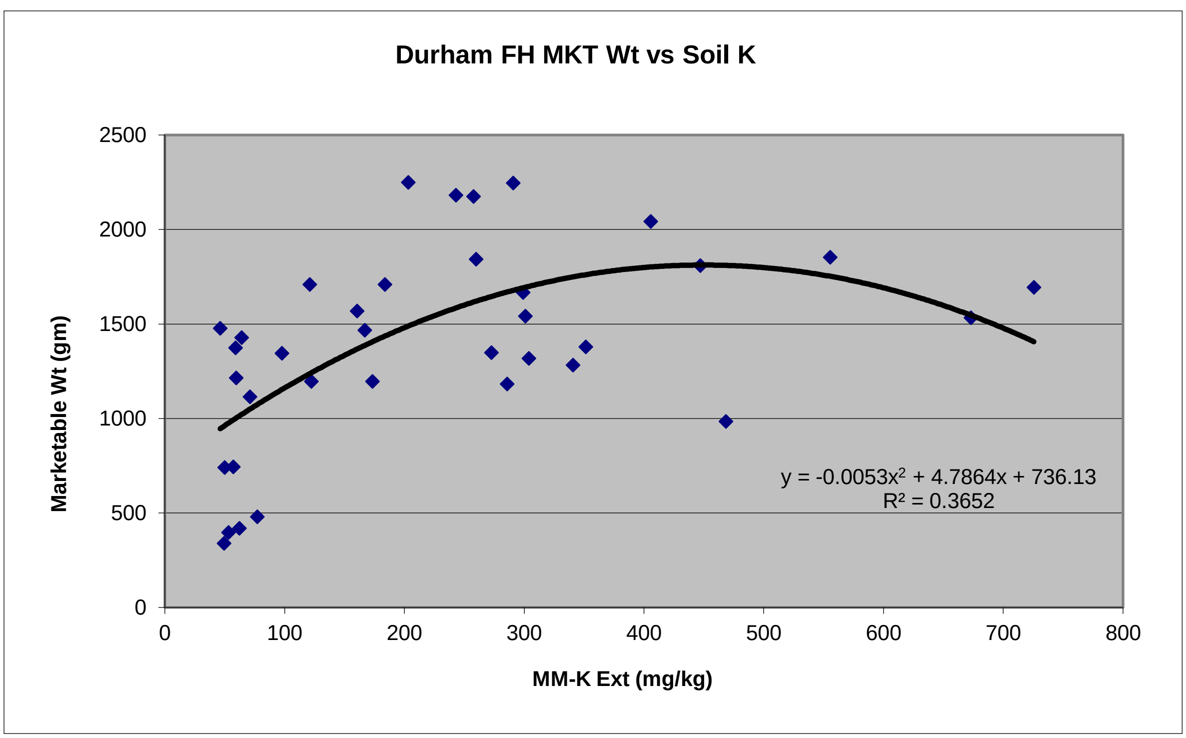


We are attempting to find critical K test levels corresponding to maximum yield and quality, using 2 common types of soil testing methods: a field soil test (modified Morgan) and a soil water test (saturated media extract or SME). The field soil test measures the total quantity of available K in the soil. The soil water test measures the short-term availability of K in soil water (often called "intensity"). The proportion of the total quantity available in the soil water at any given time (the "buffering capacity") is determined by clay and organic matter content of the soil. The 3 locations in the initial study had a range of soil textures: silt loam (higher clay), sandy loam (moderate clay), and loamy sand (low clay). On average, the 2 tests documented relative K intensities of 10 % in the silt loam, 20 % in the sandy loam, and 33 % in the loamy sand. The higher proportion of immediately available K in coarse textured sandy soils leads to faster plant uptake and depletion of the total available K reserves, compared to lower short-term availability in the heavier textured soil. Faster K depletion in sandier soils can be compensated for by applying one or two K applications through the drip later in the season, rather than front-loading all K before planting.

In both preliminary and ongoing research, total and marketable yield as well as incidence and severity of yellow shoulder (YS) were measured as a response to applied K. To document plant uptake, either leaf sap K or full leaf K content were also measured. These samples were used to establish relationships between soil test K (STK) and foliar K, STK and Yield, STK and YS, foliar K and Yield, foliar K and YS. These relationships were investigated for each of 3 locations using both first and last harvest soil and foliar data each year.

Significant relationships were found at some locations at some sampling dates (figure 3), but not consistently. In fact inconsistent relationships seem to be characteristic of all 3 locations for all years. One key observation was the wide range of STK at each treatment level, especially at high treatment levels. This indicated incomplete release of K from the potassium sulfate applications. The source used was a relatively coarse granulation (up to ¼ inch). Unreacted granules of potassium sulfate were found in archived soil samples that were not apparent during initial drying, sieving, and homogenizing. This was observed even in end of season soil samples that were taken one or even two years after application. This is one explanation of the high degree of variability in STK levels and inconsistent relationships with Yield, YS, and foliar K. K fertilizer applications were not supplying intended/assumed amounts of K to the crop. In some cases, we were measuring K in the soil test that had not actually been released for plant uptake.

Figure 3



A fundamental problem with high tunnel production is the hot dry environment and incomplete wetting of beds. This slows or prevents the release of nutrients, as opposed to open field production where soil is thoroughly wet to field capacity several times during the season. Even though both common natural K sources (potassium sulfate and Sul-Po-Mag) dissolve in water quite readily, the presence of undissolved granules at the end of one or even two years points out the severity of the problem. This is also a potential problem with natural nitrogen sources, which require sufficient soil moisture for full mineralization and release of nitrogen in plant-available form. Our recommendation is to maintain 3 – 4 lines of drip in a typical 30 inch bed to minimize dry soil zones and incomplete nutrient release in soil between drip lines. This is especially important in sandy soils which do not readily conduct water laterally, due to rapid infiltration rates.

Habitat Plants to Attract Natural Enemies into High Tunnel Crops

Cheryl Frank Sullivan & Margaret Skinner

University of Vermont, Entomology Research Laboratory
661 Spear Street, Burlington, VT 05405
cfrank@uvm.edu, (802) 656-5434; mskinner@uvm.edu, (802) 656-5440

Aphids are serious pests of vegetables grown in Northeastern high tunnels, causing major damage and revenue loss. They stunt plant growth, secrete sticky honeydew promoting the growth of sooty mold, transmit viruses and reduce crop quality. In addition, infestations can be costly demanding time and labor for management and to salvage crops from loss. Aphids are difficult to detect, but can be successfully managed if infestations are found before they reach damaging levels. To combat aphids, conventional growers have access to a wide array of chemical insecticides, though they are not always effective and may pose threats to human health and the environment. Organic growers face management limitations. They either do nothing and tolerate crop loss, spend a lot on frequent releases of natural enemies or make multiple applications of the few allowable insecticides. The greatest success is achieved with an IPM program that combines all available management tools.

Plant-mediated IPM systems (e.g., trap, banker, and habitat plants) offer innovative ways to contribute to managing aphids and other pests in high tunnels. These systems use plants to attract pests and natural enemies for scouting and to support biological control populations. For the past 3 years, we have evaluated habitat and banker plant systems for high tunnel winter leafy greens and summer crops (tomato, pepper, etc.) at several Northeast sites. The purpose was to determine if these systems attract and support populations of both naturally-occurring and commercially produced beneficials, and if these natural enemies disbursed into the crop to suppress pest populations.

The habitat plant systems consisted of alyssum, beans, marigolds, borage and dill for the summer season and alyssum, beans, marigolds, calendula and viola for the winter season. These plants provide refuge, pollen and nectars to natural enemies, offering a food source if pest prey are absent. Growers are encouraged to be proactive, releasing beneficials before a pest outbreak is observed, but without them, they need an alternate food source, which these plant systems provide.

Over the trial period, a wide variety of beneficial insects were observed on habitat plants. In addition, pest and non-pest aphid species were sometimes found. The most common natural enemies seen on the plants were parasitic wasps and their mummies, *Orius* spp., lady beetles, spiders, and assassin and damsel bugs. Among all of the plant species used in these systems, alyssum was found to be the most effective. It was attractive to many types of natural enemies, was the least likely to harbor aphids, had the greatest tolerance to extreme heat and cold conditions, flowered throughout most of the growing season and was easy to produce. This presentation will describe functions of habitat plant systems in high tunnels and report our current results for the management of aphids. *This research was supported by the Northeast Sustainable Agriculture Research and Education Program; National Institute of Food and Agriculture Crop Protection and Pest Management Competitive Grants Program; and the US Dept. of Agriculture, Extension IPM Program.*

Choosing Varieties for High Tunnel Crops

Becky Sideman

University of New Hampshire Cooperative Extension, Durham NH 03824
becky.sideman@unh.edu

General considerations. High tunnels are greenhouse-like structures with a single or double layer of plastic, with or without heat, power, or ventilation. High tunnels increase the growing season, yield, and fruit quality, and they provide some control over climate and diseases compared to field production. In some cases, however, the high tunnel environment favors certain pests, such as spider mites, powdery mildews, tomato leaf mold, downy mildews of spinach and lettuce, etc.

- When choosing varieties for high tunnel production, it is important to choose those that will not only yield well, but that will also perform well in the face of high tunnel-specific disease and insect pressures.
- No tunnel is the same! Soil type, fertility, irrigation, and crop management strategies may differ from tunnel to tunnel. Varieties that do well in one spot (or study) may not do well in another: some on-farm experimentation may be necessary.

Tomato. Several researchers have compared the performance of tomato varieties in high tunnels. Some have focused on determinate varieties, others on indeterminate varieties. Most have focused on ungrafted plants. At UNH, we compared yields susceptibility to leaf mold and powdery mildew of indeterminate red beefsteak tomatoes in high tunnels (2011-13). We observed large, and significant, differences in marketable yields between varieties, as well as different responses to common high tunnel diseases, especially leaf mold and powdery mildew. Variety selection can be a critical factor for success growing high tunnel tomatoes.

Variety	Marketable yield (lbs/plant)		% cull fruit		Leaf mold	Powdery mildew	Common defects[a]
	2011	2012	2011	2012			
Arbason	21	14	23	14	Severe	None	YS, UR
Big Beef	23	12	11	23	Moderate	Mild	YS, RC
Brandywine	11	9	45	41	None-Mod	Moderate	YS, RC, split
Cobra	17	12	13	14	Mild	Mod-Severe	YS, UR
Conestoga	18	8	22	40	Severe	Severe	YS
Geronimo	25	12	14	32	None	None	UR
Goliath	-	10	-	33	Severe	Mild	RC
Imperial 643	20	12	18	31	None	None	UR
Jet Star	19	9	9	29	Moderate	Moderate	UR
Lola	14	11	28	20	Mild	Mild	RC
Martha Wash.	-	8	-	36	Severe	Moderate	RC
Massada	18	10	15	30	None	None	CC
Rebelski	-	14	-	26	None	-	
Trust	12	7	25	35	None-Mod	Moderate	

[a] Defects: YS-yellow shoulder, CC-concentric cracking, RC-radial cracking, UR-uneven ripening

Some useful reports:

- Determinate tomato varieties, Kansas State University:

http://hightunnels.org/wp-content/uploads/2016-KSU-Tomato-Variety-Trial-Report.pdf

- Indeterminate round red slicing tomatoes, Penn State University:

https://extension.psu.edu/high-tunnel-fresh-market-slicer-tomato-variety-trial-2011

Peppers. At UNH, we conducted high tunnel bell pepper variety trials over a period of three years (2015-2017). Our objective was to compare performance of greenhouse and field pepper varieties for colored bell production in unheated high tunnels. All varieties produced very high quality colored bell peppers for a long production season (harvesting into November each year). With a few exceptions, differences between varieties were generally not significant, and total yields were considerably less than those of tomatoes.

Marketable Yields of Colored Bell Peppers in High Tunnel in Durham, NH.

		Weight (lbs/plant)		No. of fruit per plant	
Type[a]	Variety	2015	2016	2015	2016
HT, yellow	Bentley	5.0	4.1	8.3	8.0
HT, red	Felicitas	4.9	3.9	7.9	6.1
HT, orange	Orangela	4.7	4.0	8.9	8.0
LT, orange	Sympathy	4.3	2.8	8.0	5.5
F, yellow	Early Sunsation	4.3	3.0	7.1	5.8
LT, yellow	Moonset	4.2	3.1	7.4	5.9
F, red	Karma	4.1	3.7	6.0	5.5
LT, red	Sprinter	3.9	2.6	7.1	5.3
F, red	Karisma	3.8	3.7	5.4	5.8
F, orange	Orange Blaze	3.5	3.7	13.4	15.4

[a]HT – ‘high tech greenhouse pepper’, LT – ‘low tech greenhouse pepper’, F – ‘field pepper’.

Some useful reports:

- Mini- and heirloom sweet pepper variety performance in high tunnels, Purdue University: https://docs.lib.purdue.edu/fvtrials/63/
- High tunnel pepper variety trial, University of NH: https://extension.unh.edu/resources/files/Resource005720_Rep8006.pdf

Cucurbits. Cucumbers, and to a lesser extent, summer squash and zucchini are produced in tunnels. Because all of these crops typically have both male and female flowers that require cross-pollination, this requires either 1) use of pollinators such as bumblebees, or 2) use of *parthenocarpic* varieties. These varieties set fruit without pollination. There are many parthenocarpic varieties of cucumbers, and they are often marketed as being for greenhouse use. Just a few zucchini and summer squash varieties are described as parthenocarpic (Partenon zucchini and Cavili summer squash, for example), but recent research at Cornell University suggests that other varieties including Golden Glory also have this trait.

Some useful reports:

- Trellised cucumbers, Penn State University:

https://extension.psu.edu/high-tunnel-trellised-cucumber-variety-trial-2013

- Greenhouse cucumber variety trial, University of NH:

https://extension.unh.edu/resources/files/Resource002705_Rep3994.pdf

Winter Spinach. Many growers use spinach as a mainstay of winter greens production in unheated high tunnels. Spinach cultivars vary in terms of leaf shape, degree of savoy (crinkled leaves), and ease of harvest, and we have some evidence that there are slight differences in yields. However, one of the most significant factors in choosing spinach varieties for high tunnel growing is the level of resistance to downy mildew (DM) each variety has. For varieties growing in humid, cool conditions such as those prevalent in winter and spring high tunnels, choosing those with resistance to the highest possible race numbers of DM is recommended.

Some other useful reports:

- Spinach varieties in high tunnels, Pleasant Valley Farm, Argyle NY: https://www.uvm.edu/vtvegandberry/Tunnel_Conference_2012/ArnoldTunnelSpinachVarieties.pdf
- Winter spinach production in high tunnels, University of NH:

https://extension.unh.edu/resources/files/Resource006103_Rep8625.pdf

Other Crops

There are many other variety trial results available for different crops that can be grown in high tunnels. I'll list some of those resources, which you might find helpful, here:

- Raspberry production in high tunnels, Cornell University: http://nyshs.org/wp-content/uploads/2016/10/raspberry-production-in-high-tunnels.pdf
- Evaluation of strawberry varieties for high tunnel production, Purdue University: https://fff.hort.purdue.edu/article/evaluation-of-strawberry-varieties-for-high-tunnel-production/
- Season extension: Cultivar selection and variety trials, SARE Learning Center: http://www.sare.org/Learning-Center/Topic-Rooms/High-Tunnels-and-Other-Season-Extension-Techniques/Season-Extension-Cultivar-Selection-and-Variety-Trials

Nutrient Management for Fruit Farms

Mary Concklin

University of Connecticut, 1376 Storrs Rd, Unit 4067, Storrs, CT 06269-4067
mary.concklin@uconn.edu

Fertilizer decisions for fruit crops should be made based on scientific evidence of need. This is accomplished using tissue analysis every 1-2 years and soil analysis every 3-4 years. A tissue analysis indicates the levels of macro and micro nutrients present in the plant. Optimal levels of each nutrient have been established for specific fruit crops based on research. A soil analysis indicates the levels of macro (not nitrogen) and some micro nutrients available in the soil, as well as pH. However, not all fruit growers do not use these tools, and instead base their fertilizer decisions on previous experience, advice from sales representatives, recommendations listed on the fertilizer container, plant age, or plant appearance. When decisions are made based on previous experience, a grower could be missing interactions of elements that are hindering production and/or quality. This can also lead to the over-application of nutrients the plant does not need. Although recommendations on fertilizer containers have a scientific basis, they are considered a maintenance amount and are not reflective of the nutrient needs of a specific farm site. Plant age does not take into account specific plant needs, or soil nutrient levels. When fertilizer decisions are based on visual appearance, reductions in crop yield or quality may have already occurred. Diagnosing based on appearance alone does not take into account nutrient interactions.

Excessive rates of certain nutrients can cause interactions leading to deficiencies of other nutrients. For example, high rates of nitrogen can lead to an induced potassium deficiency which has a negative impact on winter hardiness and fruit size. An over application of potassium can lead to an induced deficiency of calcium. The lack of scientific evidence when making fertilizer decisions can result in over- as well as under-applications of many nutrients. The resulting imbalance can affect yield, quality, and may contribute to ground or surface water contamination. An excess amount of phosphorus doesn’t impede plant growth but creates environmental problems that are well documented. Nutrient imbalances can also affect the longevity of a planting which can have an economic impact on a farming operation. Nutrient deficiencies can result in stunted growth, reduced fruit yield and quality, and overall reduced plant health. Excessive rates of nutrients can cause a delay in fruit maturity, an over-abundance of vegetative growth, reduced bud set, and an increase in insect and disease problems. Improper soil pH for a crop can lead to nutrient deficiencies and toxicities affecting fruit quality and plant health.

<u>Combine factors to develop a fine-tuned fertilizer program</u>. Simply put, combining factors that impact nutrient usage, availability and uptake, with tests that provide the status of the nutrients in the soil and plant, will allow for the development of a fine-tuned fertilizer program, and avoid over- and under-application of nutrients. These include soil and tissue analysis, crop load, tree and plant growth, ground management, environmental conditions, fungicides and cultural practices.

Soil analysis indicates the pH level and the amount of nutrients in the soil that are available for uptake by the plants. The macro-nutrients potassium, phosphorus, magnesium and calcium are standard. Some labs will also indicate the level of several micro-nutrients – boron, copper, iron, zinc, manganese, sulfur and aluminum. Nitrogen is a ‘moving target’ and soil tests are not reliable indicators of the amount available to the plants. Relying on this test alone for fertilizer decisions does not take into account what is in the plant or other factors impacting nutrient uptake. It is important to note that if the pH is outside of the recommended range for the fruit crop, even if there is an ample supply of nutrients in the soil, one or more of them may not be as readily available to the plant as they would if the pH was within the optimum range.

At least once during the lifetime of the crop, ask the lab for the percent organic matter (OM) in the soil. This is important for nitrogen decisions. Roughly 10-20 pounds of nitrogen per acre is released for each 1% OM, dependent on soil temperature and moisture level. Of that, approximately 60% is available to the plant. For example, soil with an OM content of 4% may have 40 to 80 pounds of nitrogen released, and of that approximately 24 to 48 pounds of nitrogen per acre would be available to the plant. Some sites may not need additional nitrogen applied in a particular year.

Tissue analysis indicates the level of macro- and micro-nutrients that are in the plant with standards that have been developed for most deciduous fruit crops. Samples may be taken anytime but standards have been established for specific times during the growing season when most nutrients are fairly stable.

Foliar sampling of tree fruit is 60 to 70 days after petal fall; grape petiole sampling may be done at bloom or veraison; June bearing strawberry foliar sampling uses the first fully developed tri-foliate leaf after renovation; day-neutral strawberry sampling consists of the most recently mature tri-foliate leaf; brambles, blueberries, currants and gooseberry foliar sampling is late July through early August.

Results will vary with plant stresses including a lack of water, too much water that creates water-logged soils, crop load, pest injury (foliar pests, borers and vole damage); pesticides containing nutrients (copper, sulfur, mancozeb, etc.); and with cultural practices (pruning, ground management, previous fertilizer practices, etc.).

For troubleshooting, sample plants that exhibit visual or suspected symptoms separately from those that appear healthy.

Nutrient availability depends on several factors including:

1. **Soil texture** is indicative of the percentage of sand, silt and clay in the soil. Soil with a high percentage of sand does not hold onto or bind to nutrients as well as soils with a high percentage of clay. Often split applications of nutrients are recommended on sandy

soils to allow for maximum uptake by the plants and reduced movement away from the root zone.

2. **Soil pH** measures the acidity and alkalinity levels using a logarithmic scale ranging from 1 to 14 with 7 being neutral, below 7 is acidic and above is alkaline. pH impacts the availability of nutrients. Ideal pH differs with specific fruit grown and is based on plant needs. For example, blueberries prefer a pH of 4.5 to 5, a range where iron is readily available in the form the plants utilize; brambles, currants, gooseberries, strawberries and deciduous tree fruit prefer a pH of 6 to 6.5. The type of grape determines the optimum soil pH. Native varieties (Concord, Fredonia, Niagara) prefer a pH of 5.5 to 6; hydrid varieties (Cayuga, Traminette, St. Croix) prefer a pH of 6 to 6.5; and European varieties (Chardonnay, Pinot Gris, Cabernet Franc) grow best with a soil pH of 6.5 to 7.0 (#4). Will these fruits grow well outside of these pH ranges? Yes, if the pH is not too far off, but they will grow best within the optimum range.

3. The concentration and balance of **existing mineral nutrients in the soil** impacts the availability of other nutrients. For example, a high soil level of potassium will have a negative impact on the availability of magnesium, calcium and nitrogen. This makes a visual diagnosis of nutrient deficiencies difficult.

4. **Available water**: water is required to move nutrients through the soil and throughout the plants. During a drought, deficiency symptoms may become visually evident even though there is ample in the soil. For example, potassium deficiency was common during the drought of 2016 while soil levels were adequate. Severe deficiency results in premature drop in apples as well as necrosis on leaf margins.

5. **Ground management**: vegetation under trees and plants will compete for available water and nutrients. A permanent ground cover will often necessitate an increase in nitrogen. There are situations when this vegetation may be advantageous. A mature planting that has no crop will tend to produce excess vegetative growth. Allowing vegetation to compete for nitrogen may lead to reduced, manageable growth. However, in most situations, reducing or eliminating competition is preferred.

6. **Climatic conditions** such as heat and moisture impact soil microbial activity. Many nutrients are converted to forms readily available for plant uptake by soil microbes. Organic phosphorus is converted by soil microbes to the inorganic form plants can take up. In addition, roots don’t absorb as much in cold soils are they do in warm soils which is one reason phosphorus deficiency symptoms may be observed during a cool spring. Once the soil warms, the deficiency symptoms disappear.

7. **Condition of the root system**: impaired or damaged roots (from water-logged soils, rodent damage, soil compaction or other causes) are unable to move water and nutrients into the plants creating the potential for deficiencies of one or more nutrients to occur.

Long term management decisions:

1. Supplemental water is needed during dry periods
2. Tissue analysis annually, or at least every couple of years
3. Soil analysis every 3-4 years using the same lab each time or one that uses the same testing method
4. Combine both the soil and tissue analysis with crop load, tree and plant growth, ground management, environmental conditions during that growing season, fungicides used, and cultural practices for fine-tuned fertilizer programs
5. Comparing results from year to year will show a reliable trend.

Contact your local Extension Educator for questions and guidance developing a sound nutritional program.

Growing Our Own Nitrogen: Results from 6 On-Farm Trials in MA

Katie Campbell-Nelson[1] & Ryan Karb[2]

[1]UMass Extension, Vegetable Program, 250 Natural Resources Rd, Amherst, MA 01003
kcampbel@umass.edu

[2]Many Hands Farm Corp, PO Box 278, Amherst, MA 01004
ryankarb@gmail.com

The goal of this trial was to find out if farmers could provide sufficient nitrogen for their cash crops using leguminous cover crops alone or with reduced nitrogen fertilizers and no additional phosphorus. We also hoped to increase the use of the pre-sidedress soil nitrate test (PSNT) as a tool for measuring soil nitrate sufficiency for multiple vegetable crops. We planted cover crops on six MA farms in a completely randomized block design. In early September 2016 plots were seeded using different implements on each farm with the following treatments: **1) No Cover Crop, 2) Rye (70lbs/A) and Vetch (20lbs/A), 3) Farmer Choice** (Table 1). The cover crops were sampled for biomass and incorporated using different implements in late May 2017. Two weeks later each plot was split with half receiving 60 lbs N/A in the form of Chilean Nitrate and the other half receiving none. Four weeks after incorporation, a cash crop of the farmer's choice was planted on each farm. We sampled soil nitrate 6-12" deep every two weeks beginning on the day of incorporation in late May until eight weeks after in late July. Finally, we measured yield of the cash crop planted into each of these treatments.

Table 1.

Farm	Farmer Choice (lbs/acre)	Cover Crop $/acre[1]	Cash Crop	Crop N needs lbs/acre	% Soil Organic Matter	2016 Fall NO_3 ppm	Soil Type
Langwater	Oat (90), Pea (50), Vetch (40)	$308	Winter Squash	110-140	6.8	105	Charlton-Paxton fine sandy loam
Lyonsville	Fria rye (15), Crimson clover (15), Vetch (18)	$136	Winter Squash	110-140	2.9	25	Occum fine sandy loam
Many Hands Farm Corp	*Summer 2016 seeded:* Sorghum Sudan (90) *Spring 2017 Seeded:* Oat (100), Pea (100)	$234 $251	Cabbage	160	6.2	5	Pootatuck fine sandy loam
Tangerini	Oat (90), Crimson clover (15), Vetch (18)	$205	Chard	105-130	3.4	30	Merrimac fine sandy loam
Twin Oaks	Fria annual rye (6), Crimson Clover (4), Tillage Radish (10)	$52	Cabbage	160	2.2	28	Deerfield loamy fine sand
UMass	Rye (60), Vetch (20), Tillage Radish (5)	$96	Sweet corn	100-130	1.7	20	Winooski silt loam

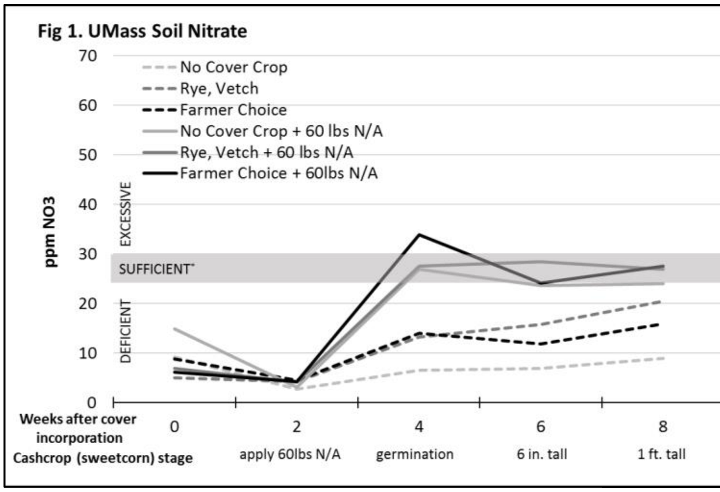
[1] The Rye (70lbs/A) and Vetch (20lbs/A) treatment cost $90/A and the additional 60lbs nitrogen cost $248/A.

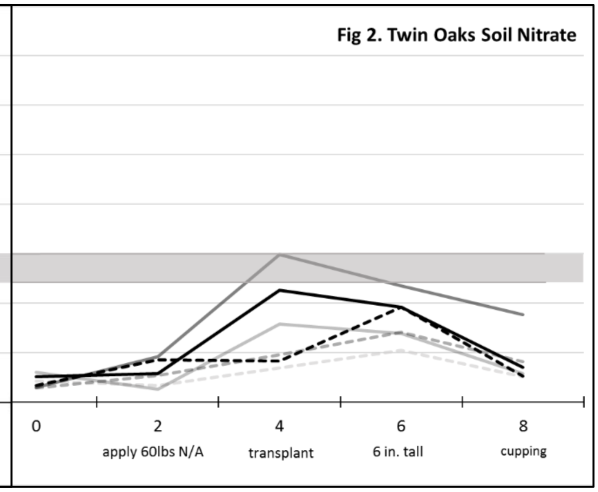
Results: Not surprisingly, there were statistically greater nitrates (NO_3) in plots with additional fertilizer on all farms and in most cases there were statistically greater nitrates in plots with cover crops than those without. Treatments in 5 of 6 locations resulted in greatest NO_3 to least NO_3 in the following order: Farmer Choice plus 60lbs N/A, Rye Vetch plus 60lbs N/A, No Cover plus 60 lbs N/A, Farmer Choice, Rye vetch, No Cover. Farmers were better at choosing treatments providing additional N compared to the traditional Rye/Vetch. In many locations, 'good' to 'excellent' cash crop yields according to those published in the *New England Vegetable Management Guide* were achieved with a combination of cover crops and less than half the required N rates applied or only with the use of cover crops.

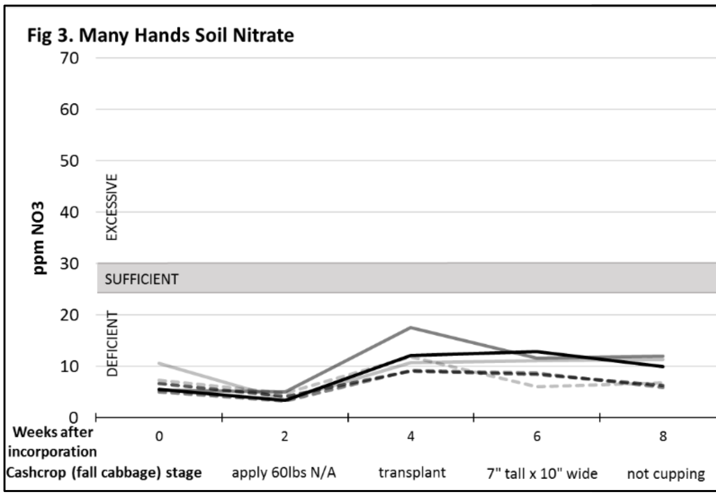
Despite these overall trends in the data, varying soil type, microclimate, and cultural practices all affected the great variability in nitrate release from treatments on each farm. Some farms achieved sufficiency ranges for their cash crops (Fig 1. UMass and Fig 2. Twin Oaks). Some farms did not achieve the sufficiency range due to poor cover crop establishment, high soil organic matter but wet soils with low mineralization rates (Fig 3. Many Hands) or poor cover crop establishment, low soil organic matter, and sandy soils with high mineralization rates (Fig 4. Lyonsville). Some farms exceeded the sufficiency range of NO_3 required for their cash crops because of prior compost applications (Fig 5. Langwater) and an early spring 5-4-3 chicken manure fertilizer application of 25 lbs N/acre to the entire plot (Fig 6. Tangerini). 25-30ppm NO_3 is considered 'sufficient' soil nitrate for most crops at the time a PSNT is taken *(New England Vegetable Management Guide 2016-2017, Nitrogen Management Section.)*

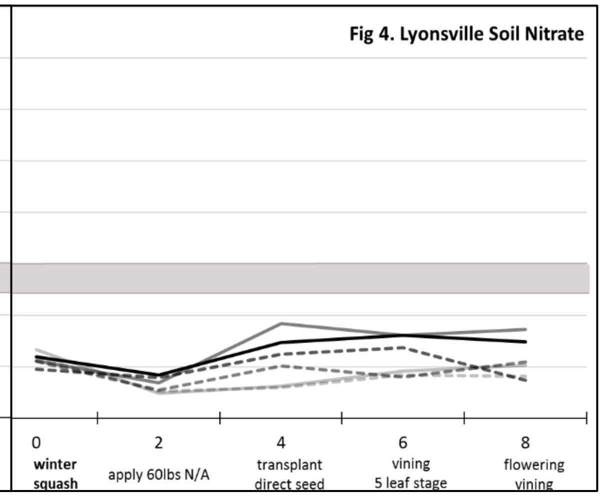
In this parable of the three bears (too much N, not enough N, and just the right amount of N), it may seem challenging to walk away with clear conclusions due to the diversity of results on each farm. However, we would like to make the following tentative **conclusions:**

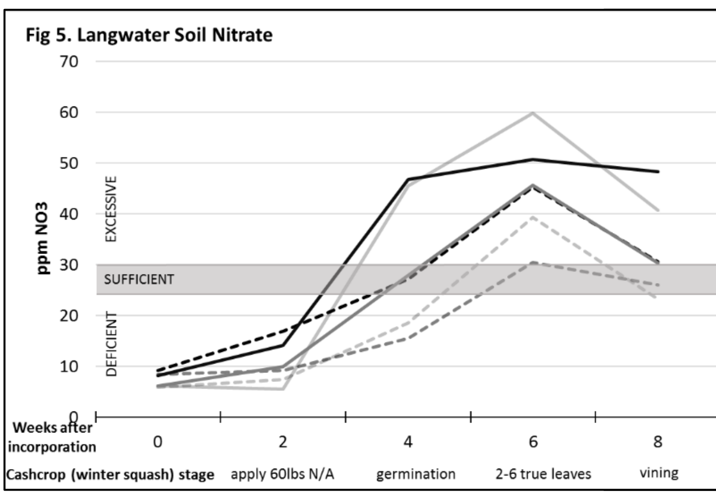
- Cover cropping takes practice and finesse, but will pay off in the end. At $4.00 per lb/N for organic fertilizer ($434-660 per acre) or $0.85 per lb/N ($89.25-136 per acre) for conventional fertilizer, a farmer is saving themselves money by planting a nitrogen fixing cover crop. The cost of 60lbs N/A in this trial was $248 while most cover crop treatments cost less than that per acre (Table 1).
- If leguminous cover crops are well managed they can provide all the nitrogen needs of a cash crop without any additional phosphorus in 4 out of 6 locations in this trial.
- It is possible to exceed sufficiency ranges for cash crop N requirements with the use of cover crops and/or compost; no commercial fertilizer necessary.
- Peak NO_3 was released 4-6 weeks after cover crop incorporation or 2-4 weeks after additional N application on all farms. Growers can take an inexpensive soil nitrate (PSNT) test 4-6 weeks after incorporating cover crops to determine if they are in the sufficiency range for their cash crop (25-30ppm NO_3), then make additional N applications if necessary.

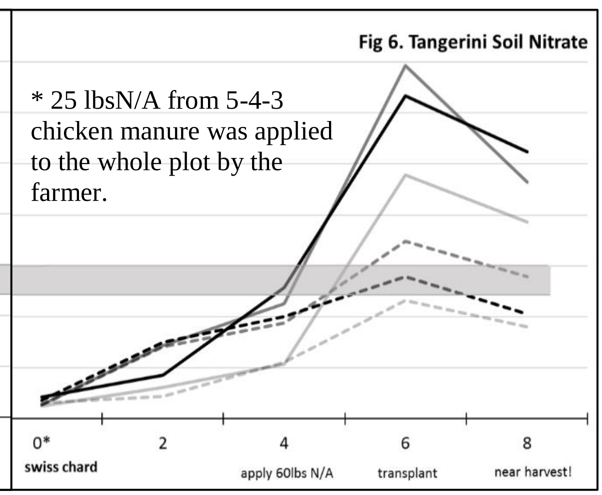












This research was funded by the Sustainable Agriculture Research and Education (SARE) program and the New England Vegetable and Berry Growers Association (NEVBGA). Thanks to the following farms for participating: Langwater Farm, Lyonsville Farm, Many Hands Farm Corp, Tangerini's Spring Street Farm, and Twin Oaks Farm. Thanks to Seedway for providing the cover crop seed for this trial.

Understanding Nitrate Availability from Legume Cover Crops

Becky Maden

UVM Extension, Rebecca.Maden@uvm.edu

Background. Vermont has new water quality regulations which require farmers to reduce P applications to fields already high in phosphorus. A review of over 600 soil test results submitted to the UVM Agricultural and Environmental Testing Lab in 2014-2015 found that over one-fourth of the vegetable fields tested had excessive soil P levels, and about half the fields did not require any additional P fertilization. This suggests that many growers will have to change their fertilization practices.

Historically, vegetable growers have relied on dairy and poultry manure as sources of nitrogen. These materials are popular because they are affordable, available in bulk, allowed for use on organic farms, and can help maintain soil organic matter because they also contain carbon. But over time, using manures to meet the N needs of vegetable crops can lead to a buildup of P in the soil.

For example, if a grower applies poultry manure with an N-P-K analysis of 2-3-2 and approximately 50% of that N is available during the year of application, then the grower would have to apply 4 to 5 tons of manure per acre to provide 80 to 100 pounds of available N to a vegetable crop. This would also provide 160 to 200 pounds per acre of P, which exceeds the annual needs of most vegetable crops except on very P-deficient soils. To avoid this type of scenario, growers need reliable information on affordable alternatives to manure-based amendments that will provide N to crops without adding excess P. The use of legume cover crops is one such alternative.

Nitrogen availability in the soil is largely dependent on temperature, moisture, and soil properties. These factors vary by location and environmental conditions, which change over the course of a growing season. Very little data exists that is directly applicable to Vermont's conditions that can help vegetable farmers understand how much N they will get from cover crops, or how to manage cover crops for optimal availability of that N. For example, an over-wintered hairy vetch cover crop potentially contains sufficient N to meet the needs of a subsequent vegetable crop, but if the release rate does not match the timing of crop needs, yields will suffer (and N from the cover crop could be lost to the environment, potentially causing pollution).

Research project. To help growers understand the timing and quantity of N available to cash crops from legume cover crops, a two-year research project was launched by UVM Extension starting in 2017. The treatments include hairy vetch or field pea with three different incorporation dates compared to with a control with no additional N, and the grower standard practice of bare-ground plots fertilized with composted chicken manure containing 3% P.

The plots of cover crops were seeded at standard rates on six commercial vegetable farms across the state. Chicken manure was applied at a typical rate of 100#N/ Acre. Each treatment was planted to sweet corn to assess the effects on yields of a cash crop.

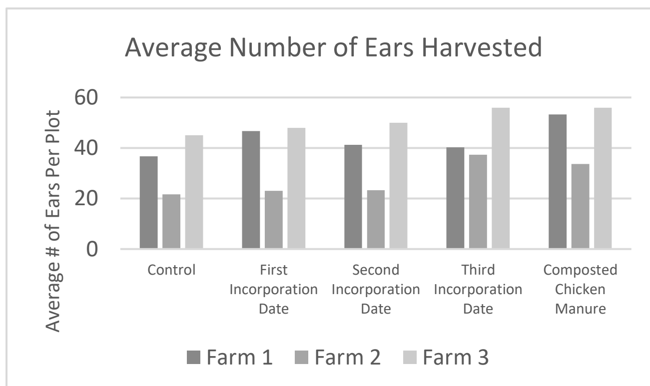
2017 Field Trial Treatments

Oat-Pea Cover Crop	Incorporate June 5
Oat-Pea Cover Crop	Incorporate June 12
Oat-Pea Cover Crop	Incorporate June 19
No Cover Crop	100# N/ Acre Kreher's composted chicken manure 5-4-3
No Cover Crop	Control--No added fertility

The pre-sidedress nitrogen test (PSNT) was used to measure the amount of available N in the soil in each of the treatments over the course of the growing season. Samples were taken every other week for 3 months to monitor changes in soil nitrate as the incorporated cover crops break down. The total amount of N accumulated by legume cover crops was also measured, by sampling above-ground biomass and N content. Taken together, the cover crop N accumulation and soil nitrate levels over time will help paint a picture of N behavior over the season.

In 2017, plots with field pea (mixed with oats) were established in early spring then incorporated at the three different dates in June. Sweet corn was then transplanted into all plots in July and harvested in October. In September, a hairy vetch winter cover crop (mixed with winter rye) was seeded in different plots for analysis in 2018. Both the field pea and hairy vetch treatments, as well as the controls, will be repeated in 2018.

The 2017 samples are still being processed, but preliminary analysis suggests that the plots with composted chicken manure had the most soil nitrate available at the time of maximum cash crop needs, about a month after transplanting. These soil nitrate levels were closely followed by plots with the third (latest) cover crop incorporation date. Yield data appears to correlate with soil nitrate levels.



The unusually wet and cool start to the 2017 season markedly slowed the release rates of nitrate compared to typical weather conditions. The timely seeding and incorporation of the cover crops, and the establishment of sweet corn were also difficult due to the cool, wet spring.

When compared with soil nitrate samples taken after incorporating legume cover crops on 11 Vermont farms in 2016 (which was unusually hot and dry), it is clear that annual patterns of soil temperature and moisture have a strong influence on the timing of N release from legume cover crops. Unlike in 2017, in 2016 we found very high levels of soil nitrate in soils after legume cover crop incorporation. The data collected from this project will help growers predict nitrate availability from legume cover crops, under different weather conditions. That information will ultimately provide farmers with better understanding of how to increase their use of legumes to meet their cash crop N needs.

Nutrient Management at Langwater Farm: Composting and Cover Cropping
Kevin O'Dwyer

Langwater Farm
209 Washington St, N. Easton, MA
langwaterfarm@gmail.com

Langwater Farm is a year round diversified organic fruit and vegetable operation about mid way between Boston and Providence. We have approximately 60 acres of cropland with 50 acres in production annually. Our produce is marketed through a busy roadside farmstand, a 300-plus member CSA, 4 summer and 2 winter farmers' markets, direct wholesale, and a local food hub. We retain 5-6 year round crew with ~25 additional seasonal staff.

In an organic system, many fertility inputs are costly and need to be selected and applied cautiously to avoid products high in phosphorous. With this in mind our goal is to minimize our use of bought in fertilizers, create and cycle N through cover cropping, and produce our own low phosphorous compost to build soil organic matter and satisfy crop nutrient requirements.

Cover crops are vital tools for the organic grower to create N and cycle existing N. Peas and hairy vetch are the favorite options on our farm for fixing N. We use hairy vetch following a cash crop when it can be seeded before the 2nd week of September and the next season's cash crop does not need to be planted before the middle of June. If the cover seeding date is before the 2nd week of September but the next season's cash crop needs to be planted before mid June we opt for field pea. If the cover seeding cannot be done before mid September, and the next year's cash crop won't be planted until early June, Austrian winter pea is a good option. We always mix peas with a grain, typically either winter rye or oats. Vetch is often mixed with rye unless the following season's cash crop requires a fine seed bed and a planting date no later than mid June. In that case we'll seed with oat or pea, oat, and vetch.

When there is not time in the planting schedules for properly timing the legumes, rye is the main choice following a main season cash crop for cycling the N. We use rye to follow a crop like tomatoes that leaves a lot of residual N because it establishes quickly in the fall and will efficiently take up N the following spring. It's important to seed the rye immediately after the cash crop to maximize its ability to scavenge all the leftover N.

When the goal for a field is to increase OM , but we can't spare it from production for a year, sorghum sudangrass is a good choice to give it a little bump while also effectively cycling the N from the previous crop. We'll use it following spring crops when it can be established before late July. If we can afford to fallow the piece for a full year, planting a rye/vetch mix and then allowing it to mature and reseed at a much greater rate is a nice way to build the OM while contributing significant N.

Composting is also an important part of our soil building and nutrient management program. While making and applying our own compost certainly requires more time, effort, and management on a per acre basis than cover cropping, its benefits are significant. On our farm we're only able to make and apply compost to around 5 acres or less than 10% of our cropland annually. However, its significant contribution to crop nutrition, OM, and soil microbial health make the effort well worth it. Typically we reserve it for our most precious crops like tomatoes, strawberries, or other fruit.

Many compost applications on farms are generally responsible for elevating P levels in the soil. Our compost is manure free and therefore has much lower P levels than those made with animal manures. In our suburban location we're fortunate to have many landscape companies eager for a place to dump leaves and grass clippings. We mix leaves taken from the previous year with grass clippings and our own vegetable waste. This mixture is turned regularly in a windrow through the summer and into the winter. After turning for one year it's then applied prior to planting the following season. An application of 100 yards/acre results in approximately 1" of coverage and raises the OM in the soil ~1% or greater. We have observed significant increases in crop health, yield, and quality in the years following these generous compost applications.

Intensive cover cropping and on farm composting have been crucial in our organic system to reduce our use of expensive organic fertilizers. As our cover cropping program has developed, we've spent less money on fertilizer and achieved more benefit from fertilizer applications by effectively cycling residual nutrients and reducing phosphorous accumulation.

Phosphorus Management for Vegetable Farmers

Bruce Hoskins

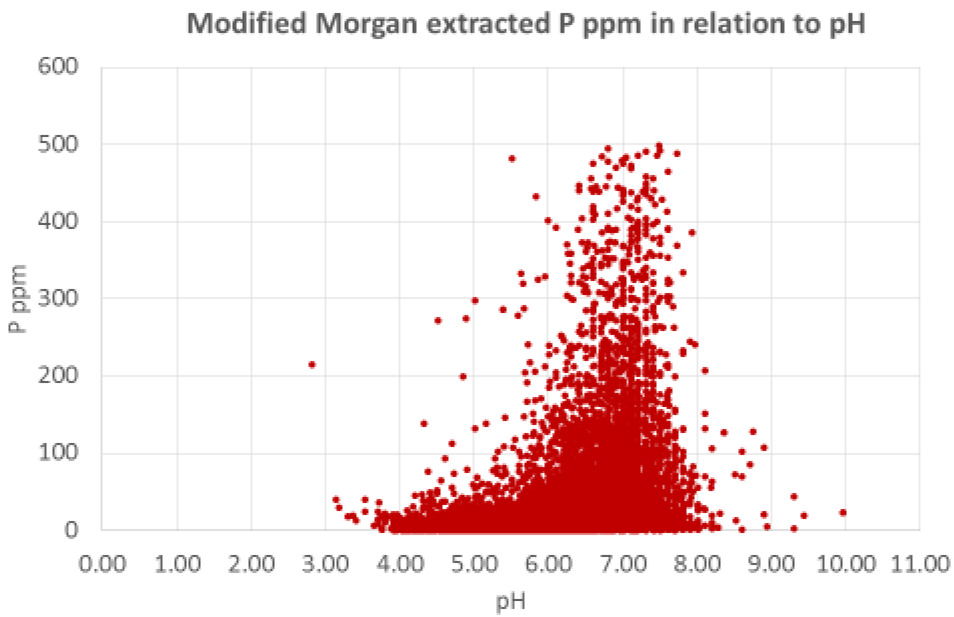
University of Maine, Hoskins@maine.edu

Phosphorus is one of the most environmentally sensitive nutrients that we manage. Widespread eutrophication of surface waters has given rise to increasingly restrictive regulation of P applications. Given the finite supply of phosphate resources and the ongoing problem of water quality issues, it is imperative that we manage phosphorus fertility as efficiently as possible.

Phosphorus chemistry in soil is exceedingly complex and variable. P will bond with whatever constituents are abundant and chemically active in the soil: aluminum, iron, and other metals in acidic soils, calcium and magnesium in alkaline soils, and with organic matter and humus at any soil pH. Plant uptake is restricted to free ionic phosphate (ortho-phosphate) in soil water. However, the vast majority of soil P is held in stable compounds or complexes, some of which are temporarily or permanently unavailable to plants. *In simple terms, phosphorus fertility management consists of minimizing its loss to these unavailable forms.* Dozens of extraction and fractionation methods have been developed to characterize the forms of P in the soil, its availability to growing plants, and the tendency of soil to hold or release P to plants and the environment.

Phosphorus can be transported to streams and lakes either by way of eroded soil (particulate P) or as ionic phosphate dissolved in surface or channelized flow (dissolved P). Environmental test methods are increasingly used as management and regulatory tools in many states. These methods include Water-Soluble P (WSP) and the P Saturation Index (PSI). WSP is used to determine the relative risk of soil P loss to the environment during periods of surface flow or from channelized flow into drainage tiles. PSI is used to gauge the soil's capacity to safely bind and hold applied P. A PSI greater than 15-25 % has been associated with greatly increased WSP and potential environmental risk.

Routine soil test P (STP), such as the Morgan and Mehlich 3 methods, index plant available P to determine the likelihood of a positive yield response to additional P application. Soil testing methods are calibrated to determine the "critical test level", the STP level above which there is a very low probability of a yield response to adding more P fertilizer. Soil testing summaries from New England states show a broad range of STP levels. The highest median STP levels consistently occur in Vegetable Production, Nursery Production, Gardens, and Organic Production (both home garden and commercial). These high levels are partially due to "insurance" applications on high value vegetable crops and the heavy use of compost in organic production systems. Agronomic (forage production) samples have the lowest median STP levels and the greatest incidence of "Below Optimum" STP levels. One of the simplest ways to extend P availability is to maintain soil pH between 6 and 7. It is no coincidence that the greatest incidence of high STP levels in New England occur in the pH range 6 to 7.5.



UMass Extension USDA United States Department of Agriculture THE COLLEGE OF NATURAL SCIENCES

Most soils have a high potential capacity to “fix” or tie up applied P in unavailable forms. The Fixation Index is an experimental method used to gauge potential loss of applied P & K to unavailable forms, to determine the relative efficiency of applied fertilizers. When measured on Maine Potato and Dairy soils, 70-95 % of applied P can be lost according to this method. A more routine way to measure P fixation potential is to measure “reactive aluminum” extracted with STP. This is used to modify P fertilizer recommendations in VT, CT, MA, and soon in ME. Less reactive aluminum implies less fixation and greater efficiency of applied P, allowing lower applications of P with no loss of yield.

Banding phosphate fertilizers is one way to limit soil contact and loss to unavailable forms, but this can cause problems with early season availability before roots can grow into or near the band. Limited amounts of P from “starter” fertilizers (liquid or granular) are meant to provide early season availability without significantly adding to overall P levels in the soil.

Incubation studies provide insights into the relative efficiency of applied P from different sources. In a greenhouse study, Montgomery and Ohno (2004) contrasted identical rates of P applied from 3 types of manure, 4 types of biosolids, and triple superphosphate (TSP). Uptake of applied P by ryegrass was < 10% from all sources, but uptake from organic sources (up to 7%) was nearly double that from TSP (4%). Residual P availability in the soil after cropping was more than double for the organic sources (up to 7%) vs TSP (2.5 %). A 2014 incubation of natural fertilizers also found 5 – 20 % of applied P remained available at the end of 16 weeks. These studies point out the improved and extended availability of P from non-chemical sources, such as manures, compost, and cover crops.

The tendency of all soils to tie up applied P in unavailable forms is compensated for by the efficiency factors built into soil test recommendations in all states. Maine recommendations assume 20 – 30 % efficiency, depending on typical crop management scenario and crop removal allowances. In forage production less P is recommended to build STP levels than with other crops, assuming higher efficiencies from organic sources. P efficiency factors in commercial vegetable recommendations in ME were recently increased from 15 % to 30 %, to reduce aggressive buildup applications of P fertilizers. Recalibration of P recommendations for potatoes and other crops, to include reactive aluminum, are currently underway in ME.

In recent field trials on potatoes and field corn in Maine and the Northeast, significant yield responses to applied P have been rare. These attempts at refining the calibration of modified Morgan and other field soil tests have been of limited utility, due to the lack of low testing, P-responsive sites. Because of uncertainty in the efficiency of applied P, phosphate has traditionally been recommended as an “insurance” application, even at Optimum soil test levels. Lack of response at Medium to Optimum STP levels indicates a need to eliminate these insurance applications and aggressive buildup factors in phosphate fertilizer recommendations.

Best Management Practices for Dickeya Management

Margaret Tuttle McGrath

Plant Pathology and Plant-Microbe Biology Section, SIPS, Cornell University
Long Island Horticultural Research and Extension Center,
3059 Sound Avenue, Riverhead, NY 11901. mtm3@cornell.edu

Dickeya blackleg, often just called Dickeya, is a new disease in the USA. It is caused by the bacterium, *Dickeya dianthicola*. This aggressive pathogen has the potential to cause more severe losses than the species of *Pectobacterium* (previously known as *Erwinia*) causing the type of blackleg that occurred in the past. High temperatures (exceeding 77 F) are favorable for Dickeya, consequently the greatest losses have been in the southern portion of the northeast (especially the mid-Atlantic region) and further south. Total crop loss has occurred. Dickeya was severe in 2015 at least partly reflecting hotter weather than previous 2 years when the pathogen likely was also present.

While *Dickeya* as an emerging pathogen has been of greatest concern, bacteria in the genus *Pectobacterium* have continued to be detected associated with blackleg stem symptoms and soft rot of tubers. Detections of *Pectobacterium* have increased recently, most notably in 2017. A new species has been confirmed in the northeast: *P. parmentieri*, which was known as *P. wasabiae* before 2017. It has been associated with extensive loss is storage.

Symptoms. First symptom is poor emergence (skips in a production field) due to rotting seed. Plants that emerge from contaminated seed wilt and typically have black stems extending upwards from rotting seed piece. Occasionally, especially late in the season, only internal stem tissue will be discolored. The fact stem symptoms start at the seed and progress upward illustrates that *Dickeya dianthicola* is in potato seed. Symptoms typically develop following a period of hot weather especially when plants are also stressed. Plants affected by Dickeya can just appear unthrifty if they have a sub-lethal titer of the bacterium. No symptoms may develop when the temperature never becomes hot during the growing season. Infected tubers may develop soft rot before harvest, but can remain symptom-less. Not all tubers in a hill have been found to be infected. Photographs of symptoms are at:

http://livegpath.cals.cornell.edu/gallery/potatoes/potato-blackleg-caused-by-dickeya/

Blackleg caused by *Pectobacterium* differs from Dickeya in that it starts on the outside of stem tissue, infects through wounds, and then moves downward as well as upward causing stem rot that is dark brown. Affected tissue typically has an offensive odor and is slimy. In contrast, plant tissue affected by Dickeya typically has an earthy smell; occasionally it has an offensive smell indicating soft rot bacteria are also present.

Management. Potato seed tubers harboring *Dickeya dianthicola* are the only confirmed source of this pathogen. It does not appear to be able to survive in soil (including in crop debris) from one growing season to the next. Consequently, rotating with a non-susceptible crop is not a necessary component of the management program for this disease, but is recommended for *Pectobacterium*. While *Dickeya* could survive in unharvested tubers, spread of this bacterium in field is thought to occur to a limited degree if at all, thus *Dickeya* developing in volunteer potato plants is not expected to be an important source of the pathogen. Best management practices listed below are encouraged to minimize potential losses from *Dickeya*.

1. Select certified seed with negligible potential to be contaminated with *Dickeya*. This is best determined by talking with the seed producer about past occurrence on the farm and what is being done to manage it. There are seed producers who have never had *Dickeya* develop from their seed, and some who did not have *Dickeya* develop from their seed in 2016 after they disposed of seedlots found to be contaminated in 2015 plus implemented a good management program.
   a. Select seed from farms where the pathogen has not been detected and seed marketed in previous years was not associated with *Dickeya* developing where the seed was planted. But note statement above; seed producers can eliminate *Dickeya* from their operation, thus it is important to talk with seed producers before purchase.
   b. Select seed from farms where zero tolerance is being implemented.
   c. Check Certificates before purchase to determine if the seed was increased in previous years on a farm where *Dickeya* has been detected and so is at risk for being contaminated.
   d. Select seed with zero blackleg levels reported on the North American Seed Potato Health Certificates or the Winter Grow Out Test results for presence of *Dickeya* in ANY seed lot from ANY source. Seed lots with field readings of blackleg present should have reports that suspect plant samples were taken for testing and found to be free of *Dickeya* (and also *Pectobacterium parmentieri*). Check Certificates before purchase and require a copy be provided for your records.
   e. Select seed that tested negative for *Dickeya*. Note that not detecting a pathogen in a sample of seed does not mean the pathogen is not present in the seedlot.
   f. Ask for ‘references’ to contact: potato growers who purchased their seed in 2017.
   g. Avoid seed lots that tested positive for *Dickeya* in previous years.
   h. Avoid seed if its Certificate is unavailable. All certified seed has a Certificate.
   i. Avoid seed from fields where symptoms of *Dickeya* were observed, even if affected plants were rogued out.
2. Request from supplier (directly from seed producer or broker) PCR testing for *Dickeya dianthicola* using an independent laboratory.
3. It is recommended that each truckload brought to a farm operation be sampled and re-tested for *Dickeya* once delivered. All results should be reported to your State Department of Agriculture or Potato Growers Association.
4. All equipment during seed piece cutting should be disinfested on a regular basis (at least daily), and also between lot numbers.
5. While it is recommended to rotate where potatoes are grown to manage most pathogens that can survive in unharvested tubers, and also rogue volunteer potatoes, these practices are not considered important for *Dickeya* because this pathogen does not readily spread in fields (thus a few tubers with *Dickeya* will not result in significant disease outbreak as can occur with late blight) and infected tubers are likely to rot while in soil.
6. Inspect fields for symptoms regularly, starting when skips and affected plants are readily visible. Examine the crop for unevenness (erratic growth) and plants that are unthrifty. *Dickeya* can be present in a plant affecting growth but not causing its typical blackleg symptom. Growers are encouraged to submit suspect samples for testing promptly to their local extension office in order to confirm *Dickeya* is the cause and to contribute to knowledge about *Dickeya* occurrence, and also to share their observations of *Dickeya* with the seed producer.

7. Avoid excess irrigation that results in standing water as *Dickeya* can move in this water. Note that surface irrigation water is not considered to be a possible source of *Dickeya.*
8. Do not apply copper or other fungicide for *Dickeya*. They are ineffective being unable to reach the pathogen, which is inside stems.
9. All growers are requested to share information about *Dickeya* occurrence and absence in their production fields. This information is needed to improve understanding about this disease. Include variety, lot number (North American Seed Certificate), field location, and testing results.
10. *Dickeya* has not been observed to continue developing in storage, which is as expected considering high temperatures are favorable, thus there are no management steps to implement after harvest for table-stock potatoes. However, it is prudent to make sure storages and pile temperatures remain cool, also reduce condensation and encourage airflow and exchange. *Pectobacterium* can continue to develop in storage.

New Potato Varieties Coming To A Farm Like Yours

John M. Jemison, Jr.

University of Maine Cooperative Extension

In the New England region, we have two types of potato growers: the large acreage producers growing primarily for the processing industry (French fries and chips), and mixed vegetable farmers growing potatoes for crop diversity and a high value crop to improve overall farm income. If you drive down Rt. 1 in Northern Maine, you can still find people selling 50 lb bags of new potatoes for $10/bag, but that is not the way potatoes are marketed today. The market has changed drastically for most potato consumers. In 2006 and 2007, we surveyed Maine consumers to study consumer preferences with potatoes, and how those preferences influenced their purchasing decisions. The most popular cooking method at that time was still baked potatoes, but mashed potatoes and roasted potatoes were close behind. I expect now, a decade later, that trend would only have increased. In city markets, I suspect that small specialty lines roasted or in stews or soups would likely be the most popular potato cooking method today. Given our fast-paced society, most consumers today are looking for food products that don't take much time to either prepare or cook, and that are colorful, healthy and attractive. Growers trying to meet that demand are looking to grow small(er) high quality potatoes that cook quickly and have diverse uses.

Potato breeders walk a fine line of trying to produce a profitable potato variety that makes growers money but also fits consumer demand. Processing potatoes are still most important for Maine's processing potato growers, and as such we spend a great deal of time trying to produce consistently high yielding, disease resistant potatoes. As well, specialty lines are still important too. Varieties need to produce well in a variety of soils, weather conditions, and remain attractive year in and year out. The task is not an easy one.

Consumers wanting a baked potato typically prefer a drier flakey meaty potato, while someone wanting a soup or stew line likely prefers a moist waxy potato. Many consumers are also learning that many of the nutrients and healthful antioxidant compounds like phenols and anthocyanins that potatoes provide are found in the skin. So, potatoes with attractive skins have become increasingly important. So, growers and consumers want consistent yielding potatoes with attractive skins that have natural resistance to pests and disease.

Greg Porter took over the University of Maine Aroostook Farm breeding program a number of years ago. He works closely with many other university programs (Cornell, Colorado State, North Dakota State, and others) and USDA breeders to develop and share new and interesting lines. This allows them to test how new lines produce in different environments. These breeders also share genetics to produce new varieties. I have helped him evaluate new specialty and red varieties. Red potatoes often have considerable year-to-year variation in color, brightness and quality of skins, and size. We are not exactly sure what causes this variation, but this is why we need to evaluate our reds over different years and locations to be able to make sure we can tell growers how soil types and environmental conditions may affect appearance and potato quality.

In our variety evaluation work, we rate factors like how fast a potato emerges from the soil, and consistency of emergence. We monitor susceptibility to commonly used herbicides such as Sencor. Other characteristics we evaluate include growth habit, foliage color, time to canopy closure, yield, skin quality, and internal defect.

The days of potatoes being primarily Russet Burbank potatoes for bakers, and round white and red potatoes for most everything else are pretty much gone. Varieties like Yukon Gold with its buff skin, pink eyes, and bright yellow flesh the first of many alternative lines that excited consumers about new and different possible potato varieties. The problem with Yukon Gold was its moderate-at-best yield potential. We have continued to work on a good replacement for that variety, and the NY 161 has potential with its nice splotches of purple around the eyes and a bright yellow flesh. Another popular variety we have worked with in Maine was the Carola potato. We tried to test the alternative potato market in Maine, and we found a tablestock grower to produce and bag this variety in small 5 lb. packages for the local grocery store market. We had recipes on the bag showing consumers how to roast and use in stews. It was very popular in our grocery stores, but the grower decided the variety produced too many off shaped potatoes to continue. The responses we received from the evaluation cards we included in the bag were extremely positive. So, if you are looking for a buff skin yellow flesh waxy variety, and you are less concerned with the occasional odd shaped potato, you might consider the Carola variety.

Fingerlings like Rose Finn Apple and Purple Peruvians offer consumers new small varieties that can be easily prepared and cooked in a short amount of time. We have tested a number of other lines that are colorful, have excellent taste, and produce a cross section of sizes. One of my favorite new potato lines is the “Pinto” potato. It has a mottled skin appearance with red and yellow splotches kind of resembling splotches on a Holstein cow. The Pinto is oblong in shape and ranges in size from fingerling to hand size, and it has a lovely waxy yellow flesh that is excellent for roasting, stews or soups. It also seems to have moderately good common scab and black scurf resistance. It is very productive in cooler environments like the Northeast and New England, but note that Pinto has had some production quality issues when grown in warmer production environments. We evaluated a small round version of this style of potato this year that has the potential to really fit consumer interest. It had beautiful bright skin and very little skin disease. Stay tuned for more on this variety.

Producers should also try to take advantage of the market for more purple skin potatoes. Some consumers enjoy making red, white and blue potato salad for the 4th of July. Greg Porter is working on a nice purple skin white flesh variety that has real promise. Harvesting early for that type of market may help avoid some of the scab, silver scurf, and black scurf issues that have plagued some of the purple skin lines. Another really nice potato variety that we have evaluated is called “Peter Wilcox”. It has a nice purple skin with a bright yellow flesh.

Consumers are willing to pay for small packages of clean, fast cooking potato varieties. We will continue to breed and evaluate new lines to fit this important market. We will also continue to explore ways to push the planting window in our cool wet New England springs. We are experimenting with forming rows in the fall so that the soil will warm and the water will drain earlier. If we can get potatoes in the ground in late April, there is a better chance to fill that early 4th of July potato market.

Growing Potatoes Organically on Long Island
Fred Lee

Sang Lee Farms, Inc.
25180 County Road 48, Peconic, NY 11958
www.sangleefarms.com
fred@sangleefarms.com

Sang Lee Farms is a third generation, family farm, originally specializing in varieties of Chinese vegetables. The farm started operations in the early 1940's in western Suffolk County, Long Island, NY for just the summer months. Crop production was expanded to a subsidiary farm for year round production in the late 1950's in Hobe Sound, FL during the winter months. Crop production entailed more than 1000 acres of cultivated vegetables within a 12 month period from the 1970's through the mid 1980's for the wholesale Asian markets in New York City, and along the east coast of the US.

Market changes from 1995 and through 2002 influenced the crop selection and amount of production to where Sang Lee Farms is today, a 70 acre diversified, Certified Organic Vegetable Farm selling directly to consumers. Sang Lee Farms, operates a retail farm stand, a 650+ member CSA and participates in (4) farmer's markets during the course of the year. We have been certified organic since 2007, with NOFA-NY, Certified Organic, LLC. Our current vegetable crop varieties number over 100.

We have been growing potatoes as one of our certified organic crops for over 10 years. We grow approximately 2 acres annually, of about a dozen mixed varieties of fingerlings and varied colored potatoes. We source most of our potatoes from Fedco Seeds and the Maine Potato Lady in Maine. Every season, we grow about 75% of the acreage with varieties that have worked well for us in the past, and 25% with new varieties that we think might perform well.

In 2017 we used an older 1950's vintage machine potato seed cutter to cut the pieces into about a 2" uniform size. In the case of small fingerlings, we just plant the whole fingerling potato piece. Our prepared beds are fertilized with about 2,300 lbs. of fertilizer per acre. Depending on the fertilizer used and the respective analysis, we usually pre-plant and incorporate a mix of Perdue 3-2-3 Pasteurized poultry liter, and McGeary's 8-1-1 Blood Soybean meal fertilizer.

We make our planting beds on a spacing of 72" on wheel centers. We use a ground driven front mounted (3) point hitch Shraper Brothers drop spreader in conjunction with a Frontier (John Deere) brand (3) Point rear mounted Rototiller to place bands of fertilizer approximately 36" apart in the bed and 5" deep. Our seed potato placement is about 9" between pieces on two lines 36" apart, at about 4" deep on each planting bed using a Checchi & Magli mechanical planter. Depending on the weather and field conditions, we usually begin our planting in the last week of April.

Our primary goal after planting is weed control. We use a Williams tine weeder to rake off the top of the beds every 10 days or so in the early stages of growth. When the plants are taller, we will go through the field with cultivating shanks to cultivate between the lines of plants. Through the course of the following weeks, when the plants are about 10” tall, we will begin cultivating with hilling shanks, a.k.a. “elephant ears” to hill up the potato beds. Also, we will side dress an additional amount of 500 lbs./acre of Perdue 3-2-3 in between cultivations and final hilling.

The primary insect problem is the Colorado Potato Beetle larvae. One application of liquid Entrust SC is made with an FMC Airblast sprayer when the first hatch of larvae is small in size. This is done about midway in the crops growth around the third week in June.

Harvesting is done with an Italian made single row rear PTO driven (3) point hitch mounted Speedo digger. This machine simply digs the potatoes and drops them back onto the bed surface. It is important to pull foliage and other debris clear of the dug row to be able to pick up as many of the dug potatoes as possible. The chain spacing is unfortunately fixed @ 2”, so many of the prime sized smaller potatoes that we market fall through to the ground and are partially buried by the loose soil falling along side from the digging chain.

Depending on the variety, size, and particular market, we sell our fingerlings and smaller sized potatoes for $5.99/lb. and the larger sized for $2.99. Other sizes and varieties may sell for prices in between those two prices. Yields vary tremendously according to potato variety. Averages can be as light as a couple of pounds per linear foot of row length. While potatoes are not a high demand item or terrifically profitable crop for us, we will continue to plant about the same acreage in the next year for our markets and CSA distributions.

Nurse Cropping in Potato Systems

John Jemison

Extension Professor: Soil and Water Quality

Issue

The time required for potatoes to emerge following planting is longer than any other major crop grown in Maine. During this time, the soil is subject to erosion loss with heavy precipitation. It would be beneficial to protect the soil during this time period. A nurse crop (NC) could be used to protect soils during this period. We recently began to study if we could plant small grains at the time of potato planting and kill them when its time to hill the potatoes. Our experiments have tried to determine: 1) which crop species makes the best NC and what sowing rate is optimum; 2) what is the optimum length of a NC growth period; and 3) is an herbicide application necessary to kill the nurse crop prior to incorporation.

Studies Conducted

In the summers of 2016 and 2017, studies were conducted at the Rogers Farm in Stillwater, Maine to study the effect of short-term nurse crops on potato yield and quality. Each study was designed as a randomized split block design with six replications. In 2016, the study compared two sowing rates (winter rye at 100 vs. 200 lbs/ac) to 20 lbs of annual ryegrass or a check plot (no NC). In 2017, annual ryegrass was not used and oats were used in its place. In addition, each of the NC treatments was either killed with an herbicide prior to one-pass hilling or just one-pass hilled. To address the question of how long to grow a NC, WR treatments were allowed to grow either three weeks or four weeks prior to being incorporated.

Methods

Dates associated with all sampling and fieldwork are presented in Table 1 below. The plots were established, and NC seed was hand broadcast within the appropriate plot areas. A tine cultivator was run through the plots to provide some seed to soil contact. Then, a potato planter was used to mark the rows, and band applied 1600 lbs/ac of 10-10-10 NPK fertilizer. Hand cut Snowden seed was planted by hand at 9 inch spacing, and red chieftain potatoes were planted in the four foot alleyway between plots. Admire was applied in furrow to protect against Colorado potato beetles and other insect pests as the planter was used to cover the seed pieces. All NC treatment plots were sampled for stand counts and biomass 17 days after planting (DAP) and the two 24 DAP NC treatments for the 4-wk NC production period in 2016 were sampled for biomass again prior to hilling. Due to environmental factors, NC treatments were given additional time to grow in 2017 compared to 2016. In both years, NC biomass samples were collected using a 0.064 m^2 quadrat randomly placed twice within each plot. Samples of above ground biomass were cut with shears, counted and dried in a drying room to a constant weight. Rimsulfuron was applied to specific NC treatments prior to hilling. Weeds were controlled with metribuzin and metolachlor at labeled rates following hilling, and plants were protected with fungicides weekly. Petioles were collected in July. The fourth leaflet from the top of the plant was sampled, leaves stripped off, and placed in a paper bag. Samples were dried, ground, and analyzed for nitrate. Plants were top killed in early September and harvested three weeks later. The potatoes were washed, graded into four size categories, and sampled for skin surface and internal defect evaluation. Data were analyzed in JMP 13 – contrasts were used to separate treatment differences.

Table 1. Research activities associated with Nurse Crop studies.

Field Research Activities	2016	2017
Worked Soil	18 May	25 May
Biomass samples	6 June (17 DAP)	14 June (20 DAP)*
Rimsulfuron applied	7 June	15 June
Hilled nurse crop	8 June	19 June **
Late biomass sampling	13 June (24 DAP)	24 June (30 DAP)
Second hilling	15 June	27 June
Petiole sampling	17 July	21 July
Top killed potatoes	8 September	6 September
Harvested potatoes	27 September	21 September

Results and Discussion

Nurse crop treatments were not found to increase potato yield or affect quality over the two years, but the extra biomass production also did not limit potato yield. Given the particularly dry production years of 2016 and 2017, the fact that the extra crop did not harm production is both interesting and useful.

Nurse Crop Stand Counts and Biomass

We found significant Year x NC interactions with both stand counts and biomass production over the two years of the study (Figures 1 and 2). In 2016, rainfall three and five days following spreading of NC seed provided soil conditions conducive for higher and more uniform NC production, whereas in 2017 rainfall after application of the seed didn't occur for 8 days, and some seed simply didn't germinate. Growth was visibly less uniform in 2017. Also, potato development was slower in 2017, and hilling was not done until 24 DAP. Nurse crops in 2017 had an additional 4 days of growth prior to hilling to allow the NC to further grow and develop and yield similarly to the more densely populated NC in 2016.

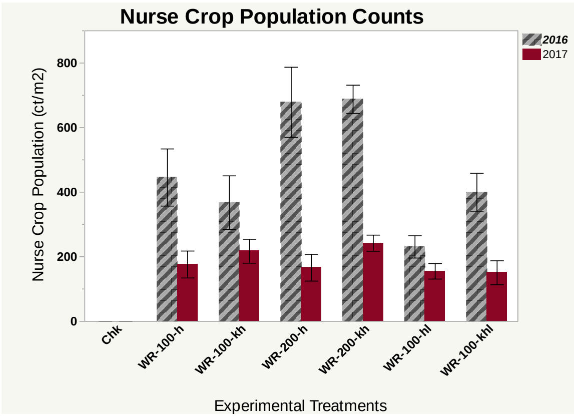


Figure 1. Nurse Crop Population Counts 2016 and 2017.

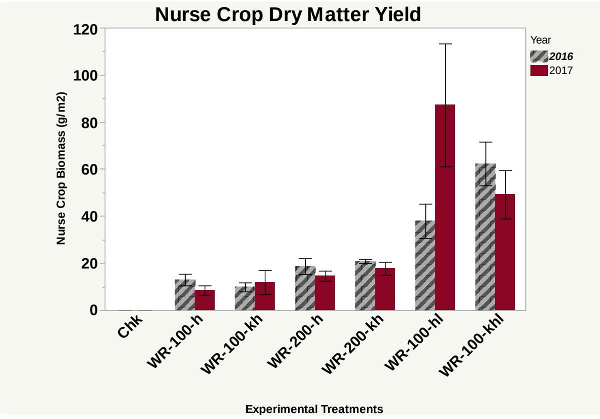


Figure 2. Nurse Crop Dry Matter Biomass Counts 2016 and 2017.

So, while NC counts were higher in 2016 than in 2017, it is likely that the additional 4 days of growth allowed the biomass to have similar yields in 2017 as 2016.

Potato Leaf Petiole Nitrate

Samples collected for leaf petiole nitrate indicated sufficient N to produce a healthy potato crop. While no one has determined specific petiole nitrate levels for Snowden potatoes, differences in petiole nitrate might show some immobilization or N release from the NC treatments compared to the control. Petiole nitrate levels were significantly higher in 2017 than 2016 likely due to less fertilizer N loss in 2017 due to the drier environmental conditions, but petiole levels were similar across NC treatments and not different from the control (no NC). From this we can surmise that NCs do not greatly influence N relations in potato production (Figure 3).

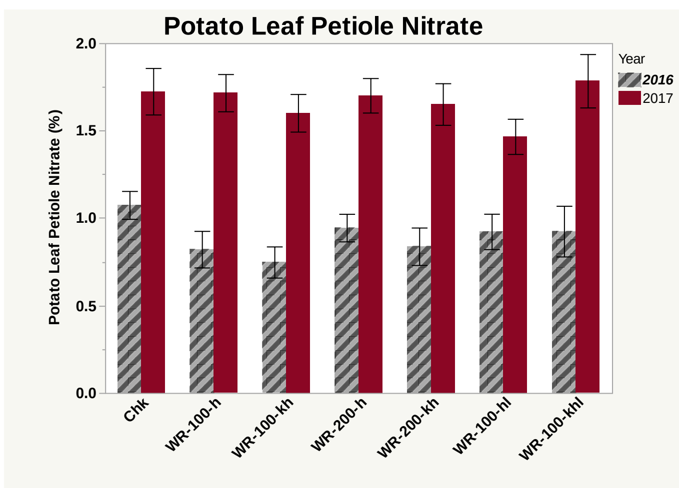


Figure 3. Leaf petiole nitrate for 2016 and 2017 production years.

Potato yield appeared to be more influenced by soil moisture than by NC treatments. Extended dry periods in both years, but particularly in 2017, led to considerably low yields. There was a statistically significant year*NC interaction due primarily to the difference in yields in the 28-day NC treatments. In 2016, NC were not effectively killed by hilling alone, and the yield of that treatment was significantly lower than the others. In 2017, NC was effectively controlled with hilling alone, and the potatoes grown in the herbicide late-killed winter rye were lower yielding due in-part to a hilling issue.

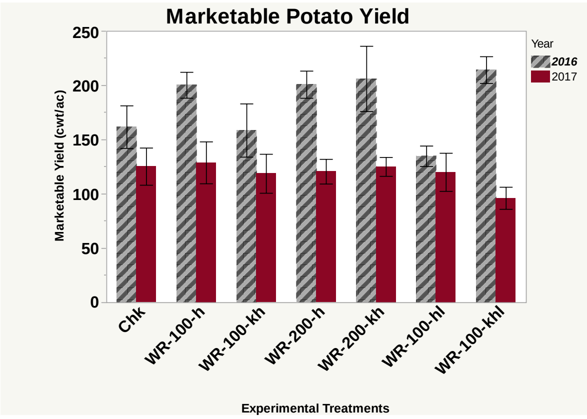


Figure 4. Marketable potato yields of Snowden potatoes

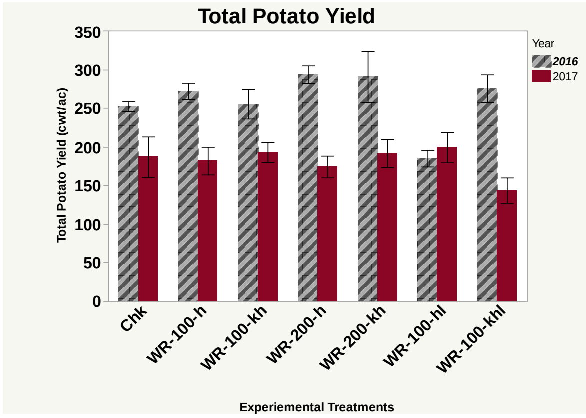


Figure 5. Total potato yield as influenced by nurse crop treatments.

Conclusions

Nurse cropping deserves further attention as a means to protect the soil before potatoes emerge from the soil. In 2016, it appeared as though one could let the NC grow as long as 25 – 30 days without hurting production so long as the NC is killed with an herbicide before 30 DAP; it does not appear to interfere with soil moisture relations, potato growth and development, or tie up fertilizer N. We did not see that in 2017, but the key to success is completely burying the nurse crop with a one-pass hilling operation. In both years, NC treatments did not affect yield or quality of potatoes despite the remarkably dry summer production seasons.

With the risk of intense precipitation events becoming increasingly common, the time is right to explore measures that might increase cropping system resilience. Given the low commodity pricing of barley and oats, growers could grow seed for their own NC use. Oats used in 2017 appeared to yield equivalently to WR, although WR germinated and emerged faster than oats. I hope that we can convince growers to try this practice at least on sloping production fields.

Ecological Pest Management for Potatoes

Andrei Alyokhin

School of Biology and Ecology
5722 Deering Hall, University of Maine, Orono, ME 04469
alyokhin@maine.edu

Potatoes are one of the most important cultivated plants worldwide, that provide excellent caloric returns per unit of arable land and are nutritionally superior to other staple crops. Not surprisingly, throughout the history their wide-scale adoption by farming communities coincided with periods of rapid population growth in many regions of the world. Unfortunately, successful potato farming requires high-intensity management regimes, resulting in considerable soil disturbance and application of large amounts of purchased inputs.

Belonging to the nightshade family, potatoes produce considerable amounts of toxins in their foliage. As a result, they are fairly well-protected from many insect herbivores. Nevertheless, the species that can attack them often cause considerable damage, often resulting in complete or near-complete losses of marketable yields. In addition, there are a number of viral, fungal (in a broad sense of the word), and bacterial pathogens that can also cause devastating losses to potato crops. All these pests form a complicated web of interactions, which could be either mutually beneficial or antagonistic. This web is ultimately responsible for the economic bottom line of potato farming.

Currently, potatoes have a rather dubious distinction of being the most chemically dependent staple crop in the world. Although such an approach is still working in a sense of allowing potato growers to stay in business, its long-term susceptibility is rather questionable. Many of the most important pests of potatoes, such as Colorado potato beetle, green peach aphid, pink rot, and late blight, have impressive abilities to adapt to a variety of chemicals. Furthermore, there are serious concerns about pesticide effects on non-target organisms, including humans. As a result, many chemicals are no longer available for successful pest management within potato fields. The situation is likely to become progressively worse in the future, as fewer and fewer novel pesticidal active ingredients enter the market to replace older chemistries lost to the evolution of pesticide resistance in pest populations and to the increase in regulatory scrutiny.

In my opinion, one of the most important steps towards improving sustainability of pest management is setting a different goal for what we are trying to achieve. At present, most effort is put into killing pests that are found within potato fields. Dead pests are considered to be an ultimate measure of success, while expenditures, environmental degradation, and eventual pesticide failure due to resistance are considered to be acceptable collateral damage. What is needed instead, however, is finding a way to maintain an agroecosystem that allows harvesting enough potatoes to support an economically viable farming operation. These two approaches are not synonymous. Simple killing could be wasteful, or even downright counterproductive. For example, potatoes can tolerate 30-40% defoliation during early growth stages, 10-60% defoliation during middle growth stages, and up to 100% defoliation late in the season without noticeable yield reduction. Therefore, chasing every single Colorado potato beetle with a sprayer results in a waste of time and money, while also contributing to rapid resistance development. In another example, microbial activity in the soil and on foliage primes immune responses in plants, making them less susceptible to pathogens and even to insect herbivores.

Overemphasizing pest killing also promotes unrealistic expectations that a single “silver bullet” solution (or at least a magazine of several silver bullets) could be invented to solve pest problems once and for all. However, the entire history of potato production proves that such an expectation is unrealistic, at least in the medium- to long-term. All silver bullet candidates either fail due to pest adaptations as described above, or create additional and previously unforeseen problems. For example, successful rogueing out of potato plants displaying PVY symptoms in their foliage resulted in current dominance of necrotic PVY strains that produce little mosaic in the foliage, but render tubers unmarketable due to sever tuber necrosis.

Ecological pest management requires an understanding of interconnections among components of an agricultural ecosystem, as well as of direct and indirect effects of management approaches on these components. For instance, impact of weeds is not limited to a competition with potato plants. It also has important effects of epidemics of viral diseases. Virus infections, in turn, affect potato plants, but also aphid vectors and even Colorado potato beetles. Spraying crop oils to interfere with virus acquisition by aphid vectors also influences behavior of Colorado potato beetles, as well as virulence of an entomopathogenic fungus *Beauveria bassiana*.

Deciphering all these interactions is not an easy task, but we are making a steady progress in the right direction. While no technique will provide a permanent solution for defending potato crops, integrated and scientifically sound use of multiple approaches is likely to provide more sustainable crop protection.

How I Grow Certified Organic Blueberries

David Ingalls, MS, CAS

Ingalls Blueberry Hill
136 Seminary Road, Milford, New York 13807
davideingalls@msn.com
ingallsblueberryhill.com

Dr. Marvin Pritts of Cornell's Department of Horticulture states that "Blueberries are quite amenable to being grown organically." Blueberries grown organically can be produced profitably.

Whether you are growing blueberries 'conventionally' or 'organically', there are seven factors that are the similar to both approaches.

- Blueberries need a **pH** of approximately 4.5.
- They prefer 5-7% organic matter.
- During the growing season blueberries need **1 ½ inches of water** weekly.
- They need full **sunlight.**
- **Fertilization** should be consistent with leaf and soil sample recommendations made by an agronomist. Note, **sulfur** is the 4th nutrient.
- Annual **pruning** should be consistent with standard culturing practice. All canes should be replaced every 7 years.
- **Weed suppression** is conducive to good plant growth. Weeds tend to use up nutrients and moisture.
- **Variety selection** is very important.
- **Pollination** is essential. A minimum of two hives per acre are needed. Consider supplementing the Carolingian honey bees with bumble bees.
-

There are **five factors** that are specific to growing blueberries **organically.**

1. For blueberries to be sold, labeled or represented as 'organic' they must meet the requirements of the **USDA organic regulations**. "These methods integrate cultural, biological and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity. Synthetic fertilizers, sewage sludge, and genetic engineering may not be used."

Organic standards describe the specific requirements that must be verified by a USDA accredited certifying agent before products can be labeled 'organic'.

NOFA, LLC – NY (Northeast Organic Farming Association, LLC – NY)is a regional certifying agency that assists us in developing and maintaining our **Organic Systems Plan.**

To maintain certification, **an annual inspection** is required. It includes a review of my field and a review of my paper which both must attest to the culturing practices of my crop season. At this annual review I provide receipt evidence of organic fertilizer purchased, soil tests, plants purchased, etc.

2. Organic weed intervention approaches used at Ingalls Blueberry Hill are:

- a Ferris mower with a 6 foot deck helps to maintain narrow plant rows;
- a Weed Badger is able to cut weeds between the plants. It is a PTO driven electro hydraulic tilt control, 3 point mount mower attachment. Cost is $12,000. It equires 35 hp tractor. It is manufactured in Marion, North Dakota;
- a shoulder-strap Stihl weed-eater is effective for close-up weed control around plants;
- hand weed pulling is helpful to remove weeds among plant cane clusters;
- wood-chip mulching applied regularly by the use of a Millcreek Row Mulcher wagon (retails for $15,000).

3. **SWD fruitfly** (spotted-wing drosophila). Management of this fruitfly is of utmost importance in determining the success of raising blueberries organically. Successful interventions include:

- Variety selection, We have grown midseason bluecrop and blueray varieties;
- A midseason variety can be harvested before sustained trappings of the swd; this increases your chance of harvesting most/all of your crop;
- A midseason variety also stands a better chance of being harvested on time with the usage of one or two applications of spinosad (entrust naturalyte – organic insecticide);
- Another environmental factor for consideration has to do with a ‘site selection’ that offers good air drainage;
- An aggressive approach to pruning increases sunlight exposure. This promote larger and an earlier amount of picked berries. Note that the bigger the berries, the more poundage people tend to pick.
- Removing or reducing boundary brush reduces the spread of the SWD.

4. Environmental interventions:

Frequent management of grass and weeds produces a clean field. This also contributes to a reduced incidence of deer ticks. Hand removal of bug-clusters like the Japanese beetles reduces the incidents of predators.

Hand removal of the tip/stem borer is useful with organic approaches.

5. **Social factors contribute** to successful growing of Certified Organic Blueberries:

- Organic ‘You Pick’ is very fashionable these days. It contributes to the over-all farm experience by being both physical and a summer outing for the whole family. And Since we don’t add pesticides to our berries or to our soil, the berries don’t have to be washed. That makes them better tasting but more nutritious.

- We discourage grazing but since we know things about 3 year olds, we acknowledge the fact that they are going to eat more than they pay for so. We tell their parents that ‘we will expect their 3 year olds to come back in 20 years to pay for all the berries they ate’.

We have charged $3.25 a pound for the past three years with only one price complaint. This evidences a socially amiable relationship between farmer and patron. (There will be a price hike in the summer of 2018).

Folks like incentives, so we offer a free pound of blueberry honey or a free jar of blueberry jam whenever anybody picks 25 pounds or more of blueberries.

Blueberry season is a social event in our town. A kindergartener registered for school this summer, when asked when his birthday was, he answered, **“Blueberry season”.**

2017 Cornell Pest Management Guidelines for Berry Crops

Cornell Cooperative Extension Office, 135 Ho Plaza, Cornell University, Ithaca, NY 14853 844.688.7620

Transition to Certified Organic Production for Ingalls’ Blueberry Farm
Prepared by Dr. Micah Ingalls, 136 Seminary Road, Milford, NY 13807
607.437.7910

Weed Control in Blueberries: Strategies for Success

Thierry E. Besançon

PR Marucci Center and Department of Plant Biology, Rutgers University
125a Lake Oswego Rd, Chatsworth, NJ 08019
thierry.besancon@rutgers.edu

Weeds remain a major challenge in highbush blueberry (*Vaccinium corymbosum* L.) production. Like for any other agronomic system, annual grasses and broadleaves account for most of the weed species. However, the lack of annual crop rotation and soil cultivation make blueberry plantations more prone to the development of hard-to-control perennial weeds. Additionally, the number of herbicides labeled on blueberry is limited compared to row crops. Thus, efficient weed management strategies will rely on various control measures that need to be tailored to weed populations specific to your blueberry plantation. This presentation will cover the basics of a successful weed management program from proper weed identification to the selection of appropriate tools to control weeds.

Weed Biology Basics: Weeds can be divided into three groups. <u>Grasses</u> are a single botanical plant family with jointed stems, leaves with parallel veins that are divided into a blade and a sheath that wraps around the stem. <u>Sedge</u>s appear like grasses at a glance. Leaves are narrow with parallel veins, but they are not divided into a blade and sheath. Sedges have a distinctly triangular stem. <u>Broadleaf</u> weeds are a large collection of diverse plant families that have wide leaves, showy flowers, and seeds that are divided into two halves. Among these three groups, species can be subdivided based on their seasonality. <u>Annuals</u> are weeds that live less than a year. Summer annuals germinate in the late spring and early summer, flower and set seed in late summer or early fall and die when it gets cool. Winter annuals germinate in the fall or early spring, flower and set seed in late spring, and die when it gets hot. <u>Biennials</u> are weeds that live longer than a year, but less than 2 full years. <u>Perennials</u> are weeds that live longer than 2 years.

Prevention: The first step of any weed management program is to consider the steps that need to be taken to prevent introduction, establishment, and/or spread of a specified weed species into an area not currently infested with that species. The purchase of weed-free seeds when sodding the row middles, the necessity of cleaning equipment before moving from infested to non-infested fields, the use of weed-free irrigation water, the control of weeds on field borders and ditches, and prohibiting weeds already present from going to seeds are some of the key elements of an effective weed prevention program.

Weed Scouting: Prevention is a necessary step but is not sufficient by itself. Weeds have generally to be targeted at the seedling stage since controlling fully developed weeds can be extremely difficult because of their size that prevent effective herbicide distribution on the plant or because of their ability to regrow following mechanical or chemical control. Scouting for detecting weed seedlings shortly after their emergence is a critical component of any successful weed management program. The goal of weed scouting is to get a representative idea of the weed populations throughout the whole field. For a 100-acre field, make 5-10 stops that are well spread out through the field. At each stop, walk 10 paces (or 30 feet) and record the weed species that are present as well as their lifecycle (summer annual, winter annual, perennial), growth stage or height, and the severity of the infestation based on number of plants (low, medium, high). An efficient scouting program should also provide information on crop phenology as this may extremely important with regards to chemical weed control. The use of farm maps for weed scouting will provide data that can be used to define the control strategy but also assess its efficiency at controlling weeds over time.

Identification: Accurate weed ID is important for effective management because herbicide recommendations vary according to species, as do some mechanical, cultural, and biological strategies. Some species can look similar to other species from afar, but may have drastically different management requirements. They should be examined closely to determine herbicide programs. Guides such as Weeds of the Northeast (http://www.cornellpress.cornell.edu/book/) or weed identification websites (http://oak.ppws.vt.edu/~flessner/weedguide/) can be helpful to accurately determine weed species and become familiar with their biology and ecology.

Cultural Weed Control: Weed control should be started even before planting blueberries. While total "weed-free" soil is not usually possible, growers should keep clean soil prior to planting by ridding the soil of weeds through a burndown herbicide application, a thick, suppressive cover crop mulch, or mechanical weed control such as tillage and cultivation. Preventing seed production of weeds already growing in the field through frequent soil cultivation will help reducing the soil weed seedbank. Additionally, light cultivation will stimulate the germination of some weed seeds contained in soil and repeated soil work will eliminate recently emerged seedlings.

Complete weed control is critical the first two years following blueberry planting to ensure high survival rates and quick establishment as weed competition can dramatically slow growth of young plants. Frequent hand hoeing or hand pulling of weeds is recommended as mechanical cultivation may damage the root system and slow the growth of newly planted blueberries.

Similar to new plantings, the use of mechanical cultivation equipment in the row of established plantings is seldom recommended due to risk of damaging the shallow roots of the blueberries. Weeds control on the row can be achieved with mulch such as sawdust, wood chips or coarse leaf mulch applied three to four inches thick when the rows are weed free. The use of mulches such as straw is not recommended as these provide a favorable environment for rodents such as field mice and voles that may damage blueberries root and stems. All organic mulches break down over time and tie up important nutrients, especially nitrogen, so the use of mulch may require additional fertilizer. Mulch should be reapplied annually or when needed to maintain weed suppression.

Weed management of the row middles can be done through the seeding of a dense sod that will compete with weeds but will require fifteen to twenty months to establish. During this period, it is critical to control broadleaf weeds growing in the sod. The flowers of dandelion, clover, mustard species and other weeds may coincide with bloom and are preferred by pollinating insects. The same weeds, and others, may also bloom before or after the crop blooms and attract bees into the field when insecticides must be sprayed. Clover can especially be difficult to control, but can be suppressed or controlled in a sod with good management practices that will favor grasses such as appropriate fertilization with nitrogen or mowing height no closer than four inches from the ground.

Chemical Weed Control: Chemical weed control has many advantages, including control and cost efficiency, safety when correctly used, and the elimination of crop and root injury caused by cultivation. However, in order to minimize potential problems with herbicides, some specific considerations should be addressed before using them.

FACTORS AFFECTING THE EFFICIENCY OF WEED CONTROL

- Target – Is herbicide labelled for the targeted weed species?
- Soil properties – Is the selected rate appropriate to soil texture and organic matter content?
- Timing - Is herbicide used at the right time in relation with crop and weed phenology?
- Activation - Has preemergence herbicide been activated with sufficient rainfall?
- Persistence - How is irrigation affecting the persistence of active ingredients?
- Resistance – Has the targeted weed developed resistance to the active ingredient?

Weed Control Challenges: Perennial weed remain difficult to control in blueberry production. Special attention should be given to remove them from the field before planting the blueberries as this is the ideal timing to safely control them with systemic herbicides and avoid damaging newly planted blueberries. Among the most challenging perennial weeds, yellow nutsedge (*Cyperus esculentus* L.) occupies a preeminent position given its specific life cycle. Although the weed can reproduce from seed, where it is established, annual re-infestation is primarily due dormant tubers ("nuts") in the soil. Tubers can re-sprout six to eight times if cultivation kills the shoot. After the plant becomes established, rhizomes begin to grow in late spring, and by early to mid-summer, the rhizomes curve upward and produce additional plants. By August, the weed can sense the approach of fall by the longer nights, and a burst of rhizome growth follows. By early fall, a pronounced swelling can be observed at the tip of each rhizome, which matures into a new dormant tuber. Later in the fall, separation of the tuber from the rhizome will occur following mother plant death. Yellow nutsedge can be controlled by preventing new tuber production. This can be done by persistent control of nutsedge from late summer through early fall. The results of the effort will not be evident after one year. Too many "old" tubers remain dormant in the soil for several years before they sprout, but after several years, success will be evident.

Development of herbicide resistant weeds is an increasing challenge for blueberry production. Herbicide resistant weeds are weeds that have developed genetic resistance to certain herbicide groups, or sites of action. This is mostly due to widespread reliance on a small array of common herbicides. When the same herbicide is applied to an area year after year that contains resistant weeds, the susceptible plants die while the resistant ones survive and spread their populations every year. This is especially concerning in blueberry where effective herbicide options remain limited. We will discuss some of the most concerning herbicide resistant weeds in blueberry production and the strategies that can help to improve their control.

Blueberry Diseases: An Overview for New England Growers

Peter V. Oudemans

PE Marucci Center and Department of Plant Biology, Rutgers University
125a Lake Oswego Rd, Chatsworth, NJ 08019
oudemans@rutgers.edu

Diseases of the highbush blueberry (*Vaccinium corymbosum*) are caused by a wide variety of pathogens including bacteria, fungi, nematodes, phyoplasmas and viruses. Each pathogen requires specific control measures because each one exhibits a unique life cycle, seasonal activity as well as sensitivity to toxins. In this talk I will cover the basics of tailoring a disease management program specific to your situation by using a few basic principles and applying the right tools at the right time. This talk will apply to everyone who grows blueberries, because, to paraphrase Ray Kinsella in the movie "Field of Dreams" *….If you plant it…. they will come….*

In developing a disease management program there are certain strategies that must be chosen before moving forward. I will discuss the following principles as they apply to Blueberry Disease Management:

1. Protection – through application of fungicides or biocontrol agents that form a protective layer between the plant and pathogen.
2. Exclusion – In planting new fields only clean plants are used. Through this approach systemic pathogens such as viruses are excluded. Eradication or removal of infected bushes goes hand in hand with exclusion.

I will not go into other principles such as resistance or avoidance in this talk.

Scouting: Developing good scouting strategies is a key element to establishing an effective pest (disease) management program. A scouting program should provide information on crop development, appearance of specific symptoms as well as signs of pathogens in a format that provides both spatial and temporal information. Farm maps make excellent templates for recording scouting information.

Diagnosis: Know the enemy. Pathogens come in many forms and each requires control or management methods that will work only when used properly. Therefore, use of guides such as the Compendium of Blueberry, Cranberry, and Lingonberry Diseases and Pests, Second Edition (https://my.apsnet.org/ItemDetail?iProductCode=45362) can be extremely helpful in becoming familiar with these troublesome organisms. Knowledge of the common diseases is essential for routine scouting but diagnosis of unique symptoms is critical for identifying new problems as they arise.

Economics: When does a pathogen become economically important? Are some pathogens benign? This requires some evaluation of the problem. For example, in many growing regions stem canker (*Botryosphaeria corticis*) has only a minor impact on crop productivity. However, this was not always the case and prior to the introduction of resistant varieties it could be a devastating disease. Today, the occurrence of cankers on highbush blueberries does not signal an alarm because the pathogen causes minimal loss on modern varieties. This could, of course, change if the pathogen developed a new, virulent race. Therefore, scouting for disease involves both recognition of the pathogen as well as evaluation of the economic impact.

Fungal diseases and protection: It is critical to use the correct timing when managing blueberry diseases. We often discuss the importance of growth stages in timing of disease development. For this presentation we focus on three key stages: bud break (T3), flowering, and ripening (Fig. 1). These stages signify the timing of disease onset and when preventative measures should be in place. For diseases such as anthracnose, botrytis blossom blight, mummyberry, phomopsis twig blight and Phytophthora root rot it is important to utilize fungicides at the proper timing since these chemicals act, for the most part, as protectants they are most effective when used prior to infection. In Fig. 2 I provide an outline for managing fungal diseases using fungicides and taking into consideration phenology.

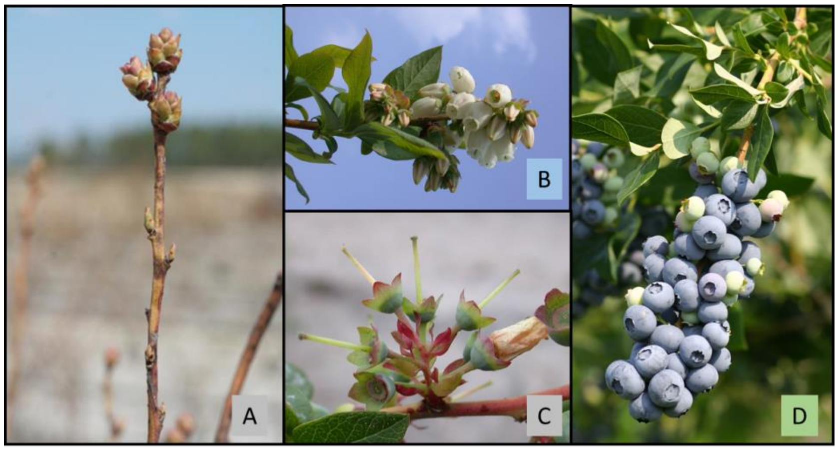


Fig. 1. Key stages in blueberry development A) Bud break (T3) B) Bloom C) Blossom drop D) Ripening

Fungicides and protectants: Efficacy is the ability to produce a desired effect. In using fungicides or other types of protectant failure is sometimes inevitable. In this section I will provide a check list of reasons for failure (By failure I mean not reaching your disease management goals).

WHAT FACTORS AFFECT EFFICACY?

- Toxicity – Is the material used at the correct concentration and active ingredient present?
- Spectrum of action – Is the target organism sensitive to the active ingredient?
- Persistence – What is the wash off time and has the active ingredient dissipated?
- Distribution – Has the active ingredient reached the location where infection occurs?
- Timing – Was the active ingredient applied too early or too late?
- Resistance – Has the target organism developed resistance to the active ingredient?

Viruses and phytoplasmas: These pathogens are very different from the fungal pathogens we commonly encounter in blueberry production. They are systemic and thrive within living plants however, they cannot be cultured and identified in the lab. Diagnosis is typically based on symptom development and followed up with a serological or molecular test such as PCR. All of these pathogens require help to move from one plant to another in the form of another living organism. Aphids, leaf hoppers, nematodes and even pollen can transmit them from diseased to healthy plants. Once inside the plant, the disease is not curable (with one notable exception). Therefore, exclusion is the best approach for controlling these systemic pathogens. Since blueberries are propagated from cuttings, these pathogens can be easily transmitted from a mother plant and then carried to new locations on new planting material. Nurseries supplying cuttings for new plantings should be certified virus-free for at least the viruses known to infect

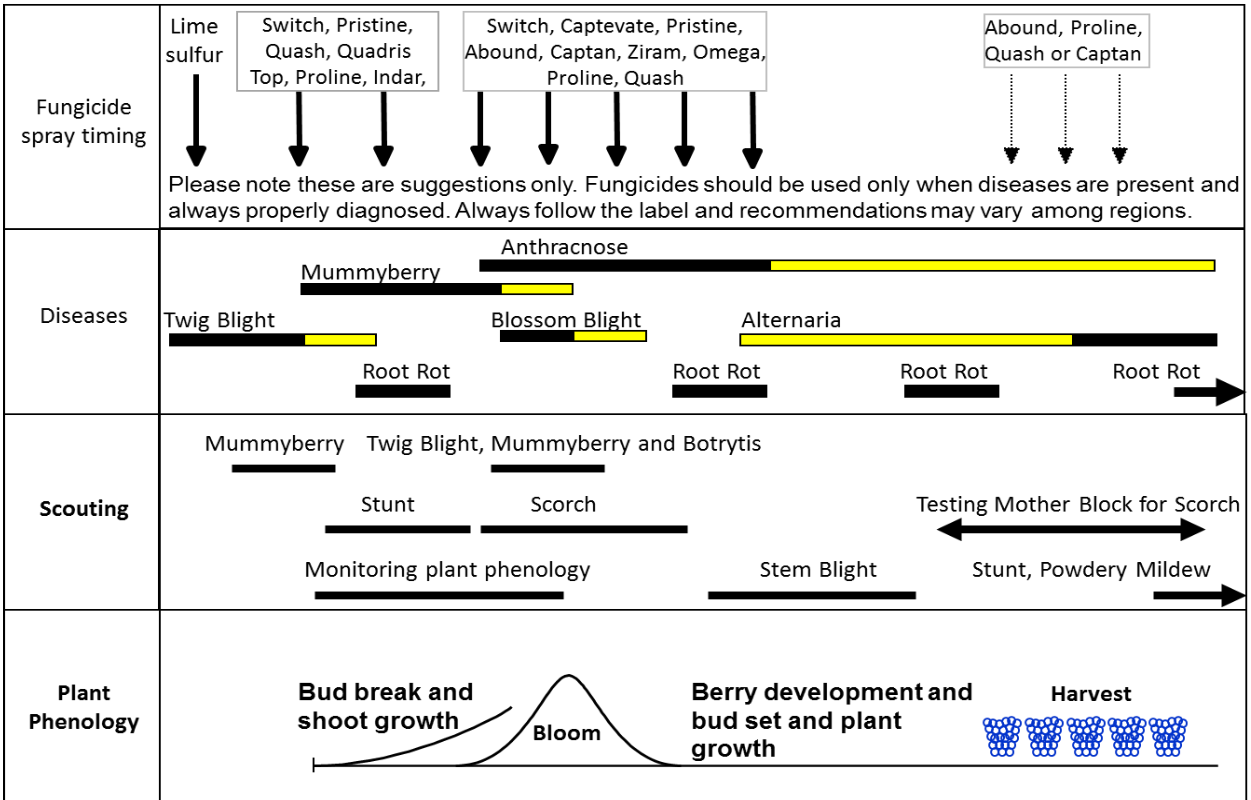


Fig 2. A diagram outlining a hypothetical sequence of fungicide applications for disease management based on host plant phenology.

blueberry. You should never accept cuttings from questionable sources. Once a virus has been introduced into an area the best means of management is through the vector.

Nematodes: These microscopic worms feed on blueberry roots and reduce overall root volume. This leads to less efficient water and nutrient uptake. Affected plants will decline slowly showing reduced yields, nutrient deficiencies and increased drought sensitivity. Soil tests in late summer and early fall can tell you if the nematodes are present. There are very few effective chemicals for nematode control. Many of the nematicides are designed for nematodes attacking cotton and soybean and these are different from the ones on blueberry. Maintaining a high organic content can help with nematode control. Several studies aimed at improving soil health provide recommendations for cover cropping in blueberry.

Invasive species: Although blueberries are grown widely throughout North America as well several foreign countries many pathogens are limited to certain geographic areas. For example, Valdensinia leaf spot has been described from eastern Canada, Maine and recently Poland. Viruses like Necrotic Ring Spot, Blueberry Shock, Fruit Drop and other diseases such as leaf scorch and Ralstonia wilt have limited distribution but can be introduced when non-certified plant material is moved between growing locations. Growers who purchase plants from non-certified nurseries are at risk for introducing new diseases that are often very difficult to control.

Thus, when purchasing new planting stock pay close attention to the source and verify that the plant material has been inspected and tested.

Root and cane diseases: Blueberries are susceptible to some very recalcitrant diseases. These include Stem Blight, Phytophthora Root Rot, Crown Gall as well as some minor diseases such as Armillaria Root Rot. Management of these diseases follows a series of cultural practices that are aimed at soil health, good pruning practices, proper timing and application of fertilizers, efficient irrigation, as well as other practices such as ploughing row middles that help reduce plant stress.

Setting Goals: One of the most important long-term goals should be to implement plans for maintaining the organic content of the soil. As soils age from years of clean cultivation, organic matter declines. This results in soils that are less forgiving in terms of nutrient availability, water use, herbicide toxicity and the population of microbes tend to shift towards a pathogen dominated community. The subsequent increase in plant stress leads to lower yields and increases in recalcitrant diseases. Blueberries in the New England are capable of producing 15,000lb/acre. However, this goal cannot be reached without careful planning and site selection. Growers should select varieties that are adapted to their growing region. Soils should be below a pH 5 and definitely below 5.5. Frost protection may be necessary in some areas. Labor for picking is critical since many varieties require regular harvest intervals. Post-harvest processing is also critical for fresh fruit. Refrigerated storage can greatly prolong shelf life. Also, growers are increasingly being trained and certified for current food safety standards.

Blueberry Pollination

Frank Drummond

School of Biology and Ecology & Cooperative Extension, University of Maine
email contact: fdrummond@maine.edu

Reproductive biology of blueberry – Blueberries are native North American plants. As such they have evolved with our climate and pollinator communities. They have bell shaped flowers arranged in terminal racemes. The flowers have specialized anthers that are referred to as poricidal. These anthers have pores in them that allow pollen to be dispersed when they are shaken vigorously. This is a means of regulating pollen dispersal to pollinators…why regulate pollen dispersal? In the wild, most blueberry plants need to be cross-pollinated. Self-pollen generally does not result in pollination. Regulating pollen dispersal so that multiple pollinators transport pollen may increase the chance of cross-pollination. However, breeding specific cultivars has resulted in self-compatible plants. Selection of specific cultivars determines the bloom phenology and constrains flower size variation that can determine the active pollinator community.

Pollinator community – Pollinators of blueberry are "chosen" by the unique flower morphology: poricidal anthers, flower size, and nectar content. While birds, moths, flies, ants, hornets, and bees have all been recorded visiting blueberry flowers, the bees are the only significant pollinators. Even among the bees, not all are efficient.

Native bees – in most areas there are about 100 species of native bees associated with blueberry production areas. Individual farms may have from 10 to 50 or 60 species of bees. Bees vary in their efficiency as pollinators. This may be due to their faithfulness to blueberry flowers when other plant species are also in bloom (this is called floral constancy). Bumble bees, some digger bee species (andrenids), and some mason bee species (Osmia bees) have been documented as mostly floral constant to blueberry during bloom, even when the field edge is blooming with raspberry and cherry. A high number of native bee species complement each other and generally result in some floral constancy (to become familiar with the major groups of bees in blueberry see: https://extension.umaine.edu/blueberries/factsheets/bees/630-wild-bee-conservation-for-wild-blueberry-fields/).

As stated above, native bee species have different efficiencies at extracting pollen from blueberry flowers and then subsequently placing pollen on the female organ for capturing pollen, the stigma. Bumble bees, are the most efficient, placing an average of 23 pollen grains on a stigma after a single visit. Digger bees and mason bees are a bit less efficient (12-18 pollen grains). These native bee efficiencies can be compared to the commercial honey bee that dislodges few pollen grains and only deposits 3-5 pollen grains on a stigma per visit. This is in large part due to their behaviors used in working the flowers…Bees that can vibrate or shake the poricidal anthers dislodge large quantities of pollen. Bumble bees do this by holding on to the corolla and vibrating their wing muscles (called buzz pollinating). Digger bees can do this too. Mason bees will climb inside the flower and drum the anthers with their front legs.

The landscape surrounding a blueberry field often determines the native bee species numbers and abundance. A tool such as BeeMapper in Maine can allow growers to assess the potential of their field and surrounding habitats for supporting native bee communities (see:

https://umaine.edu/beemapper/). Enhancing native bee communities can be facilitated by managing weeds and wildflowers along field borders or by planting pollinator pastures next to blueberry fields (see: https://extension.umaine.edu/blueberries/wp-content/uploads/sites/56/2010/05/2015-Bee-Pasture-Fact-Sheet.pdf).

Commercial bees – One can own and manage or rent honey bees, purchase bumble bees, or purchase and manage mason/leafcutting bees. Each of these bees will be mentioned in the talk and their attributes discussed. The advantage of relying upon commercial bees is that stocking densities can be adjusted to the needs of the grower and the context of the native bee pollinator force on the farm. Therefore, if a farm has a high density of native bees, the farmer can decide not to bring in commercial bees or bring in a low number of pollinating units. If the farm has a low density of native bees, the grower can make up the difference with commercial bees. Estimating the native bee force on a farm can be arrived at by using BeeMapper (described above) or by measuring the actual bee density and fruit set (see: https://www.youtube.com/watch?v=rgVav2byI8o).

Fruit set – When flowers are viable (0 to 1 -1.5 week old flowers) and a suitable number of compatible pollen grains are placed upon the stigma, set occurs 3-4 days later. Blueberry flowers have from 50-80 ovules (average of 60) and on average 12-15 (range 3-75) ovules need to be fertilized for the flower to develop into a fruit. Therefore, a bumble bee will set a flower into a fruit in one visit, but a flower only visited by a honey bee will need 4-5 visits. Factors that affect fruit set are: 1) weather (affects floral development and aging AND bee activity), 2) disease, 3) bee species (as mentioned above), 4) bee density, 5) compatible pollen deposited on stigmas, and 6) landscape vegetation or plant diversity. These are addressed in talk.

Yield – Poor fruit set guarantees poor yield while great fruit set does not guarantee a high yield. Actually, on average fruit set only explains 25 - 50% of the yield in blueberry. If one is going to invest in pollination then it only makes sense to do so if one ALSO invests in nurturing and protecting the developing fruit. Factors affecting yield are many. For instance, higher pollination levels result in higher fruit set, but ALSO more ovules fertilized and this results in larger fruit. So, both more flowers set and more ovules fertilized result in higher yields. In addition, blueberries are very plastic…by this I mean that blueberries can loose up to 60% of their flower buds prior to bloom and not experience yield loss due to compensation by the plant in allocating water and nutrient resources. This means that often we PUSH the envelope way too much in terms of trying to attain extra high pollination levels, approaching 80-90% fruit set. This can result in another compensatory mechanism – June drop. Therefore, yield is dynamic, complex, and difficult to predict, but it is worth thinking about crop production in this manner, in other words, pollination in “context”. Figure 1 below shows the dynamics of fruit set and yield in lowbush blueberry, but many of these factors hold for highbush blueberry.

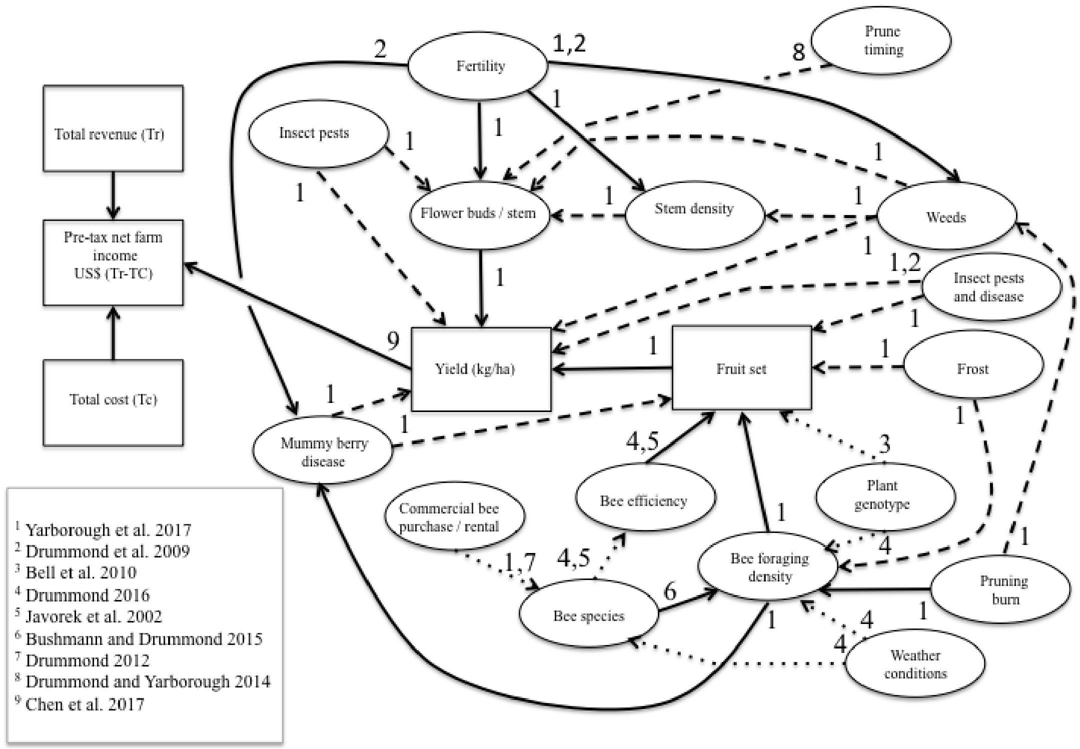


Figure 1. Factors that affect yield of blueberry are shown. The solid lines are positive effects and the dashed lines are negative effects (from Asare et al. 2017).

Future – Climate change? … bee species diversity and abundance shifts, pollinator day shrinkage, blueberry dormancy termination…these are phenomena that have been documented and will be mentioned.

Further Reading:

1. Asare, E., A.K. Hoshide, F.A. Drummond, X. Chen, and G.K. Criner. 2017. Economic riskof bee pollination in Maine wild blueberry, *Vaccinium angustifolium* Aiton. J. Econ. Entomol. Doi: 10.1093/jee/tox191: 1-13. See: https://academic.oup.com/jee/article/110/5/1980/4036106/Economic-Risk-of-Bee-Pollination-in-Maine-Wild?guestAccessKey=c9418ee2-7f0d-4d10-89ce-913f044a05b7

2. Delaplane, K. S. and D.F. Mayer. 2000. Crop Pollination by Bees. CABI Publishing.

3. Drummond, F.A. 2002. Honeybees and Lowbush Blueberry Pollination. http://wildblueberries.maine.edu/FactSheet/NEW629HBPollin.pdf

4. Stubbs, C.S., F.A. Drummond, and D. Yarborough. 2001. Commercial bumble bee, *Bombus impatiens*, management for lowbush blueberry. Wild blueberry fact sheet No. 302(Bulletin No. 2421). University of Maine Cooperative Extension Publication. 4 pp.

https://extension.umaine.edu/blueberries/factsheets/bees/302-commercial-bumble-bee-bombus-impatiens-management-for-wild-blueberry-pollination/

5. Gibbs J, E. Elle, K. Bobiwash, T. Haapalainen, and R. Isaacs. 2016. Contrasting pollinators and pollination in native and non-native regions of highbush blueberry production. PLoS ONE 11(7): e0158937. doi:10.1371

Planning for Growth
Julia Shanks

Julia Shanks Food Consulting, Cambridge MA
www.juliashanks.com
Julia@juliashanks.com

You've heard that expression: If you don't know where you're going, any road will take you. And if you want to get somewhere in business (that is, grow a profitable business) then you need a plan to get there. Growth may mean enter a new market, offering a new product, or just generally growing your customer base and sales.

Creating a plan also helps you think through the details… it can reduce stress because you've tested the numbers. It helps you figure out what you can afford and when, and if you need to borrow money.

There are four basic steps to the planning process:

1. Review and understand your current operations
2. Evaluate the different opportunities to grow (and pick one or more that make sense based on your review of current operations)
3. Create the plan which includes both the implementation strategy and financial (cash flow) projections.
4. As you implement your plan, periodically look back at your written plan and financial projections to make sure you're on track. If you're not, then make necessary adjustments.

I. Review Current Operations

You've heard that standard disclaimer from investment firms… "past performance doesn't promise future returns." But looking at your past can help you decide where to grow, and if you do grow, what will it look like.

The review of current operations takes on two forms. First, you want to understand where you've been most profitable. You may think, for example, that the farmers' markets are more profitable than selling wholesale because you earn more revenue. But looking at your expenses may revel a different story. Similarly, you may want to expand sales of a certain crop because they generate more profit.

Second, you want to understand how your revenue and expenses will change in the execution of your growth strategy. You'll want to think about your costs in terms of fixed and variable. Variable costs vary and revenue varies: as produce sales increase, you need to purchase more seeds, and as egg sales go up, you need to purchase more feed. As you harvest more, you need to hire more labor. On the other hand, your fixed costs stay the same. Whether your revenue is

$100,000 or $1,000,000, your phone bill will be the same; and it costs the same to prepare your taxes.

Another way to think about fixed and variable are the incremental costs vs. sunk costs. If you build a new greenhouse, you'll have extra labor in addition to your current labor, or seed expenses in addition to what you already have. The incremental expenses can also be new expenses. If you're building a greenhouse, you might have new heating costs that you didn't have if you just grew in the open field.

On the other hand, sunk costs will vary differently on your decisions to grow. Whether you grow or not, you still need to pay rent for your land, and you still need to pay the phone bill. You still need to manage your current productions. So as you evaluate your opportunities for growth, you'll want to recognize that these sunk costs will happen regardless of what you do, so they should be isolated as such.

II. Decide Where/How to Grow

There are many ways to grow a business. You can do more of what you're already doing, whether it's growing more vegetables, planting more fruit trees, or increasing your land in production. You may decide to add more markets to accommodate the added growth.

Of course, you want to think about how to focus your energies… should you expand the winter greens operation or the flowers? If you've been tracking your revenue and expenses by enterprise, then you can see which is most profitable.

You can also expand into new enterprises. As an example, Kitchen Garden Farm, in Sunderland MA, started making salsa in addition to their srirachas, and decided to build a new processing facility. Stillman's Farm decided to add value added products so they built a processing facility. And Colby Farm built a new farmstand.

With a new opportunity, you'll need to dig into the numbers a little differently. Let's say you want to build a greenhouse. You need to ask yourself some questions… and I like to organize them by start-up phase and ongoing phase; as well as what are cash inflows and what are cash outflows:

a. In order to get the greenhouse into production, you need to purchase the greenhouse, air circulator, heating, as well as labor to install it (Start-Up Expenses, Cash Outflow)
b. Once it's up and running, how much can you expect to earn? A little research suggested that about $6 per square foot is reasonable. (On-Going, Cash Inflow)
c. What does it cost to operate? You'll need seeds, fertility, and packaging. (On-Going, Cash Outflow). You may know these numbers based on your previous operations; or you need to dig a little more – ask other farmers, NCAT has some great info on their website.
d. Will you need financing to launch this new venture? (Start-up, Cash Inflow)

You want to look at this as incremental profit to your business… The other aspects of your business are still happening… so this is just gravy… and does it contributes enough

III. Create a Plan

Depending on the nature of your enterprise or growth strategy… you may or may not need a business plan. If you're getting a grant, let's say from MDAR, they want a plan to make sure you'll be good stewards of their money; they will want a full business plan. If you're making smaller changes to your business, a one page sketch with numbers could be enough. If you're planning a $300,000 investment, then you'll want to spend more time with the business plan and the financial projections.

The Business Planning Process

a. It helps to understand the industry; it can lead you to the products and services you offer. I worked with an organic growers' association and they were looking to create value-add products with their organic apples. As we looked at the market, we discovered there are lots of organic products, and lots of local products but no local & organic. This created an opportunity for them. It not only helped to clarify the product they decided to offer, but also how they wanted to position themselves.

b. And with the marketing plan you can start to project revenues.

c. Knowing what you want to sell, will give you a lot of guidance into your day to day operations – and help you lay out your Operating Plan + Development Plan, as well as your Start-Up/Capital Expense, Operating Expenses, etc. so that you can create financial projections

d. Above all, you need to tell your investors you know what you're doing as part of the section on Critical Risks

In short, you need to convince your investors that you are the right person to execute on this vision. Especially with start-ups, investors are looking at the team just as much as the numbers.

IV. Track and Measure

When you create your business plan and budgets, you mapped out a strategy that would be financially profitable. As you continue from the planning stage to the execution stage, you want to make sure you stay on track. It's too easy to let a few expenses creep up, or slack a little bit in sales. You want to make sure you catch the shortfalls, and adjust, before it's too late.

For more details on how to write a business plan or create financial projections, you can purchase my book, The Farmer's Office or visit my website.

Effective Marketing for the Busy Farmer

Laura Biasillo

Cornell Cooperative Extension of Broome County
840 Upper Front St, Binghamton, NY 13905
(607) 584-5007/lw257@cornell.edu

Farmers typically go into agriculture due to a love of farming, to preserve open space, and become a fixture in their community. Rarely are they equipped with the savvy marketing skills required to compete in the local foods arena where big box stores and home meal delivery caters to both millennials and busy two-income families with young children. This presentation will cover a variety of marketing methods for direct marketing fruit and vegetable growers. These will include, but not be limited to, display techniques, labeling and packaging, written materials, customer service, and social media presence. We'll discuss how you can make a few, effective, changes to how you market your products that will positively increase your sales – whether your goal is increased customers or increased amount of sales per customer.

Without a market for your products, it does not make business sense to start growing/production of any agricultural item. So here are the:

Top Ten Tips for Effective Marketing for the Busy Farmer:

1) **Profitability:** In order to remain profitable, a farmer needs to know their total costs (production, processing, storing and selling).
2) **Records (we don't need no stinkin' records):** In order to have confidence when going through the cost determination steps, you need good financial and production records. Production records should reflect what you actually sold; not what was produced.
3) **Field of Dreams….I will grow it and it will just sell itself.** You should do research before you purchase seeds to ensure that there is a demand and profit potential for the products you are looking to grow. You will want to understand how your local community purchases local foods, the level of disposable income, etc…
4) **Avoid the middleman and do it all yourself:** Often you will hear that you need to go direct and "cut out the middleman…All they do is add costs". Your best advice is to always try and use the Supply Chain. They are there for a purpose and if you have a good idea and product it will move efficiently through the chain and make your life a lot easier.
5) **Social Media:** You need to become proficient at using social media. Social media outlets such as Instagram and Facebook are becoming the new way that consumers get their information and interact with other consumers and farmers. Choose one channel and become proficient. Post at least every other day. Learn to take decent pictures.
6) **Specialize (and don't be the 27th sweet corn grower in your community).** You will want to figure out how you can be competitive in the local foods arena in your community. What types of produce isn't being grown that you can do well? Do you want to specialize in greens, root crops, "baby" vegetables, Asian vegetables, etc Can you cater

to a specific population, ethnic group, religious entity, etc…? Don't be the 27th farmer to just grow sweet corn and put it on a table.

7) **Understand local foods buyers have different motivations.** It has been said that there are four segments of local foods buyers:
    a. Environmentally focused
    b. Social justice motivated
    c. Health & Nutrition focused
    d. The foodie

Understanding who each of these are and their interests/motivations will allow you to narrow down who your target customer is and the types of messaging you may want to use to communicate with them regarding your products.

8) **The 10/4 rule:** Farmers markets can be a busy atmosphere. Acknowledge a customer with a smile, nod or eye contact at 10 feet, and then greet them at 4 feet. Doing so will not only let the customer know that you see them, but that you welcome them into your area and invite them to ask questions and interact with you. And make sure that your staff (or you) do not have your cell phones out while customers are around!
9) **The Customer is King:** The customer is always right. Make sure that you always work with a customer if they have a question, quality issue or complaint. Your best marketing is word of mouth, and it only takes one to ruin your reputation. It is easier to often cut your losses than make a scene with someone. As well, it may just take some education to help the customer understand they didn't store the produce correctly to ensure quality (i.e. leaving a tomato in the refrigerator, or their fresh picked berries in their hot car all afternoon).
10) **Be a Price Setter, Not a Price Taker:** Once you understand all your costs (see tip #1) you can start thinking about setting your price → price = perceived quality to many customers, which plays into your marketing strategy. It is fine to have certain products be a loss leader, but you want to take your costs into account and then look at what your competition is doing. And no, your competition is not Wegmans, Price Chopper or any other mainline grocery store. Where are your customer shopping and then use that as a baseline.

Planning Farm Infrastructure for Maximum Efficiency

Erin S. Pirro

CAC, Farm Business Consultant
240 South Road, Enfield, CT 06082
(860) 377-0053
erin.pirro@farmcrediteast.com

Architects or Builder: which are you?

An architect spends the time to lay out a plan, looking at the project from a 10,000-foot view, making sure it meets the needs of the client. A builder takes those plans and starts from the ground up, beginning with the foundation and adding layer after layer until it's complete.

What if the builder didn't have those plans to go by? What if s/he decided to plan in his/her head as s/he went? We've all been through a construction project where we wish the outcome was just a little (or a lot) different, and more often than not some additional planning time would have

Here are a few tips to get the most out of your project planning.

1) **Form follows Function.** The ultimate use of the project will help you decide on what's needed. While you want to maintain some flexibility, leaving the options too open makes it hard to progress. Stick to your main goal(s). If these are clearly outlined, you'll be well on your way to a more efficient design.

2) **Consider the big picture** and **lay it out with a clean slate.** What do you want this project to accomplish? What does it need to do for your farm? How does it fit with the other infrastructure? How will it be used in conjunction with what's already there?

Grab a map of the farm, the facility, or the room where you plan to do the work. Just because a structure is there doesn't mean it has to stay there. Sure, you'd invested time and money to build it and it will take time and money to move or demolish it. But that's not a waste if it's in your way and will cost you hundreds of dollars each month to work around! So don't get hung up on keeping it there. If there is a 'no touch' rule (i.e. a historical designation or zoning/building regulation), what else can be changed instead?

3) **Follow the flow.** How will you use this space? Draw a schematic and move people and product through it. Better yet, lay it out on the ground with rope, chalk, or lumber to give you the basic structure.

4) **Where are the bottlenecks or trip points?** Where will activity (people, product, processes) start to bunch up? Figure these out and then decide what to do about them.

5) **Take the time to adjust.** Planning is not a 'once and done' activity. Assess your work above and go back through #3 and #4, working out the kinks. You'll still find some along the way, but the more you can work out on paper, the less frustration you'll have to deal with later.

Farm Mechanizations and Efficiencies

Richard Wiswall

Cate Farm
135 Cate Farm Road, Plainfield, VT 05667
www.catefarm.com
www.richardwiswall.com
catefarm@gmail.com

With all the inherent risks in farming, profit margins can be low. Efficient production is paramount to succeeding financially. Using employee and farmer hours to their greatest potential is a goal for every farm. Numerous photos will highlight some of the best tools for efficient diversified vegetable production. The talk will open with quick look at primary tillage tools, and then take a more in-depth look at cultivation strategies, harvest tools and tips, to packhouse design and processing equipment. Greenhouse seedling tools of the trade will be addressed as well. A simple way of determining cost/benefit and payback period of equipment will be explained in a farmer friendly manner.

The Way We Use Irrigation for Fruit and Vegetable Production (panel)

David Wadleigh

Kimball Fruit Farm
184 Hollis Street, Pepperell, MA 01463

At Kimball Fruit Farm we grow 185 acres of vegetables, small fruits, and tree fruits but are known for our heirloom tomatoes, apples, and corn. We grow our produce using a mixture of zone tilled soil, plasticulture, high tunnel, greenhouse, and hydroponic systems. Most of our business is retail at our farm stand in Pepperell, MA and at nine weekly farmers markets in the greater Boston area but we also sell wholesale to other farms, over 50 area restaurants, and to brokers at the Chelsea Terminal Market.

Because we grow a wide variety of crops we use a wide variety of irrigation methods. We have a system of underground pvc pipes connecting our irrigation pond to a series of hydrants throughout our fields. From these hydrants we can connect overhead full-sized and micro-sprinklers (used on brassicas, strawberries, lettuce etc.), drip tape (raspberries, grapes, solanaceous and curcurbit crops), and a traveler (mostly corn but also on the same crops that we use our overhead systems). Our conventional and hydroponic greenhouses both run micro-irrigation systems fed from two wells which also feed our farm stand, packing room, and spray barn.

For fertilizer we have a handful of removable in-line pumps with built in filters. In conjunction with our underground pipe system this makes it easy to put out specific feed to specific crops; rather than running one fertilizer at one pump in one field we can run multiple irrigation systems, with multiple fertilizers, in multiple fields and switch after a couple hours.

In our greenhouses we use in-line DEMA and Dosetron pumps to run custom fertilizer blends through micro-drippers. Our hydroponic system pumps from a major nutrient tank, a micro nutrient tank and a tank of sulfuric acid (to control pH).

Our hydroponic greenhouse is on a computer controlled watering schedule and our conventional greenhouse is watered daily at the same times. In the field we irrigate based on soil dryness (based on observation without the use of an irrometer) and plant growth.

There are some gaps in our irrigation program that I would like to fill some day. The first is the incorporation of irrometers. These tools allow you to utilize irrigation before the plants show signs of stress. They also give you an idea of the available moisture in the entire subsoil growing area rather than just the surface.

It would also be beneficial to incorporate the same sort of custom fertilizer recipes used in our greenhouses in the field. This would require an increased utilization of soil and leaf nutrient testing to increase or decrease nutrients in the fertilizer mix as the specific plants need.

Another tool used in the greenhouses that should be used in the field is a schedule. The biggest problem for us to overcome in our field irrigation program is time management. In the greenhouse there are set times that we irrigate. In the field it would be beneficial to use the same type of system - (i.e. Water tomatoes and peppers at these times, cucumbers at these times etc.).

There are some things I think that we do right in our program. First, we have redesigned all of our systems so that we can blow out the individual lines before use and after storage. In the greenhouse all of our main feed lines have quarter turn ball valves at the end for this exact purpose. Similarly we have removable endcaps for all of our in field systems.

We also try to pre-design and invest in our systems with the intent of reducing the amount of man hours required to set up and run our irrigation. We installed the underground pipes, put bigger gas tanks on our pumps so we can start them less frequently, bought the automated computer system for the greenhouse, and bought micro sprinklers that can be set up and torn down faster, draw less water, and can be transported without a trailer.

Finally, we try to design our field layouts with irrigation in mind. This is as simple as planning the direction of rows based on the easiest direction of a header pipe from the water source or planting more heavy feeding crops closer to an irrigation source. Or as complex as planting celery and onions near solanaceous crops because they all need more water. Also, we try to keep our field ends as straight as possible when preparing beds to ease in laying the header pipe.

The Way We Use Irrigation for Fruit & Vegetable Production – Farmer Panel

George W. Hamilton (Moderator)

Extension Field Specialist, Food and Agriculture
UNH Cooperative Extension - Hillsborough County
329 Mast Road - Room 101, Goffstown, NH 03045
Phone: (603) 641-6060 e-mail: george.hamilton@unh.edu

The Way We Use Irrigation for Fruit & Vegetable Production

- Jim Ward, Ward's Berry Farm, Sharon MA
- David Wadleigh, Kimball Fruit Farm, Pepperell MA
- Russell Holmberg, Holmberg Orchards, Gales Ferry CT

Each of the three farmers will have approximately 15 minutes to address the questions listed below. We will open it up to the audience for questions for the last 15 minutes.

Introduction – slide of farm

State type of farming business you have:

- Vegetable
- Small Fruit
- Tree Fruit
- Greenhouse
- High Tunnels

Acres of crops

Type of marketing:

- Wholesale
- Wholesale to Other Farms
- Farm Stand
- Farmers Market
- Pick-Your –Own
- CSA

Types of irrigation used on farm:

- Drip

- Overhead-nozzles
- Traveler
- Micro Sprinklers
- Greenhouse

Source of Water:

- Pond
- River
- Brook
- Well
- Municipality

Irrigation Components to Your Systems:

- Pump
- Filters
- Fertigation
- Drip type
- Sprinklers type, distances between sprinklers

How Do You Determine When To Water?

- Guess
- Feel Soil
- Sensors
- Plant Growth Response

What do you wish you had to make the irrigation job easier? (List 3 to 5 items)

What would you recommend to others that works for you, to make the irrigation job easier? (list 3 to 5 items)

The most important item that you wish someone would have told you, when you first started irrigating your crops.

Drip Irrigation Uniformity

Bill Wolfram

District Sales Manager, Toro Ag Irrigation
Bill.Wolfram@Toro.com
757-710-0320

What is it?

Drip irrigation systems consist of blocks of lateral pipes with online or inline emission devices that emit water directly to the root zones of crops, and sub-main pipeline networks that supply water to the laterals within a block.

The system uniformity tells how evenly water is applied throughout the block and indicates how much **over-irrigation** must occur to ensure the driest part of the block receives enough water and nutrients to support the crop i.e., how much over-irrigation will be required to compensate for imperfect uniformity. Drip irrigation uniformity is typically expressed as distribution uniformity (DU) or emission uniformity (EU), either as a decimal or a percentage. A system's uniformity at the time of design is considered theoretical "design uniformity", while measured uniformity in an operating drip system is considered actual "field uniformity". The system's gross application rate is usually stated in GPM or inches per acre, and once known it is downgraded by the system's uniformity to determine the net application rate for irrigation scheduling purposes.

How is it determined?

The system uniformity may be predicted by the designer, (ideally above 90% for drip applications) or measured in the field. The predicted design uniformity is a result of the designer's component selection, sizing and layout considering block shape, size and topography. Since flow is directly affected by pressure, and pressure is directly affected by topography and friction loss through pipelines, uniformity is best when pressure variation within the block is minimized, or when components are selected that minimize sensitivity to pressure variation.

Measured uniformity in the field is the result of design uniformity after installation and under actual operating conditions. This includes the effect of water quality and actual system pressure and flow. For example, if emission device clogging is occurring due to poor water quality or lack of system maintenance, if there are leaks in the mainline, submains or laterals due to poor installation or field damage, and/or if system operating pressures are not maintained within the design operating window, then field uniformity will be lower than predicted uniformity. Field uniformity may be determined by taking flow measurements from several of the emission devices within the block and then dividing the average measurement of the "low quarter measurements" (lowest 25% of the readings) by the overall average.

Why is irrigation uniformity important?

Irrigation uniformity is important because it directly affects crop performance, operating costs, and control of applied water and nutrients to the environment. One of the main advantages of drip irrigation is the opportunity to obtain high system uniformity. In general, drip irrigation systems often achieve over 90% uniformity with proper design, installation and maintenance. This is in contrast to typical uniformities of 40-60% for gravity systems and 50-75% for sprinkler systems. To help translate the importance of uniformity, the following table illustrates how many hours are required to apply a minimum of 1.0 inch of water to all plants in an irrigation block assuming various emission uniformities and assuming an application rate of 0.10 inches per hour.

Emission Uniformity	Net Application Rate	Hours to apply 1.0 inches
1.00	0.100	**10.0**
0.95	0.095	10.5
0.90	0.090	11.1
0.85	0.085	11.8
0.80	0.080	12.5
0.75	0.075	13.3
0.70	0.070	14.3
0.65	0.065	15.4
0.60	0.060	16.7
0.55	0.055	18.2
0.50	0.050	**20.0**

Note that if the system were perfectly uniform (EU = 1.0), then the system would need to run 10 hours to apply 1.0 inch of water, whereas if the system had an EU of 50% (EU = .5), then the system would need to run for twice as long, 20 hours, to apply a minimum of 1 inch of water to the driest part of the field. Running the system twice as many hours means twice as many gallons of water and fertilizer applied, twice as much fuel use and twice as much labor expense

to achieve the same result of applying 1.0 inch of water. Another way to view this is as a percent increase in runtime shown below, where, for example, a 75% EU results in the necessity for a 33% increase in runtime:

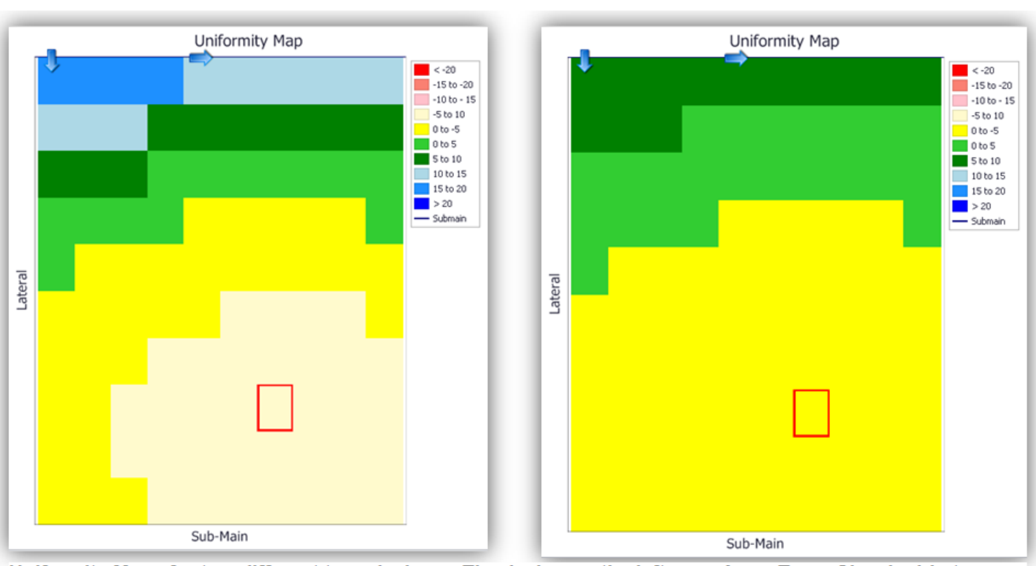
Perhaps more importantly, in addition to avoiding the costs associated with unnecessary system runtime, high uniformity leads to more uniform crop production and enhanced crop health and vigor since all plants in the block receive the proper amount of water and nutrients, ideally at the right time. As a result, yield and quality are increased while inputs are reduced. Another way of stating this is that water use efficiency, nutrient use efficiency, and/or overall resource use efficiency is improved and more “crop per unit of input” is achieved.

How can drip irrigation uniformity be maximized?

Drip irrigation uniformity may be maximized with proper design, installation, operation and maintenance. Although all irrigation system types share some basic hydraulic principles and equipment, such as pumps and delivery pipe, there are differences in drip irrigation that require specialized knowledge to choose the right types and sizes of system components to ensure that the system applies water uniformly to each plant, and so that the system may be flushed and maintained to ensure a long life. Prior to the availability of software, designers manually calculated system hydraulics including friction loss and flow uniformity, or they used charts and nomographs developed for this specific purpose. With the introduction of consumer computers, early versions of drip irrigation design software automated many of these tasks and allowed a higher level of accuracy.

Today, drip irrigation design has never been easier or more accurate. Toro's AquaFlow drip irrigation design program takes advantage of recent advancements in computer processing, programming techniques and display screen technology to optimize drip irrigation design. Designers can now evaluate more selection options more quickly, and with more accuracy than ever before, thus improving the decision-making process for selecting drip irrigation system components. This results in higher uniformity and better, more cost effective drip irrigation system performance which improves the return on investment (ROI) for the farmer.

The figure below shows two of AquaFlow's Uniformity Maps that illustrate block uniformity with color where highly uniformity blocks will have fewer colors. For example, the uniformity map on the left used Aqua-Traxx Classic drip tape and has more colors, and lower uniformity, than the uniformity map on the right which used Aqua-Traxx FC flow control drip tape. Each design used a drip tape with the exact same flow rate, spacing, internal diameter and length of run under the same topography conditions and with the same submain supply, but since Aqua-Traxx FC has superior hydraulic performance than Aqua-Traxx Classic, the resulting uniformity is improved using Aqua-Traxx FC. Thus, with all other variables remaining constant, the choice of drip tape alone can significantly affect drip irrigation system uniformity.



Uniformity Maps for two different tape designs. The design on the left uses Aqua-Traxx Classic drip tape, the design on the right uses Aqua-Traxx FC drip tape.

In addition to design, system installation, operation and maintenance are also extremely important. Even though recent innovations in drip irrigation component design and manufacturing have made clog-resistant, highly uniform drip tapes, dripline and other emission devices readily available, the nature of agricultural water sources, fertilizer injection practices, natural limitations of filtration equipment and the general agricultural growing environment make maintenance a priority. Toro's Drip Irrigation Owner's Manual helps growers understand system set-up, irrigation scheduling, fertilizer application and system maintenance including flushing and chemigation.

In summary, high drip irrigation uniformity may be achieved and maintained over many years with proper design, installation, operation and maintenance. With highly uniform drip irrigation systems, farmers may efficiently spoon feed their crops water and nutrients to achieve higher, more uniform yields with fewer inputs. This results in improved farm profits, more food production with fewer inputs, and more sustainable farming practices.

How to Measure Irrigation Needs with Soil Moisture Sensors

Trevor Hardy

Brookdale Fruit Farm Inc.
38 Broad Street Hollis, NH 03049
tractortrv@aol.com

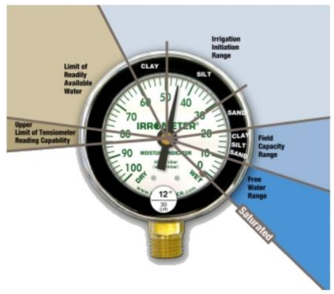
Crop irrigation needs can be calculated and or adjusted via local weather inputs, computer calculations, historical trends, and local crop condition. The best way to determine a crops specific moisture needs during the growing cycle is by measuring directly the soil moisture condition of that crop in that field. The current available analytical tools are just that tools for the toolbox of determining a crops water needs. At Brookdale we use and distribute products from The Irrometer Company to measure soil moisture and determine our irrigation cycles for our crop. IRROMETER soil moisture measurement is based on the tensiometric method, because of the fact that the amount of water is not as important as how difficult it is for the plant to extract it from the soil. Soil water tension (or matric potential) has to be overcome for the plant to move water in to its root system. Different soil types will have different tensions even at the same volumetric measurement, making volumetric information relative to local conditions and improved soil health. Soil water tension is the best method for reading local soil moisture as it pertains to the specific condition that the crop is being grown in rather than reference points or analytical tools based on regional weather events.

There are two tools we use. The first is the Irrometer Tensiometer. This is a liquid filled tube with a clay tip that is charged with a vacuum and measures soil tension on a scale of 0 to 100 Centibars. 0 being Saturated or “wet” and 100 being dry. The functional range in which we make irrigation decisions is based on readings greater than 40 centibars to start an irrigation cycle and stop at around 20 centibars. Each crop requires 2 sensors in order to measure the soil moisture at the upper and lower range of the root zone for the crop. Looking at the difference between the two readings of soil moisture at the top and bottom of root zone helps determine the length of the irrigation cycle relative to the amount of available moisture for the crop at its deepest-rooted depth. On the irrometer the gauge looks just like a pressure gauge and is easy to read. See figure 1

The second method is using a Watermark sensor. This sensor works on the same principle as the Irrometer Tensiometer but rather than drawing its reading through a vacuum tube filled with liquid the watermark measures electrical resistance in the sensor that translates to the same tension value in the soil. Where we find the watermark sensors more beneficial is in the design as a permanent installed sensor not requiring periodic calibration. The other major savings for the watermark sensor and use in the New England region is there is no freezing concern relative to the sensors longevity. If you freeze and irrometer it breaks. A watermark sensor uses no liquid to obtain its reading therefore it is less costly over time to operate. The watermark sensor reading of soil tension is displayed on a reader when 2 leads are connected to the sensor and the read button is pushed. This allows a grower to have multiple sensors but only requires one reader.

Soil moisture readings should be taken at the same time every day as a representative point in which you are using to check soil moisture. The reading will be different from the morning to the afternoon daily, that is why it is important to take your measurement at the same time of day so a false reading is not used in decision making. Local crop history and field knowledge now plays a role in irrigation decision making with soil moisture readings. If you had a problematic field with a sandy soil and the forecast was for 5 days of sun with heat and the soil moisture readings were both near 35 kPi one would choose to irrigate and keep consistent soil moisture through a hot dry condition. Without the sensors a typical irrigation decision would have been made a day or two into that dry condition resulting in more water needing to be applied to achieve a wet condition. The soil moisture sensors not only help determine a crops irrigation needs, but they can also aid in preventing over irrigation and help conserve water during a drought condition.

Figure 1



Soil moisture sensor depth table

CROP	SHALLOW INSTRUMENT (INCHES)	DEEP INSTRUMENT (INCHES)	FOR EXTRA DEPTH, SET AT (INCHES)	CROP	SHALLOW INSTRUMENT (INCHES)	DEEP INSTRUMENT (INCHES)	FOR EXTRA DEPTH, SET AT (INCHES)
ALFALFA	18-24	36-48	60-70	MELONS	18	36	
ALMONDS	24	48	72	MILO	24	48	
APPLES	20	40	60	MINT	12	24	
APRICOTS	24	48	72	MONTEREY PINES, FIRS	12	24	
ARTICHOKES	18	36		MUMS	4-6		
ASPARAGUS	18-24	36-48		MUSTARD	18	36	
AVOCADOS	12	24	36	NECTARINES	18	36	
BANANAS	12	24		OATS	18	36	
BARLEY	18	36		OKRA	18	36	
BEANS (bush)	10		18	OLIVES	24	48	60
BEANS (Lima)	18	36		ONIONS	12		
BEANS (Pole)	18	36		PAPAYA	12	24	
BEETS (sugar)	18	36		PARSNIPS	18	36	
BEETS (table)	12-18	24-36		PEACHES	18	36	60
BLUEBERRIES	12	24		PEANUTS	12	24	
BROCCOLI	12	20		PEARS	18	36	48
CABBAGE	12	20		PEAS	18	36	
CANAIGRE	18	36	48	PECANS	18	36	48
CANTALOUPE	18	36		PEPPERS	15	30	
CARNATIONS	4-6			PERMANENT PASTURES	8-15		24-30
CARROTS	12	24		PERSIMMONS	18	36	
CAULIFLOWER	12	24		PINEAPPLE	15	30	
CELERY	10	20		PISTACHIO NUTS	24	48	60
CHARD	12	24		POMEGRANATES	18	36	
CHERRIES	24	48		POTATOES (Irish)	8-10	18	
CHRISTMAS TREE	12	24		POTATOES (sweet)	18	36	
CITRUS: Orange, Lemon, Grapefruit	18	36		PLUMS	24	48	72
COFFEE	18-24	36-48		PRUNES	24	48	72
CORN (sweet)	12	30		PUMPKIN	18	36	48
CORN (field)	18	36		RADISHES	12		
COTTON	18	36	48	RASPBERRIES	18	36	
CRANBERRIES	18	36		SORGHUM	18	36	
CUCUMBERS	18	36		SOY BEANS	18	36	60
DATE PALM	24	48	60	SPINACH	12	24	
EGGPLANT	12	24		SQUASH (Summer)	15	30	
FIGS	18	36		STRAWBERRIES	6	12	
GARLIC	12	24		SUDAN GRASS	18-24	36-48	
GRAIN and FLAX	18	36		SUGAR CANE	18	36	
GRAPES	24	48	60	SUNFLOWERS	24	48	60
HOPS	24	48	60	TEA	12	24	
JOJOBA	18	36		TOBACCO	8-15	30	
KIWI	18	36	48	TOMATOES	18	36	
LADINO CLOVER	10	20		TURNIPS	18	36	
LETTUCE	12			WALNUTS	24	48	72
MACADAMIAS	12	24	36	WATERMELON	18	36	48
MAIZE	18	36		WHEAT, HAY	18	36	

Building the Farm of Your Dreams

Caroline Pam

Kitchen Garden Farm

131 S. Silver Lane, Sunderland MA 01375

info@kitchengardenfarm.com

Setting up your farm with the proper infrastructure can significantly improve efficiency and productivity – and profitability. Evaluating which projects will have the greatest impact on your farm is an ongoing process necessary for deciding where to most effectively invest your resources. We start by identifying roadblocks: Where are we consistently losing time? What is preventing access to specific marketing opportunities? What could we sell more of if we could grow it and what is the limiting factor – labor, land, storage, season extension?

Once you've identified a need and a solution the next step is figuring out how to pay for it.

Building infrastructure takes time so it's essential to develop a multi-year plan for growth and improvements. If you're increasing capacity, you'll want to be developing new markets during build-out and have a workable interim plan.

Grants

Grants can make a project more affordable and speed up your return on investment but they can also draw out a project's timeline. Application deadlines vary but quite often they're due in spring or early summer when you're busy so you'll want to start communicating with grant administrators in fall or winter to confirm your project's eligibility and make sure you know what's necessary for the application. MDAR grants tend to be relatively simple and straightforward but some federal grants require business plans and detailed financials.

It's also important to have a good understanding of the grant timeline. Most grants we've been awarded were reimbursement grants that required us to pay up front for the project – but not until the award notification (usually in fall). So in order to take advantage of grant funding it often takes a year from the time you decide to apply and figure out what's necessary to the time you can start spending money. Reimbursement can take 6 weeks or more after project completion depending on whether you need to just submit proof of payment and receipts or schedule an inspection for approval.

Grants we've received over the past 12 years:

2008-2010 USDA NRCS EQIP – $13,701 for irrigation system, cover crop and nutrient management

2011 MDAR/MEGA for beginning farmers - $10,000 for high tunnel

2011 and 2016 USDA NRCS high tunnel – $10,000 (2011) and $28,141 (2016)

2016 Grinspoon Farm Award - $2,500 for subsoiler to improve drainage

2016 MDAR APR Improvement Grant - $75,000 for new wash/pack barn

2016 MDAR Ag Energy Grant - $25,000 for solar panels on new barn

2016 USDA REAP - $20,000 for solar panels on new barn

2016 Fair Food Fund/CISA/PVGrows - $2,000 for sriracha business plan consulting and financial projections

2017 Grinspoon Farm Award - $2,500 for BioTherm bench heat system for greenhouse

2017 MDAR Food Safety Improvement Grant - $11,277 for stainless bagging table and rinse conveyor

2017 USDA Value-Added Producer Grant – $49,922 working capital to make sriracha from peppers

2017 CISA wholesale grant - $1,200 for custom wax box design and initial printing set up

Financing

Even if you are planning to use grant funding for a project you'll probably need to secure financing first since most grants are on a reimbursement basis. Some grants require proof that you have secured financing in order to be selected. And some grants are matching, which requires you to contribute some portion of the project cost from your own funds.

We try to avoid using cash flow for large projects because inevitably we need access to cash for payroll and other expenses. We also prefer to spread big investments out over a few years in case of a change in projected income that season – to spread the risk and be sure that we'll be able to afford it.

We have a revolving operating line of credit from Farm Credit East payable in full every year. We also take out separate capital loans with 7-10 year terms as needed for larger fixed asset purchases like tractors, vehicles, etc. We find it convenient to borrow from Farm Credit because they already know our financial situation and require us to update our financial reporting annually so it's usually quick to request approval for funding so long as our financials demonstrate that we can afford the debt maintenance and we have sufficient collateral for the loan amount. Since Farm Credit is a cooperative we also receive annual dividend payments so that offsets the cost of the interest payments. Interest rates on our loans are currently 5.25% and are subject to change.

FSA offers lower interest rates (currently 2.5%) but has a far more complicated loan application including several years of financial projections and business plan. FSA Direct Farm Ownership loans are up to a max of $300,000 and can be used to purchase land or farm buildings, or for new construction with up to 30-year terms. FSA operating loans are for a max of $300,000 and can be used for equipment, facility upgrades, working capital, etc. over a 7-year term.

Other lenders include The Carrot Project, Fair Food Fund and PV Grows. These organizations may also offer technical assistance to help you prepare the financial and business plans needed to demonstrate project viability.

Partnerships

We think of the service providers at MDAR, USDA, Farm Credit and FSA as partners in our farm business since they provide essential support that has helped our farm grow and thrive. It’s worth investing time and energy into developing relationships with these knowledgeable people. I would also consider as partners the local town administrators you may need to consult on zoning and permitting questions, as well as the building, electrical and plumbing contractors you rely on for construction projects. If these partners are invested in your success, you’ll have a much easier time navigating the bureaucratic process and you’ll have allies who can help you.

Positioning the Farm so Expansion and Change Is Embraced by Our Neighbors and Community

John E. Moulton

Moulton Farm

The challenge of operating our farms has never been greater. Thin profit margins combined with Federal, State and Local regulations test our skills every day. Very few of us are surrounded by like agricultural entities and instead find ourselves embedded in neighborhoods facing local regulatory jurisdictions sometimes being driven by well-intended though sometimes misinformed citizens or Boards influenced or pressured by residents.

As the complexion of our farms and neighbors change we all know conflict can develop resulting in control tactics that may restrict or add expense to the farm operations.

Moulton Farm is a 65 acre retail produce grower, commercial kitchen operator and garden center in Meredith NH and has received excellent community support during expansion of activities and structures. This support is also very evident through steady sales and customer growth.

In the early 1990's the main activity at this "part time" farm was a farm stand operated from mid-July to Labor Day offering sweet corn, fresh vegetables, and a few "value added" items. This activity took place in a 20'L x 20'W "room", inside a pole barn, compliant to Meredith's zoning regulations restricting farm stands to 400 square feet of retail area.

As the farm progressed through the 1990's, turning to "full time" operation and on to the next decade, the need to expand the retail area and diversify with a commercial kitchen was desired. To do this required zoning law changes.

I went directly to the town planner with my plea and reason(s) for pursuing this diversification. My emphasis, of course, was the need for alternative profit centers or activities that would support the farm especially during years of low or unstable field production. Fortunately our planner worked hard developing an ordinance that would allow farms to expand and diversify.

After better than a year of public hearings, town meeting votes, site plans, more hearings, architectural review, it all came together with the issuance of a building permit. Every step of the way I felt support from community officials and residents.

So as we are close to seeking a site plan amendment for a new expansion, how do we try to insure our good standing in the community?

First of all we continue with our core mission of a fully operating 65 acre diversified produce farm growing for our own retail market offering "best possible farm experience and outstanding customer service."

Continual staff training and education is invaluable to insuring customers feel well, are treated fairly and will take pride in "their" farm! This goes a long way to instilling community appreciation.

Secondly, we further enhance the community value of the farm, fee free, by hosting school to farm events, allowing groups to use the farm for functions, organizing classes and workshops, allowing property access for recreational purposes, donating maze time to groups and keeping an updated presentation ready to roll out to any group that will have us!

A third approach we use is giving back to the community in terms of time and donations. Personally I am a current member and past president of our local Rotary Club, member and current president of our Chamber of Commerce, Director of our local mutual bank, Cooperator Belknap Economic Development Council and involved in several agricultural organizations, giving the farm good representation in multiple settings.

Finally, the farm regularly donates produce to the local Altrusa Club for distribution to local soup kitchens and food banks. Contributions to groups for silent auctions, door prizes, raffles, and advertising in yearbook, programs and public radio sponsorships are frequent. We select a couple of non-profits to provide a major contribution and in 2017 provided a complete 50 plate farm to table diner to a local regional social services agency, another dinner to the local County Conservation District and sponsored a 5K road race at the farm with proceeds going to the local Humane Society.

Everything I have identified is costly either in dollars or time. However, this expense is an investment in the community and our neighbors that will pay off in support of our business in both the short and long term.

In my first paragraph I referred to "influence and pressure" by residents…..my goal is to see that these efforts are in favor and support of the farm because of the value the farm entity brings to the community.

**What to Consider When Building a Large Capital Structure:
A New Barn for Edgewater Farm**

Pooh Sprague

Plainfield, NH 603 306 2530

Edgewater Farm is a family farm that has been involved with horticultural and agricultural production for 44 years. Like many small New England farms, the farm model has been developed to be highly diversified. There are retail, wholesale ,PYO and CSA components. Additionally, we are in the process of transitioning ownership to the next generation.

There are many hurdles to jump in considering any capital on- farm investment, many questions to be considered. The considerations that loomed before us were much more consequential because of the enormity of the scope of the project. We are currently constructing a 50 x94 structure that will serve as a washing , packing and storage structure for produce. The following points outline the decision making process, but would apply to any farmer considering a similar sized capital investment.

1 **The Benefit**: The object would hopefully achieve several goals. Our primary goal was to provide storage with some atmospheric control of fall and early winter storage crops, and help reduce loss and shrink. A dedicated wet wash area would allow us to let our wash stations to remain stationery all year , under cover, as well as being fully food safety compliant. A dry pack area would allow us to house scales, shipping materials and a climate moderated area to work in in late fall and early winter. A loading dock would allow us to more ergonomically load and unload trucks. Additionally the dry pack area would provide space for us in the winter to house and prefill containers for the ornamental side of the operation.

2: **The Cost**: As a new and dedicated structure, the cost of construction is on par with the cost of acquiring land. Recent meteorological events this past fall have literally doubled and tripled the cost of building supplies. A lot of soul searching was done over the last 2 years before we initiated the project.

3: **Helpful Questions to ask yourself** 1) Can you swing the extra payments as well as your current operating loan? 2) Will it help you with marketing or advancing your business model? 3) Will assuming extra debt encumber you from future needed capital repairs or acquisition? (ex: now that you are maxed out on operating mortgage and short term structure loans, are you prepared to have the old IH 1066 blow its motor in 2 years and finally force you to consider a replacement tractor? What if the field next door that you have coveted is finally offered to you for sale…are you in a position to consider purchase at that point?

4: **Helpful Answers**: **1)** I feel personally that banks are not always the best source for this answer. There is a willingness to lend if your history of repayment is good. This can be a double edged sword, but less of a hurdle if you have a long history and candid conversation with your loan officer, They are more than happy to lend if they can attach property as collateral. Rarely do they risk anything by lending you money. However, they do have some metrics by which they can share with you concerning the risk and ability to pay.. Debt to equity ratios are one of many, and it is always good to know how you look to the banking industry compared to other operations of similar size. . **2)** Ask other farmers what they think. We farmers as a group generally have a pretty good understanding of what our ability to payback loans are, and farmers are often very candid about sharing information. Farmers more than anyone understand the risks involved in agricultural that are not built into banking formulas. Much of my decision making over the years has defaulted to the conversations that I have had with my friends and colleagues.

Infrastructure Design with the FSMA Produce Safety Rule on the Mind

Christopher W. Callahan

UVM Extension, Agricultural Engineering
310 Main St, Bennington, VT 05201
chris.callahan@uvm.edu

The Food Safety Modernization Act (FSMA) was passed by Congress in 2011 and resulted in the development of seven new rules related to the safe production, sale and distribution of food. One of these laws is the FSMA Produce Safety Rule (PSR), finalized in 2015 by the Food and Drug Administration (FDA 2015). **The FSMA PSR is the first mandatory federal standard for the production of fruits and vegetables in the United States.** Although not all producers have the same coverage or required practices under the rule, it is likely to affect most growers in the Northeast in some way either due to direct regulatory coverage or as a result of market demands resulting indirectly from the rule. It is also important to note that not all crops are covered by the rule.

This paper and the associated conference presentation are intended to highlight the key areas where produce related infrastructure may be influenced by the PSR and to provide some guidance for on-farm considerations. "Infrastructure" in this case is meant to include the foundational structures and systems necessary to grow, wash, pack and store produce on a typical Northeast farm.

The PSR as published in the Federal Register comprises three parts (11, 16, & 112) with part 112 being the most directly relevant for this topic. Within part 112, there are a total of 18 subparts lettered A-R, with some currently vacant and reserved. The Produce Safety Alliance (PSA) is a federally funded initiative at Cornell University charged with training trainers and growers about the FSMA PSR. The PSA have developed the national training curriculum, the PSA Curriculum (Bihn et al, 2016), which covers the core concepts of the PSR. The PSA Curriculum comprises 8 modules, each covering a portion of the rule as it relates to a specific on-farm area. **The PSA Curriculum modules and common infrastructure topics are summarized in Table 1 showing their relationship.** The PSA Curriculum includes FSMA PSR subpart references for more detailed information. Several PSA Grower Trainings are offered every year and growers are encouraged to attend one. The PSA's website (www.producesafetyalliance.cornell.edu) is a good source for course listings.

Although this list of considerations may seem daunting, most of these topics are things already considered on the farm and are likely to already be a focus for improvement for other reasons such as efficiency, productivity, yield improvement, and product quality improvement.

In my experiences working with farms in the region, the key infrastructure considerations include **production water** (sources, distribution), **containers** (new, dedicated), **separation of operation** (produce from livestock, compost from wash/pack, etc.), **buildings** (wash, pack, and storage), and **building improvements** (floors, drains, walls, doors), **wash line upgrades** (equipment, layout), **cooler upgrades** (more zones, improved materials), **material upgrades** (smooth and cleanable), **postharvest water** (antimicrobial solutions, change procedures), **recordkeeping systems**, and the development of a **produce safety plan**. Each of these topics are covered in more detail below and will be discussed in the conference presentation.

Production Water – "Production water must be safe and of adequate sanitary quality for its intended use." The specific test methods, calculations and thresholds are currently being reviewed, but are likely to involve a test for generic E. coli. The safest water sources are treated water such as that from a public water supply, risk increases as the source tends to surface water. Distribution systems that minimize or avoid direct contact of production water with the edible portion of the plant (e.g. drip vs. overhead irrigation) are considered lower risk. Growers should inventory and map their production water sources and start collecting generic E. coli test results, inspect distribution systems and consider alternative application methods to minimize contact with edible portions of the plant.

Containers – A key aspect of the FSMA PSR is how "food contact surfaces" are handled, namely that they need to be cleanable and sanitizable. One of the most common food contact surfaces on Northeast farms is the inside of resuable harvest, packing and storage containers. Many containers in use are not cleanable, let alone sanitizable. Growers should consider replacing harvest, packing and storage containers over time with cleanable and sanitizable containers, consider dedicating color coded containers to specific and separate uses (e.g. harvest vs. storage or marketing), and develop standard procedures for washing, sanitizing and storing containers to avoid product contamination.

Separation of Operation – Many farms in the Northeast are highly diversified including production of fruits, vegetables and livestock and often buildings are used for multiple purposes. To avoid cross contamination, spaces should be dedicated to separated uses. Some examples include tractor maintenance being done in a workshop that is separate from a location where greens are washed, avoiding close rotations of crops and livestock grazing, storing chemicals in a separate location from vegetable washing and packing, and conducting processing (slaughter of livestock, canning of pickles) in a separate location from raw vegetable washing and packing.

Buildings & Improvements – The buildings that house fruit and vegetable operations in the Northeast are varied in age, condition, and design. Many were originally designed for other purposes such as dairy cattle housing and have been adapted for use in produce operations. Exposed wood with chipping paint can be refinished with fresh paint and can also be enclosed with smooth and cleanable finish surfaces such as galvanized roofing, fiber reinforced plastic (FRP / dairyboard), and other plastics (see http://go.uvm.edu/smoothnclean). Consideration of product flow can also help to ensure pre-washed ("dirty") produce flows in one way and washed and packed ("clean") produce flows another to avoid cross contamination and to improve efficiency. Newly poured concrete floors provide a smooth surface for rolling heavier loads and can be pitched to ensure drainage. Intentional interior drainage using trench drains or spot drains can help to prevent standing water in wash areas and coolers. Exclusion of animals such as rodents is a perpetual challenge, but some simple actions such as removing culled produce daily, closing gaps in the building envelope and implementing a baited trap program outside the wash area can be effective (see http://go.uvm.edu/rats.)

Wash Line Upgrades – Since the inside of most wash line equipment is a food contact surface area, it needs to be cleanable and sanitizable. This presents a challenge for many of the pieces of equipment in use on farms for washing produce. Dunk tanks, barrel washers, brush washers, conveyors, greens spinners, and sorting tables in use are generally falling short of this requirement. Manufacturers, engineers, and tinkerers are working on improvements and replacements in the future will likely include improvements such as design for easier access, disassembly, and cleaning as well as use of smooth and cleanable surfaces, and even some alternate washing techniques. Growers should consider all options when thinking about replacing existing equipment and not default to an in-kind replacement.

Postharvest Water – Unless a farm has access to a public water supply for postharvest water, it will most likely need to consider treatment of some sort. This, so far, has taken the form of antimicrobial solutions (a.k.a. "sanitizers", germicidal bleach, peroxyacetic acid (PAA) solutions, etc.) which are added to water in dilute concentrations to prevent cross contamination during the produce washing process. Safe, accurate dosing is important and there are good options available (see http://go.uvm.edu/sanitizerfactsheet). Some farms have implemented ultraviolet water treatment systems. Monitoring wash water during use for turbidity (suspended solids such as dirt), pH, and concentration of antimicrobial solution is an important practice that is most frequently accomplished visually (turbidity) and with test strips (bleach and PAA). Electronic means are available for all of these measurements, though cost effective solutions for smaller scale operations are still in development.

Recordkeeping Systems – They may be pen and paper on a clipboard or a distributed, cloud-based, computer system that integrates with your production planning and farm management work, but records are in your future. There are a variety of record keeping templates available, including some from the PSA that relate specifically to the training curriculum and PSR requirements. A recent project by the presenter explored commercially available software options and how they align with the FSMA PSR recordkeeping and tracking requirements. Due to a relative lack of feature alignment among the solutions reviewed, the project worked to develop a produce safety module within FarmOS, an opensource farm management system that is intended to ease record keeping with accessibility from any web-enabled device (computer, phone, tablet) using automatic time and date stamping and use of phone photos for quick documentation (see http://go.uvm.edu/producetracking or http://farmos.org/guide/contrib/produce-safety/).

Produce Safety Plans and On Farm Readiness Reviews – Due in part to the significance of the FSMA PSR and the complexity embodied in the rule, there is an earnest effort among regulatory bodies to "educate before and while they regulate." This is evidenced by the support provided for educational programs at the national, state, extension, and farmer organization levels using the PSA Grower Training Curriculum. It is also apparent in the On Farm Readiness Review (OFRR) process which is being finalized for use in Spring 2018. The OFRR is not an inspection, but is rather a collaborative walk-through of a farm enterprise with a FSMA PSR lens to assess readiness for a future inspection. A key element of both the PSA training and an OFRR is consideration of a produce safety plan. The process of developing a produce safety plan is a good way to control one's own destiny, identify hazards and assess risk, plan for mitigating action, prioritize investment based on risk, and celebrate where the farm is doing well. A list of resources for developing a produce safety plan is available from the PSA, see go.uvm.edu/producesafetyplan

CITATIONS

Bihn, E., G. Wall, & M. Humiston. (2016). Produce Safety Alliance Grower Training Manual. Version 1.0.

Callahan, C. (2015) Sanitizer Dosing Systems and DIY Doser Build Instructions. Fact Sheet. October 21, 2015. Retrieved from http://blog.uvm.edu/cwcallah/files/2015/10/Dosing-Options-and-DIY-Doser-Build-Notes.pdf.

Callahan, C. and A. Chamberlin. (2017) Rats (and Other Rodents). Fact sheet. October 9, 2017. Retrieved from http://blog.uvm.edu/cwcallah/files/2016/10/2017-10-09-Rats-and-Rodent-Facts-Sheet-cc-edits.pdf.

Callahan, C. and A. Chamberlin. (2017) Smooth and Cleanable Surfaces. Fact sheet. Retrieved from http://blog.uvm.edu/cwcallah/files/2016/04/Smooth-and-Cleanable-Surfaces-Fact-Sheet-2017-09-29.pdf.

US FDA. (2015). FSMA Final Produce Safety Rule: Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption. 21 CFR Parts 11, 16, and 112. US FDA. Retrieved from https://www.fda.gov/food/guidanceregulation/fsma/ucm334114.htm

US FDA. (2017). Guidance for Industry: Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption: What You Need to Know About the FDA Regulation - Small Entity Compliance Guide. Retrieved from https://www.fda.gov/downloads/Food/GuidanceRegulation/GuidanceDocumentsRegulatoryInformation/UCM574456.pdf

Tomato Pest Management

Ann Hazelrigg, Ph.D.

PSS Department, Jeffords Hall
63 Carrigan Drive, UVM, Burlington, VT 05405
ann.hazelrigg@uvm.edu

This talk will include an overview of field tomato diseases and pests from seedborne issues through harvest. Diseases and pests will include bacterial and fungal leafspots, bacterial canker, late blight, powdery mildew, leaf mold, non-infectious disorders, tomato hornworm, potato leafhopper, armyworms and stink bugs. Basics on how pathogens cause disease will be covered as well as how to identify the diseases in the field and how manage them before and after planting using IPM strategies. Management options covered will include hot water seed treatment, rotation, sanitation, use of resistant varieties, etc.

Breeding for Better Disease Resistance & Flavor

Emily Rose Haga

Johnny's Selected Seeds
955 Benton Ave, Winslow, ME 04901
ehaga@johnnyseeds.com

Tomatoes are an important and high value crop for direct market farmers due to their popularity with consumers and synonymy with seasonal freshness and flavor. Local markets demand both traditional and specialty types, with more emphasis on fruit quality and heirloom appearance compared to the long-distance shipping markets. However, as a crop, tomatoes can present significant production challenges- especially for organic growers, who face many disease problems that affect productivity and fruit quality but have limited control options. These growers need varieties that not only appeal to local markets, but that can produce reliable yields of high quality fruit without dependence on chemical inputs; yet availability of such varieties within the wide range of types desired by these markets is limiting.

To address these varietal constraints, Johnny's R&D program is committed to finding new varieties that have the combination of heirloom flavor, unique appearance, and disease resistance needed by these unique markets. The trialing team works with a vast network of vendors world-wide to test available products under organic conditions and select the best we can offer to support field and greenhouse growers. In addition, our in-house breeding team helps address remaining gaps through targeted breeding goals that further compliment and diversify our offerings. Toward this end, the tomato breeding program at Johnny's is focused on creating new OP and F1-hybrid varieties that combine heirloom qualities with late blight resistance (LBR) in unique and colorful market types.

Resistance to late blight is strongly desired by organic tomato growers who want to reduce or avoid the use of chemicals, but availability of high quality LBR varieties desired by local and specialty markets is limiting. The development of LBR germplasm by public breeding programs like Cornell University and North Carolina State University offers a large opportunity for small breeding companies like Johnny's to address this market gap. These universities have done valuable work towards "pre-breeding" resistance from various wild species sources into commercially adapted material that we can incorporate into our breeding programs. They have also done work to understand the genetics of LBR, which has provided us the ability to use molecular marker selection as an additional breeding tool. This modern (non-GMO) breeding technique supplements our traditional pedigree selection methods with genetic information that helps select for disease resistant genes in the absence of infection.

Superior flavor and texture are additional qualities considered to be hallmarks of our breeding work, and we rigorously select for high eating quality in new varieties. Routine taste evaluations of experimental new varieties involve scoring flavor, texture, and overall eating quality on a 1-9 rating scale, with comparison to commercial standards. In early testing stages, varieties simply receive a pass or fail outcome. As promising candidates are identified, more extensive taste evaluation and culinary testing is conducted to get feedback, with an emphasis on characterizing specific flavor attributes that help to describe the variety and its culinary potential. A growing network of farmer cooperators, culinary partners, and university researchers in several regions help us test our promising new varieties to make sure they taste good and perform well across a wide range of environments. These regional trials are a particularly insightful part of the commercial testing process for experimental new varieties from our breeding programs because they provide a means of determining stability, adaptability, and real-world potential. They also help us understand specific market, regional, or production considerations that could affect a customer’s success with a new product.

To date, Johnny’s has introduced three varieties from its tomato breeding program with high resistance to late blight. Defiant PhR F1 (released in 2011) is an extra early, determinate, small round red slicer with very good flavor and eating quality. Jasper F1 (released in 2013) is an indeterminate, small red cherry that won an All-America Selections (AAS) award for its outstanding flavor and home garden appeal. Cherry Bomb F1 (released in 2016) is another classic and delicious indeterminate red cherry with slightly larger size for market harvest ease. We are also currently working on several more future introductions from our program in additional market classes.

Getting Started With Grafting

Andrew Mefferd

Editor and Publisher, Growing for Market Magazine
news & ideas for local food producers
andrew@growingformarket.com
www.growingformarket.com
207-649-2828

For many years grafting tomatoes has been broadly adopted by large commercial growers. Now grafting is becoming more common with growers of all sizes. If you are considering grafting or buying grafted plants, it is worth understanding the benefits and the drawbacks, which are sometimes misunderstood. We will discuss why and how grafting can boost yield, disease resistance and vigor, what situations grafting is most useful in, potential drawbacks, and tips for making a good rootstock/scion match. Though how to do grafting is beyond the scope of this presentation, we will highlight sources of information or plants so you can try grafted plants on your own farm.

Response of Determinate Field Tomatoes to Foliar Nutrients

Andy Radin

University of Rhode Island Cooperative Extension
Kingston, RI 02881
andy_radin@uri.edu

Introduction

Not too long ago, determinate field tomato production involved: application of pre-plant fertilizer, laying of black plastic mulch and drip tape, transplanting, irrigation and fungicide spraying when necessary, and then harvest over 3 or 4 weeks.

In the quest for higher yields, fertigation and foliar feeding have become part of the standard operating procedure. Fertigation provides a more efficient delivery system for fertilizer nutrients as required through the growing season, which is important in coarse, leachable soils.

Definitive early documentation (1950s) of **absorption of nutrients by plant leaves** was performed using radioactive isotopes. Until recently, foliar feeding has only been recommended for rapid correction of deficiencies of a limited number of nutrients (Zn, B, Ca, N) during the season. Now growers routinely spray nutrients, and many products are available in both conventional and organic formulations. But the science isn't settled as to whether it is an effective means of getting nutrients into plants, both where they are needed and when.

Research Question

Do foliar fertilizer sprays increase yield and marketability of determinate tomato fruits?

How the study was conducted

Soils varied between three study locations: Farm 1 has pH 6.2 loamy sand with 1.5% o.m., with all macronutrients testing at "below optimum" except P, which tested at "excessive"; Farm 2 has pH 6.2 sandy loam with 3% o.m., with all macronutrients testing at "optimum" except for Ca, which was "below optimum"; URI Agronomy Farm is pH 6.7 silt loam with 3.4% o.m., with all macronutrients at "optimum" except Ca, which was "excessive".

'Red Deuce' was planted at the same density at all locations: 24" between plants within rows, rows spaced at 6'. Pre-plant controlled (polyacrylamide) release **fertilizer** was applied at all three sites at a rate of 72 lbs N/ac, 42 lbs P2O5, and 78 lbs K2O/ac, along with additional Ca and S in the blend (12-7-13-14Ca-4S). This was the rate recommended by a fertilizer dealer representative. Tomatoes were transplanted into black plastic mulch-covered raised-beds on May 22 at URI and Farm 1, and on June 16 at Farm 2. Transplants at all locations were watered in with high P soluble dilute fertilizer solution. At URI, there was one fertigation applied on June 20 using the same transplant fertilizer (8-32-5). At the Grower's fields, a wide variety of liquid fertilizers was applied by fertigation on a weekly basis (as recommended by the dealer representative) until a week after first harvest.

Foliar fertilizer sprays were applied on half of the areas planted to 'Red Deuce' at both of the Grower's sites, according to dealer representative recommendation. At URI, one tomato planting (1/6 acre) was divided into 8 equal-sized plots; four randomly selected plots were sprayed with the same fertilizers and around the same dates as those recommended for Farm 1, and four were left unsprayed.

Products (Table 1) were sprayed in combinations on two occasions at Farm 1 and on three occasions at Farm 2 and URI. **Note** that most of these were also applied via fertigation at the Grower's fields on a regular basis throughout the growing season. They were **not** applied at URI via fertigation. Only foliar sprays were applied at URI.

Fruit was sampled from eight marked-off plots within each of the fields. Each of these plots was 24 feet of row. All but rotten fruit was harvested and weighed (Gross Yield), "marketable" fruit was graded out and weighed (Net Yield), and Marketable Percentage was calculated.

Leaf tissue was sampled and analyzed for nutrient concentration from all three locations **at first flowering** and **early fruit set.** First samples were taken prior to applications of sprays.

Note: foliar fertilizer treatments were prescribed by the dealer representative according to the calendar. Those materials that were sprayed at the Grower's fields were also applied at URI.

Results

Foliar nutrient sprays had no effect at any location on **Total Yield, Net Yield, or Marketable Percentage**. (See figures). Had yield or quality effects been detected from foliar fertilizer sprays, **leaf tissue nutrient status** might have been closely looked at to determine if sprays had provided benefit. As it turns out, leaf tissue nutrient concentrations of both sample dates at all three locations fell within the "sufficiency" range. Ranges are useful guides, but not absolute.

The complications of On-Farm Research

Studies conducted in more "ideal" conditions (experimental farm) can give a sense if a practice or product has potential, but these then have to stand up to "real world" conditions on working farms. In this study, there were, indeed, some "real world" situations encountered:

1) Spring of 2017 was cool and wet, which delayed planting and crop growth
2) Nearly 100% of transplants were infected (tested +) with bacterial canker. At the URI planting, transplants from the same source were used, and they also tested +, though yield and quality were not as severely affected as were the Grower's.
3) Foliar spraying at Farm 1 was supposed to start earlier and be more frequent, but one sprayer was available and dedicated to herbicides until all weed spraying was finished.
4) Three successions of these tomatoes had been planned for both the Grower and URI, but:
    a. The Grower's second planting established poorly and plants meant for the third succession were used to fill spaces in their second.
    b. Many of the flats that provided to URI for its second planting were mismarked; the planting ended up being mixed types, so yield comparisons could not be made
    c. URI's third planting did not take place because all of the Grower's transplants for the third planting were used up to fill spaces in their second planting!
5) The investigator was not aware until late July that weekly fertigation had been prescribed by the dealer representative and was being carried out.

Discussion of the results and the season

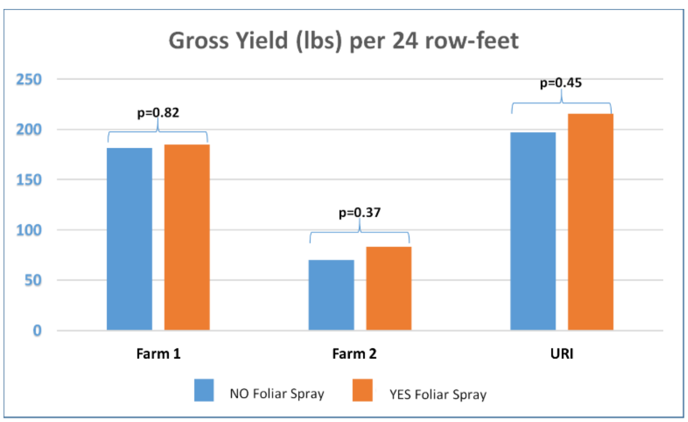
In comparison to nutrient quantities applied pre-plant and via fertigation, the amount of nutrients applied to foliage was miniscule, and only a small fraction of that is absorbed.

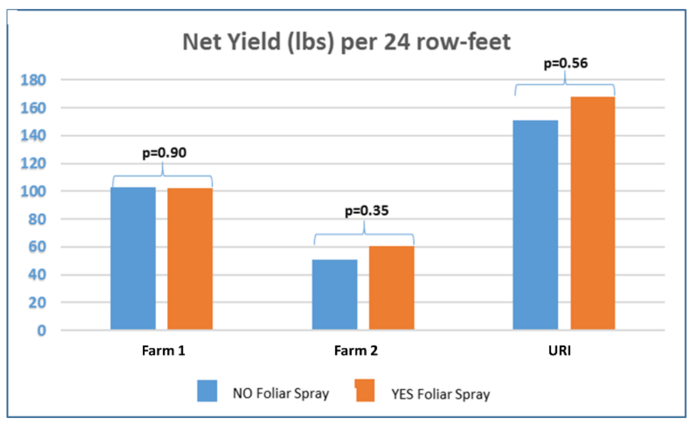
Under stressful disease conditions, one might speculate that supplemental foliar nutrients might improve fruit quality. However, the foliar fertilizer sprays had no effect on fruit yield or quality. Mancozeb/Copper hydroxide spray was applied regularly on the Grower's fields, but bacterial canker continued to affect plants, causing early loss of foliage cover at Farm 1 and reduced vegetative growth and fruit yield at Farm 2. At URI, where copper alone was applied on two occasions, plants were clearly afflicted with the disease but produced respectable yield. In fact, marketable yield at URI was substantially higher than the Grower's at either location, while fertilizer input at URI (no fertigation) was much less. Superior soil health at URI may explain this difference.

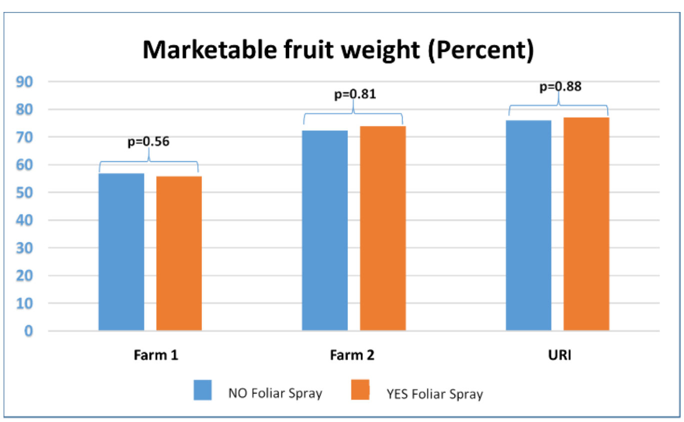
Because of the high probability of complications, such as unexpected pest or disease problems, weather irregularities, miscommunications, and other foul-ups, field experiments have to be performed for at least two seasons. Therefore, the conclusion that these foliar fertilizer sprays have no effect is tentative.

Table 1: Foliar fertilizer products.

N	P2O5	K2O	Additional	Product Name	Lbs/gal
6	24	3	0.75 Zn; 7.1% humic acid	HumaZinc	~11
10	18	4		Nachurs	10.6
6	0	0	8 Ca	Solucal	
0	0	24		Nachurs	10.65
7	0	7		Nachurs	11.26
3	0	8		Megafol (Valagro)	10.2
3	0	15		(Valagro)	11.1
25	0	0	0.5 B	CoRoN	10
5	10	27	chelated Ca, Mg, Co, Cu Mn and Zn, plus B and Mo	Harvest More Urea Mate (water soluble)	







High Quality Heirloom Production

Jonathon Berube

Heron Pond Farm
290 Main Ave, South Hampton, NH 03827
(978) 504-1722
jonathon.berube@gmail.com

At Heron Pond Farm tomatoes are a giant asset to us. Whether it be retail at our farm stand and markets, wholesale or as a part of our CSA pick-ups. We have moved away from planting any tomatoes outdoors relying completely on four greenhouses and an acre of Hay Grove high tunnels.

The first two houses we plant are 28’x 48’ houses. In these houses we grow our tomatoes in coconut coir bags on top of landscape fabric. We try to have these fully planted by March 1st and with soil temperatures being so low the bags have proven to be vital for such an early planting date in New England. We run five rows of coir bags about 28-30 bags per row roughly a foot apart.

The second two houses we plant are 30’x 96’houses. In these we plant six rows of tomatoes into the soil through slitted landscape fabric. We plant both of these houses by April 1st. Just this fall we installed ground heating into these houses to improve the soil temperature at the root zone for this time of year.

With these four early houses we run a two-lead pruning system using black clips and twine so the plants grow in ‘Y’ formation. Airflow and keeping the plants dry are vital. I know it sounds counterproductive to run a heater with the vents open (especially on your wallet) but this has helped tremendously with keeping diseases out of these houses in the cool, damp early spring weather. Along with pruning or “suckering” in these houses we do a lot of leaf removal at certain stages of the plants growth to help with better air flow between plants. We’ve found that keeping twelve to thirteen leaves is more than enough for the plants to perform their basic functions. To help with pollination we provide each house with some good old fashion bumble bee hives each season.

(Post leaf removal on tomatoes in coir bags)

Our Hay Grove high tunnels is where most of our production comes from. The other green houses are nice for having tomatoes early in the CSA and being one of, if not the first to have them at the markets we attend, however they don't produce enough to meet wholesale needs.

The Hay Grove consists of 5 bays. Each bay being 400' long. We lay four beds of plastic mulch per bay and we lay out strips of landscape fabric in between each bed creating an acre of 'black' if you will. This is for obvious weed control so there is minimal in-hole hand weeding to be done at the base of the plants. These beds are staked and trellised like your normal field planting with drip tape running under each bed for root zone watering.

Monitoring temperature is must in every indoor environment but especially in the Hay Grove.

Plants are likely to abort flowers if temperatures stay above 85°F or below 55°F for too long. Opening doors and rolling up the sides in the morning to vent heat and any moisture built up from having them closed from the night before and closing doors and rolling down sides to trap heat overnight is crucial. During the warmer months you can choose to keep the bays completely open through the night or closing just the doors or sides depending on the night time temperatures.

We monitor heavily for diseases and nutrient deficiencies throughout the growing season. Since there is no crop rotation to speak of, soil testing is a sound way to see what you need to amend year to year. Getting a test done in the fall at the end of your production season to see what you need to change for the coming year is important. Along with fertilizer amendments pre-planting, we also run a fertigation system through our drip tape irrigation throughout the crop's life cycle.

Even when the plants have been waist high and showing signs of nutrient deficiencies, running specific water-soluble fertilizers has shown significant results in as little as one weeks' time. In the Hay Grove we prune a lot less than in our greenhouses. Leaving mostly everything above your first trellis line on the plant and removing anything below. Especially removing anything below where the root stock meets the fruiting part of the plant if you choose to go with grafted tomatoes. This can easily be done while also weeding the holes in the plastic mulch if necessary.

Heirloom tomato variety choices are something to be factored in as well. We use to grow twelve to fifteen varieties in the Hay Grove. All of which had different issues at different stages of the year. Some died off well before any of the other varieties and some were more prone to diseases, etc. We have since whittled our variety choices down one each 'color' that, for us, has proven themselves to produce better than other 'like' varieties of their kind. This will obviously be different from farm to farm and you should decide what works well versus what doesn't for you.

As of this year we are still focusing on Black Krims, Pineapples, German Johnsons and Cherokee Greens for our production. Not saying other varieties aren't worth growing, these are just the ones that have out shined others for us year to year.

(A peek at the first bay of the Hay Grove mid staking)

At the end of the day a lot of our practices for a complete indoor tomato environment can be used in field plantings as well, knowing that not everyone has the infrastructure on hand to transition into growing completely indoors. Being extremely observant of this finicky crop should be your goal. A lot of hands on maintenance may seem like too much for you labor costs but keeping a close eye on plant health, be it disease or nutrient related, will significantly increase your yields. And in return, make up for what seems like a lot of time, labor, and money invested into one crop on a diversified farm.

Worker Protection Standard Training: WPS Update & WPS Train the Trainer for Workers

Andrea Szylvian

EPA Region 1 WPS Coordinator
US EPA Region 1, 5 Post Office Square
Mail Code: OES-05-04, Boston, MA 02109
Szylvian.andrea@epa.gov 617-918-1198

EPA's Agricultural Worker Protection Standard (WPS) is aimed at reducing the risk of pesticide poisoning and injury among agricultural workers and pesticide handlers. The WPS offers occupational protections to over 2 million agricultural workers (people involved in the production of agricultural plants) and pesticide handlers (people who mix, load, or apply crop pesticides) who work at over 600,000 agricultural establishments (farms, forests, nurseries and greenhouses).

On November 2, 2015, EPA revised the WPS to implement stronger protections for agricultural workers, handlers and their families. The WPS revisions are intended to decrease the pesticide exposure incidents among farmworkers and their family members. Fewer incidents means a healthier workforce and avoiding lost wages, medical bills and absences from work and school.

Most of the revised WPS requirements became effective on January 2, 2017. Three requirements go into effect on January 2, 2018:

- pesticide safety training must cover the expanded content;
- pesticide safety information (posters) must meet the revised standards; and
- handlers must suspend applications if workers or other people are in the application exclusion zone.

For compliance information, please visit: https://www.epa.gov/pesticide-worker-safety/agricultural-worker-protection-standard-wps#details

Training resources and other tools may be available from your State Lead Agency (SLA) for pesticide regulation, or at the Pesticide Education Resources Collaborative at: http://www.pesticideresources.org/

New England State Lead Agencies (SLAs):
Connecticut Dept of Energy & Environmental Protection (DEEP):
http://www.ct.gov/deep/cwp/view.asp?a=2710&q=324266&deepNav_GID=1712%20
Maine Dept of Agriculture, Conservation and Forestry (DACF):
http://www.maine.gov/dacf/php/pesticides/index.shtml
Massachusetts Department of Agricultural Resources (MDAR):
http://www.mass.gov/eea/agencies/agr/pesticides/
New Hampshire Department of Agriculture, Food and Markets:
https://www.agriculture.nh.gov/divisions/pesticide-control/index.htm
Rhode Island Division of Agriculture:
http://www.dem.ri.gov/programs/agriculture/pesticides-wps.php
Vermont Agency of Agriculture:
http://agriculture.vermont.gov/pesticide_regulation

Please Note:

This information is current as of November, 2017.

The regulatory process may make changes to this information.

Thank you