SARE Project LNE91-28

Proceedings of the Northeast Farmer to Farmer Information Exchange

Sweet Corn Meeting

1992 and 1993 Winter Meetings

edited by Ruth Hazzard

Northeast Organic Farming Association
University of Massachusetts Cooperative Extension System

with the support of the
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Introduction

The Northeast Farmer to Farmer Information Exchange

The Northeast Farmer to Farmer Information Exchange, a project of the Northeast Organic Farming Association and the University of Massachusetts, held two-day meetings of small groups of farmers in the winters of 1992 and 1993 with the support of the USDA's Sustainable Agriculture Research and Education Program. Each group focused on one of five commodities for which there are significant barriers to organic production in the Northeast: apples, sweet corn, greenhouse bedding plants, livestock herd health, or strawberries. All of the participating farmers were interested in management methods which can be used on organic farms, but many of them are not organic growers and do not intend to use only organic methods.

At the request of the farmer participants, resource people were also invited to attend. These included researchers, faculty, IPM specialists and Extension agents from land grant universities, professional organic farming technical advisors, representatives of state departments of agriculture, and farmers recommended by others because of their experience and knowledge. Each meeting had a facilitator who assisted farmers in setting and following an agenda and moderated the discussions. Resource people sometimes made informal presentations but primarily were participants in discussions.

The Farmer to Farmer Information Exchange gave participating growers, and others reading these proceedings, a chance to become very familiar with the farming practices of a group of farmers. Farmers have an enormous amount of experiential knowledge about growing crops, raising livestock, marketing, managing labor, and all other aspects of running their farms. Farmers trying to grow crops using new or unusual methods may have experimented with techniques that few others have tried. In most cases, the results of these informal experiments never leave the farm to be shared with the larger agricultural community. Through these meetings and the written proceedings, the experiences of both farmers and researchers working on these crops can build upon each other.

A wide variety of activities has been generated by the meetings. Several growers in the sweet corn group set up trials in insect and weed control on their farms, with the help of Ruth Hazzard, Vegetable IPM Specialist at the University of Massachusetts and co-coordinator of the Farmer to Farmer project. At the urging of growers in the strawberry meeting, the Strawberry IPM Program at the University of Massachusetts did a scouting workshop in Vermont, at the farm of one of the Farmer to Farmer growers. Due to the interest of many of the livestock producers in alternative herd health remedies, a two-day homeopathy workshop was organized in Vermont. Several of the groups are continuing to meet in 1994, although the funding support from the USDA has ended.

These proceedings are a summary of the information provided by growers and resource people at the 1992 and 1993 meetings. They include discussion of specific production methods, marketing, and philosophy, and are intended to make available the expertise that was shared at the meetings to a wider group of farmers, researchers, and other interested people. They are not intended to provide complete information on how to produce these crops, nor to discuss only those production practices which have been verified by the research community. Additional sources of information on production and research-based information can be found in the list of sources at the back of the proceedings.

Participating Institutions

The Northeast Organic Farming Association

The Northeast Organic Farming Association (NOFA, formerly the Natural Organic Farmers Association) provides education and services for farmers, gardeners, consumers, and others interested in organic agriculture. NOFA has chapters in seven states: Connecticut, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. The activities of state chapters vary, and include such things as organic certification, conferences, farm field days, country fairs, and cooperative purchase of farm and gardening supplies. Together, the state chapters hold an annual summer conference, publish a bimonthly newsletter, *The Natural Farmer*, and engage in regional projects such as this one. Information on becoming a NOFA member is provided on the inside back cover.

University of Massachusetts Vegetable IPM Program

The University of Massachusetts Cooperative Extension System conducts Integrated Pest Management (IPM) Programs in many commodities, including three that were part of this project: vegetables (including sweet corn), strawberries and apples. The purpose of these programs is to assist farmers in reducing pesticide use in their crops, and to develop alternative pest management methods such as biological and cultural controls. Increasingly, IPM programs seek to integrate all aspects of crop and pest management into whole systems, and to direct research efforts into "bio-intensive" methods, many of which are compatible with organic farming practices. Farmers have always played a key role in using, evaluating and helping to develop IPM methods; this project provided further opportunities to build links between IPM programs and organic farmers across New England, and to understand how both researchers and farmers can benefit from direct information exchange.

Sustainable Agriculture Research and Education Program

Mandated by Congress in the 1985 Farm Bill and first funded in 1988, the Sustainable Agriculture Research and Education Program (SARE, formerly LISA) funds research in sustainable agriculture. The program encourages projects in which several institutions cooperate, including non-profit groups and other non-university institutions. In addition, the program promotes farmer involvement in planning and carrying out research, and in 1993 began giving "mini-grants" directly to farmers. In 1993, the Northeast Region SARE Program awarded grants to 35 farmers, totalling $94,347, and 13 projects of research and education institutions, totalling $1.3 million. Further information about the Northeast Region SARE Program can be obtained from:

Northeast Region SARE
Hills Building
University of Vermont
Burlington, VT 05405-0082
(802) 656-0471

Acknowledgments

The proposal for the Northeast Farmer to Farmer Information Exchange was developed by Margaret Christie, Alex Stone, and Enid Wonnacott at the request of the Northeast Organic Farming Association (NOFA) Interstate Council. Input for the proposal came from a range of farmers and researchers who attended planning meetings and a pilot meeting of the Apple Growers Group organized by Alex Stone. Several Extension personnel, including Ruth Hazzard of the University of Massachusetts Vegetable IPM Program, Dan Cooley, Sonia Schloemann, and Arthur Tuttle of the University of Massachusetts Apple and Strawberry IPM Programs, and Vern Grubinger of University of Vermont Cooperative Extension, provided input and agreed to help with the project.

Funding from the Northeast Sustainable Agriculture Research and Education program allowed the project to begin in 1991. Meetings were held in the winters of 1992 and 1993. Margaret Christie and Ruth Hazzard coordinated the project, while Enid Wonnacott and Alex Stone acted as workshop coordinators and helped to provide project direction. Ed McGlew managed the money and complicated billing procedures, and the NOFA Council, under the leadership of Bill Duesing, provided valuable oversight. Margaret Christie did the final editing and layout of the proceedings, and Jack Kittredge accomplished their printing and distribution.

A number of additional people helped to make the project successful. Thanks are due to the researchers who agreed to attend the meetings, particularly to those noted above, who helped to plan and facilitate the sessions and provide research and training help requested by growers between meetings. The cooks at Rowe Camp and Conference Center kept us exceptionally well fed at our meetings. Most especially, we want to thank the participating growers, who were willing to share both their successes and failures. Not only did they supply the bulk of the information presented here, review the proceedings, and provide useful editing suggestions and corrections, but their enthusiasm and humor made for wonderful meetings. Although much of the information presented at the meetings is available here, the pleasure of the company of the grower groups is impossible to reproduce on paper.

Participants in the Sweet Corn Farmer to Farmer Group

Farmers

Peter and Chris **Craig** raise 6.5 acres of certified organic vegetables on their 140 acre farm in Goshen, Connecticut. About 4.5 acres is devoted to corn, an acre to melons and about 3/4 acre to strawberries. They started revitalizing what used to be the family dairy farm eleven years ago and now have a farm stand and also sell about half of their products wholesale. Off-farm work as a teacher keeps Peter busy for much of the winter, while Chris is farming full time.

Jake Guest has been a market farmer on about 40 acres in Norwich, Vermont for 12 years. He grows vegetables primarily for his own farm stand, but sells about 15% of his produce wholesale. He also produces greenhouse tomatoes and bedding plants in about 13000 square feet of greenhouses and cold frames. Jake grows about 10 acres of corn, mostly on rented land. His operation is not fully organic, although he uses organic methods for most of his crops. In corn, he uses herbicides for weed control and commercial fertilizer. This is partly because corn is a low-value, high-acreage crop and he feels he can't afford to invest in cultivation and manure for it. He is especially interested in using propane flamers for weed control, got a grant to build a flamer in 1992, and has been experimenting with using it in a variety of ways. He is also excited about no-till techniques that use cover crops for fallow or winter annual soil-building, kill them back before planting, and no-till plant into the residue. The problem, he says, is that they generally require herbicides.

Jeff Grant is a teacher-turned-farmer on a diversified family farm in the Berkshires of western Massachusetts. He has been farming about 14 years and grows about 10 acres of corn and a variety of other vegetables for a small stand at his farm. He uses organic methods as much as possible but in corn sometimes depends on commercial fertilizer and has recently moved from herbicides to cultivation for weed control. He participated in a University of Mass. study in which an imported species of Trichogramma wasp was released for European corn borer control. In his location, this is the primary insect pest in corn --- the migratory pests rarely reach the Berkshires.

George Hall has been farming in the hills of western Connecticut all of his not-so-short lifetime and learned organic methods before anyone called them that, when that was just how everyone farmed. He cultivates 65 acres, of which 15 acres are certified organic. Twelve of his fifty acres of corn is grown organically and he says he would grow more of it organically if the demand were there. Often, he sells his organic produce through regular channels that do not even care if it's organic.

Tom Harlow farms river bottom land in the Connecticut River Valley in southern Vermont and New Hampshire. All of his eleven acres of sweet corn and about six acres of other crops are certified organic, sold through Deep Root Cooperative and his brother's farm stand. He plants SU varieties early but has moved to all Se and Sh2 varieties for mid- and late-season crops. Tom uses hairy vetch and rye along with compost applications for soil fertility. He has had good luck with B.t. products against European corn borer, but is stuck with wormy corn when corn earworm makes it as far north as Vermont in the late summer. He has experimented with a range of techniques and equipment for weed control, but still finds that

he is unable to get satisfactory weed control without a single hand weeding. For him, satisfactory means clean enough that weeds won't be going to seed and causing problems next year.

Steve Mong, with his wife Kirsten and brother Ray, have carved out a farm and retail operation in the rapidly suburbanizing landscape west of Boston, Massachusetts. They have been farming about 13 years and raise their vegetables organically, but are not certified. About 15 acres of their 45 cultivated acres are sweet corn. Insects have been a major problem, especially corn earworm which comes in heavily by August at their location. They have "trained" their customers and provide a knife for cutting tips off in the stand ("you can leave the worms with us") but are very interested in finding a way to cut down on the worms. In 1993 they worked with Ruth to test out B.t.s and oils -- with good success. Steve and Ray keep experimenting with new strategies for weed control and with a combination of a Lely, Bezzerides, and Lillistons are finally getting close to a achieving a clean field -- without hand weeding.

Ken Muckenfuss grows over 100 acres of certified organic crops in Medford, New Jersey. A full range of vegetables are only part of his operation, which also includes hay, wheat, straw, beef, chicken, and berries. Sweet corn occupies about 4 acres and field corn 10-15 acres. He has experimented with a CSA as well as depending on other direct marketing and wholesale marketing channels. Ken is in an area with high insect pressure and has used mineral oil, applied directly to the silk of each ear, with good success. He says he learned it from the old-timers around him, who used to use oil before the arrival of synthetic pesticides. Ken got others in the group interested in oils, as the only currently viable option for organic earworm control. After the first meeting, Ken tried switching from his old standby variety, Silver Queen, to an Se bicolor (Bodacious) which several of the others recommended. He returned in 1993 extremely enthusiastic about how it produced and excited that his customers had quickly adopted something other than a white corn.

Paul Pieri grows an open-pollinated traditional Rhode Island flint corn that he sells to mills around New England. He joined the group because faces lot of the same problems as sweet corn growers and although his operation is not entirely organic he is very interested in alternative methods. His farm overlooks Buzzards Bay and is subject to large flights of migratory moths which damage the grain and allow disease to enter the ears. However, he is able to separate damaged kernels before he sells the grain. Weed control without herbicides, which he has been practicing for 12 years, is accomplished with a series of well-timed cultivations. He has been especially interested in adopting new cover cropping and nutrient practices, and after the first meeting arranged for a local manure source to help him build soil organic matter and feed the corn. He also realized that an earlier planting date would help his corn avoid some insect damage, and with the help of custom plowing was able to do this, with good success.

Dan Tawczynski has been farming a 200 acre vegetable, potato and small grain operation in the Berkshire mountains for over 40 years. Most of his products are sold through his year-round farm stand and other local outlets. Sweet corn occupies 70 acres, and all of it is grown without insecticides. Dan has released Trichogramma wasps for European corn borer control and believes they give him good control. He is enthusiastic about the value of hairy vetch and grows a mixture of vetch and rye for seed, which he sells locally. Dan is not optimistic about providing for weed control or fertility with completely organic methods in

sweet corn, but he keeps on experimenting with alternatives. A propane flamer that he built for vine killing in potato is being tested for weed control in corn, beans, and other vegetables.

Resource People

Ruth Hazzard facilitated and coordinated both meetings. She works as Vegetable IPM Specialist in the University of Massachusetts Cooperative Extension System, coordinating IPM programs in sweet corn, tomato, potato and crucifers. This project grew out of collaboration with NOFA on the Mass NOFA organic certification committee and other NOFA projects, and out of contacts with farmers from her IPM work in Massachusetts and former farming days in Vermont.

Enid Wonacott also facilitated both meetings, as well as coordinating the livestock meeting. She is the farm inspector for the Vermont Organic Certification Program and is active in promoting sustainable agriculture in Vermont, specializing in livestock and dairy issues.

Vern Grubinger is Sustainable Ag Small Fruit and Vegetable Specialist in the Univ. of VT Cooperative Extension System. He serves vegetable growers throughout the state, with an emphasis on helping them develop sustainable practices. His research specialty has been cover cropping systems, especially legumes and living mulches, and cultivation methods.

Frank Mangan is a Vegetable Specialist in the Univ. of MA Cooperative Extension System. He has conducted extensive research on cover crops, focusing especially on legume/grass mixtures that can be used for nitrogen contribution and weed suppression as annual winter cover crops. He has collaborated with New Alchemy, Univ. of Maine and Univ. of Vermont in LISA/SARE grants studying cover crop systems, and has worked with farmers across Massachusetts in testing hairy vetch with oat or rye on vegetable farms.

Mary Jane Else is Weed IPM Specialist at the Univ. of MA. In addition to sweet corn and other vegetables, she does research and extension work in cranberries, apples, strawberries, and nurseries. He research has focused on non-chemical weed control methods using cover crops, solarization, and cultivation as well as reduced-herbicide methods.

David Ferro is Vegetable Entomologist in the Dept. of Entomology at the Univ. of MA. He developed the potato and sweet corn IPM programs and has focused his research on the biology and biological control of Colorado potato beetle. He is involved in research on *Trichogramma ostriniae*, a parasite of European corn borer which he imported from China in 1990.

Bob Christensen is a professor in Resource Economics at U. Mass who has focused on farm management and the economics of crop and livestock production, most recently specializing in vegetables. He provided the economic analysis of the on-farm study of weed management methods which included several of the Farmer-to-Farmer participants.

Don Prostak is Extension Specialist in Pest Management in the Dept. of Entomology at Rutgers University. He coordinates IPM programs in vegetables for New Jersey and has conducted spray trials for several years on microbial and botanical pesticides for controlling caterpillars in sweet corn.

Weed Management

Philosophy

Weeds were regarded as one of the more difficult problems in organic sweet corn. Philosophically, there were two viewpoints on weed management: the "keep it clean" view and the "let a few through", or "threshold" view. Several farmers felt that it is well worth the cost of maintaining a completely clean field as a long term investment in preventing weed seed production. They weed really well *this* year for the benefit of *next* year's crop, to reduce the quantity of weed seed that will trouble them in the future. Tom Harlow is willing to invest in the cost of sending hand weeders through his corn, because it means the field will produce few weed seeds and he'll be able to grow hard-to-cultivate crops such as parsnips and carrots there next year. According to Mary Jane Else, it may take at least five years of clean-cultivation, tilling several times a year, in order to eliminate weed seeds. Repeated cultivations bring up new seeds, which then germinate and are killed by subsequent cultivations. In this way, even weed seeds with extremely long viability in the soil, such as velvetleaf which can last up to 35 years, would be eliminated. Galinsoga may be one of the shortest-lived seeds. She has found that there has been surprisingly little research done, especially in the United States, on weed seed longevity. Farm practices do affect the seed bank, however. Where she has studied the weed composition in fields that farmers have kept clean-cultivated for several years, she has seen a shift away from grasses and high-growing annuals like lambsquarters, and toward low-growing broadleaves like purslane and chickweed.

The other point of view, held by several others, was that it is most practical and cost-effective simply to keep weeds below a threshold, so that yield is not affected. In this approach, some weeds could be tolerated and allowed to go to seed. These farmers feel that it's just not practical to try for a clean field. Several farmers commented that if you use raw manure, you will remain in the threshold category because seeds will be introduced. Composting could solve this problem; compost temperatures of 110°F will kill most weed seeds, and 140°F will kill all of them. Paul Pieri commented that he has used raw dairy slurry that was lagoon-stored for at least 6 months and has had no weed problems from it. Ken noted that chicken manure does not have weed seeds. If you already have a moderately weedy field, the addition of manure is probably not that significant.

Which viewpoint each farmer held seemed to depend on how he viewed the trade-off between the time and expense invested now, or in future years, and also seemed to depend on whether he was able to achieve clean control if he wanted it. An intermediate strategy -- for the whole farm -- is to use the threshold approach in some fields that are devoted to low value crops or crops that can handle moderate weed pressure (like corn) and use the sanitation approach in other fields that are reserved for crops that have high value, are particularly sensitive to weed pressure, or are especially hard to keep clean if weed pressure is high (like carrots or onions).

Cultivation Strategies

For some of the farmers, weeds are the major obstacle to growing sweet corn organically. Several do use herbicide in their corn (although maybe not in other vegetables) because they find that good weed control with cultivation is too expensive, time-consuming and difficult for such a (relatively) low-value, high-acreage crop.

However, several other farmers are completely organic and have worked out effective systems. They agreed that control of weeds at the time of corn emergence is the most critical -- and the trickiest -- part of using cultivation. Their cultivation systems varied, but had several key elements in common:

1) *Prepare the seedbed immediately before planting.* Any delay between the last disking and planting gives weeds a head start. Ken sometimes allows weeds to come up after a first disking, then disks lightly again just before planting. Paul disks the same day as corn is planted, and uses no broadcast N, because he wants to feed only the corn, not the weeds. (This may not be an option if fertility comes from broadcast manure, only with a commercial blended fertilizer. Legume cover crops as a nitrogen source release N more slowly and do not "feed" the weeds as much as synthetic fertilizer does.)

2) *After planting, but before the corn emerges, do a blind cultivation that covers the entire field.* Dig up a few seeds to determine when seeds are starting to put up a spike, but the spike is not yet all the way to the soil surface. By this time, you often see weeds at the "white thread" stage, underground, or just emerging. Equipment that farmers have used successfully for this include the Furst harrow, an old-fashioned corn weeder, and the Lely cultivator. Both Steve and Tom reported that if they used the Lely too aggressively or too late, some corn spikes could be broken underground; but otherwise, they like the Lely a lot for this purpose. Super sweets seemed to be more brittle and prone to damage than standard varieties. A rotary hoe was also suggested for cultivation at the spike stage, timed to hit weeds just after emergence. Each tooth is spring loaded. The rotary hoe goes right over the spike, and though there was some loss from damage, the farmer who had used this reported it to be only about 4%. Some research suggests that damage may be higher, especially for non-vigorous varieties of corn.

3) *Cultivate when the corn is 4-6 inches high.* At this point, you want to get as close as you can without damaging the corn, and not throw much soil.

Steve Mong uses a Bezzerides spring-hoe and Spyder weeder, which cost him $120 for a one-row setup. He said that refuse gets jammed, so you need a clean soil surface. It takes time to set it up just right, but it is gentle on plants while getting very close to them and can be set up to disturb soil in the row without hilling. It uses a torsion weeder set behind 2 spyder weeders and is mid-mounted (it can go on John Deere high crop or Allis Chalmers G) and can be used in combination with disks. It needs fast speed to work well (7 mph), and the angle is important.

Tom Harlow uses a Buddingh in-row finger weeder, in a single belly mount (e.g., John Deere 900). He said it can be used from pre-emergence to knee-high, but may snap spikes at spike stage. It is relatively inexpensive ($600-700 new).

George Hall uses a spring tooth harrow, set for 2-3 inches, traveling at 4-5 mph when the corn is 5-6" high. The teeth are 3-4" apart and staggered. He felt it works best on a sunny day, when weeds will dry out quickly.

Several farmers also like the Lilliston for both early and later cultivations. Tom sets up the Lilliston for 36" rows with a gang on each side of the row and 18" sweeps on the back to cover between rows. To throw less soil, he uses wide flat sweeps; to throw more, he uses disk hillers. Ken accomplishes all his weed control in field and sweet corn with 1-2 cultivations with the Lilliston.

4). *In the last cultivation, throw soil into the row to bury any remaining weeds.* At this point, the corn is 12-20" tall and can handle some hilling. Tom Harlow uses a disk hiller, hilling as much soil as possible (8-10") when the corn is at 20 inches. In addition to covering weeds, the soil helps the corn stand up. If there are big weeds, its best to hoe or hand pull them before this last cultivation. Smaller weeds will be buried. Hilling gives Tom good control of crab grass and bindweed, which used to be real problems for him. Others use Lillistons with sweeps for the last cultivation.

There are, of course some disadvantages of repeated cultivations. Organic matter oxidizes more quickly, soil aggregates are disrupted, there is compaction and root damage, and it may disturb some beneficial insects such as carabid beetles, whose soil pathways are disrupted. Tom Harlow noted that, yes he worried about root pruning when he hills, but "you have to do *something*!"

Four of the farmers worked with Mary Jane Else and Ruth Hazzard in an on-farm research project on weed management, funded by the Univ. of Mass IPM Program. The study assessed yield effects, weed numbers and biomass, and the costs of weed control with cultivation. In the study fields, sub-plots were kept weed-free with hand-hoeing to compare with the rest of the field. In some fields there was significant weed pressure but despite this, there was no statistically significant impact on yield in any of the fields. The cost, which included labor as well as the ownership and use of cultivation machinery, was approximately $50 per acre. (This was about twice the cost of the reduced-herbicide methods, such as banded herbicide or delayed application of reduced rates, that were also included in the study, on other farms.) The addition of hand-weeding, which some farmers regarded as necessary and worthwhile to prevent weed seeds (see "philosophy", above) drove up the cost of weed control to at least $125 per acre, and in some cases much more. Farmers with more experience in using cultivation were able to achieve weed control that was as good as that found under herbicide regimes, but clearly the success of cultivation improves with practice and varies with weather conditions, soil type, weed pressure, weed species, equipment, and timing. (Detailed report is available; see references)

Flamers

Propane flamers as an alternative or a complement to cultivation were discussed briefly in 1992 and more extensively in 1993, after Jake Guest had an opportunity to build and use one. Dan Tawczynski also had a flamer that he built for vine-killing in potato but that he has been using more and more for weed control. They were still experimenting with how to use them effectively, especially in sweet corn. In 1993, Paul Pieri received a SARE grant to build a small flamer for use in intensive flower production.

Flaming is used as a "stale seedbed" technique: the seedbed is prepared well ahead of the planting date, weeds are allowed to germinate, then killed by a pass with the flamer. Then the crop is planted. Weeds can be flamed again, just before the crop emerges. As an

alternative, the crop can be planted into the germinated weeds, and then the field flamed only once, before the crop comes up. Dan has used this method in corn and beans. He reported that it worked best against young broadleaf weeds, especially at the point when they set their first true leaves. However, purslane and crabgrass were hard to kill with burning, and galinsoga was not killed if it was big because of the large root mass.

Both Dan and Jake's flamers use liquid propane. Burners were obtained from Flame Engineering (West Highway 4, PO Box 577, LaCrosse, KS 67548, 1-800 255-2469) or from Thermal Weed Control Co. (Rte 1, Box 250, Neillsville, WI 54456, 715-743-4163) and were assembled on the farm with the assistance of local propane dealers. Both flamers are rear mounted; Dan's has the propane tank mounted on the front of the tractor, while on Jake's the tank is mounted with the burners as one unit on a 3-point-hitch frame. Dan's has ten torch heads to do four rows, and Jake's has six burners to cover a 52" bed from wheel center to wheel center, with the outside torches facing in toward the side of the bed. The object is to produce an even, very hot band of flame across the rows or the bed. For details of flamer design, contact Jake or Dan.

Jake built his flamer with Pooh Sprague in 1992 with a grant from VT Fruit and Vegetable Assoc. Jake says anybody mechanically inclined with good welding skills could build one. Theirs cost about $2,000 for all components, including burners. Jake got a 3 point hitch frame for less than $100, and the flamer and cradle for the propane tank were built onto the frame. Burners were obtained at a cost of $1,100 for six burners and all the hardware to go with them; if the gas hardware components were obtained locally from a gas dealer, the burners alone would cost between $700 and $900. They got a used propane tank very cheap, in exchange for $150 worth of fruits and vegetables. It would have cost $700 new. Jake estimates that someone who wants to build one should expect to pay between $2,000 and $3,000 for the burners, hardware, tank and frame, depending on their sources.

Needless to say, there are dangers associated with using flamers. Both farmers take safety precautions, such as watching the wind direction and strength, and not trying to flame when there is more than a small breeze. Dan mentioned to make sure all orifices are covered for the winter to prevent insects from making their home in them. On Jake's, there is no master shut-off; you can turn off the burners from the tractor seat, but there's nothing that will kill the pilot, without turning around and turning the valve off on the tank. Because it's liquid propane, it keeps burning after you come to end of the row. This can be disconcerting, especially early in spring when there's a lot of trash around. There are certain regulations about how it should be built, such as having a metal shield over the valve and solenoid on the tank so that if it fell on the ground the valve won't snap off. Jake believes that farmers will have to assemble flamers themselves if they want them to be affordable, because the liability risks and safety features might make them prohibitively expensive to manufacture commercially. Anyone who decides to build one should work with a local propane dealer on the design and safety features. The risk of working with flamers is high.

Jake has used the flamer on permanent beds of succession-planted crops such as spinach in combination with a harrow or rotovator for soil preparation, and a cultipacker to roll the beds and mark rows within the bed. He let the weed come up after cultipacking, then flamed just before planting spinach. The next flaming was done before the spinach came up in that bed, and just before planting the next bed. He tilled several plantings ahead, but made sure to leave 2-3 weeks between the last cultivation and planting to give time for

weeds to germinate, so they can be flamed. After the crop came up, one cultivation with a basket cultivator was sufficient. He estimated it took about 1.5 minutes to do a 500 ft bed.

There was also discussion of whether flamers could be used after the corn is up 12-18 inches or more. It could be used with shields to protect the corn leaves, or without shields if burners are directed toward the ground. Jake tried flaming without shields when weeds had grown up almost as high as the corn, but found that if he went slow enough and set the burners high enough to kill the weeds, the flame damaged the corn back significantly. The best time to do it would be when weeds are small.

Cover Crops and Fertility

Cover Crops

This group is using a wide variety of cover crops. Cover crops are being planted as winter annuals, between harvest and spring planting; as soil-building green manures on fallow ground that is out of cash crops for one or more seasons; and as an overseeded ground cover after the crop is up and growing. The grasses being used include winter rye, oats, ryegrass (annual and perennial), barley, timothy, sorghum/sudangrass, and buckwheat. Legumes included various clovers (white, red, mammoth and alsike) as well as hairy vetch and alfalfa.

Some farmers are deriving a substantial portion of the nitrogen for their corn from cover crops. Many also use manure. Ken Muckenfuss plants corn after plowing down an alfalfa sod, and supplements with alfalfa meal in the planter, which he believes is an excellent N source. Tom Harlow plants rye and vetch as a winter annual (60 lb rye, 20-40 lb vetch) in mid-August to mid-September and plows it down in the spring, supplemented with manure or compost. George Hall rests his fields one year with clover or two years with timothy and clover, and then uses manure. Paul Pieri has tried overseeding annual ryegrass or hairy vetch into corn at last cultivation, with mixed success. After the 1992 meeting, he arranged for a local manure source and now depends heavily on manure for fertility. Both Steve Mong and Jake Guest use winter rye and apply manure before plowing it under. Several use supplemental fertilizer as a side dress, including non-organic sources like urea.

In the discussion, Vern pointed out that the key to effective use of cover crops is deciding what your purpose is. Are you trying to supply nitrogen, mop up leftover nitrogen, build organic matter, build sod, loosen a hardpan, cover soil and prevent erosion over the winter, or provide weed control? Different cover crops have different strengths. If you want something that will do well overseeded into an existing crop, you need a shade-tolerant variety (e.g., red clover, hairy vetch). If you want weed control, you need something that comes up quickly and produces a thick, competitive live mulch (buckwheat, annual ryegrass, rye or oat). The above-ground matter can either be incorporated or left on top of the soil as a mulch. A good choice for a mowed, living mulch is Dutch white clover. If you want to supply N, you need a legume that will fix N rapidly and effectively (hairy vetch for an annual winter cover, alfalfa in a one to three year fallow/rotation). If you want to build organic matter, choose one that produces lots of biomass rapidly (sorghum/sudangrass, ryegrass). To soak up remaining nitrogen after harvest and prevent leaching of nitrate,

choose a grass such as oat or rye (and if corn received enough nitrogen to grow well, there is probably excess N there after harvest, even with organic sources of N).

The discussion included comments from growers as well as slide presentations by Vern Grubinger and Frank Mangan. Frank has been conducting research on cover crops, especially hairy vetch combined with oat or rye, for several years. The following summarizes observations by farmers as well as notes from Frank and Vern:

Grasses/grains

a) **winter rye** - the standard cover crop in New England. It s very winter hardy, cheap and easy to get. Can be planted as late as October and still establish, however will not give much erosion control when planted that late.

b) **oat** - unlike winter rye, oat will winter-kill here in the Northeast. Some consider this a disadvantage, however some like this aspect since spring management is easier. It should be planted in August to get best fall growth. Suitable following early corn.

c) **ryegrass (annual)** - establishes very quickly and can be very competitive with weeds. A much higher percentage of its biomass is in roots than other cover crops.

c) **ryegrass (perennial)** - does not establish as quickly as annual ryegrass and may not overwinter in northern New England

e) **winter wheat.** Some growers have expressed interest in it because it will not grow as vigorously as winter rye in the spring, thus making it easier to manage.

f) **sorghum/sudangrass.** Used for fallow ground or after early corn. In Vermont, it can be planted until mid-August, but it provides more biomass if planted earlier, because it does winter-kill. It is good for building biomass if soil fertility is already good, and grows well following a manure application. Solubilizes phosphorus.

g) **buckwheat.** Performs well under low fertility, gives quick weed control, but is low in biomass. Will reseed itself if you let it go to seed, then harrow.

Legumes

The benefits of legumes include fixing atmospheric N, providing N via a renewable resource; providing a slow-release N source; and the potential to produce your own seed if you let the crop mature. Legumes have a lower carbon: nitrogen ratio than grasses (usually lower than 20-25), which means that you get an immediate supply of N to the crop. Grasses tend to have a high C:N ratio; however, the earlier they are tilled under, the lower the C:N ratio.

Legumes should be inoculated with the correct bacteria, especially the first time that you use them. The bacteria can live in the soil for up to five years without having the host (i.e. cover crop). In other words, if you want to seed crimson clover on a piece of land that has had inoculated vetch within the past five years then you should not have to inoculate a

second time. However, the inoculant is usually very cheap. It may not hurt to inoculate anyway.

a) **hairy vetch** - a winter-annual cover crop that can overwinter in most years here in New England. It is less likely to survive the winter if it is planted late, but overwinter survival varies with the winter conditions as well as the condition of the vetch going into the winter. It has been shown to provide more nitrogen than most other legumes planted in the same cropping system. Can be planted up to mid-September in southern New England. Works well in combination with oat or rye. Seed should be drilled or harrowed lightly. Rate should be 30-40 lb/A to get a significant N contribution. Several farmers reported using this with success. Can be spun on over late-harvested crops, although overseeding may not always give a good stand. Cultivation (not too deep) and irrigation helps with germination. Vetch was also mentioned as a good habitat for beneficial insects, including aphid predators such as ladybeetles, because it attracts aphids early in the season.

b) **alfalfa** - like hairy vetch, it is a tremendous fixer of nitrogen. It is a good candidate as a cover crop to fallow a piece of land for 1 year or more. Since it establishes slowly, weed control can be a problem. Ken uses alfalfa in rotation with corn and other crops. The hay can be sold as a cash crop or traded for manure. Even if you sell off the hay, you get the benefits of crop rotation and nitrogen fixation.

c) **red clover** - good for overseeding because it can tolerate shading. To overseed, cultivate, then spin the seed on by hand just before a rain. Farmers who cultivated after spinning it on found that the seed got pushed to the center of the row. After the corn is harvested, clover takes off. Leave it over the winter, because most of the nitrogen fixation takes place in the spring. Can be planted up to early July in Vermont. Farmers reported success with the same overseeding method with alfalfa, ryegrass, and hairy vetch (though HV may not overwinter if planted this early). Red clovers can also be frost seeded into winter rye (at 10 lb/A) and allowed to grow on after the rye is mowed, for a fallow cover crop. Paul Pieri has had good success with this.

Mixtures

a) **rye/vetch** as annual winter cover - This mixture is best for crops harvested after mid-August. Frank Mangan says that although he has in the past recommended rates of vetch as low as 20 lbs/acre to be seeded along with winter rye, but he now feels that this rate may be too low. To get substantial nitrogen, rates should be 30-40 lb/A. Use a bushel of rye. Much will depend on how the cover crops are seeded. Drilling the crops will give you better and quicker germination. If the cover crops are spun on and disked in, then rates 30 lbs/acre or higher should certainly be used. The rye establishes quickly, takes up N, and provides support for vetch vines in the spring. Planting date should be from the last week of August to first week of September in Vermont, or up to Sept. 15 in Massachusetts. The cover crop should be allowed to grow at least until May 15 to get maximum organic matter and nitrogen in return for the cost of seed. Frank's research has found that this system produces all or nearly all the nitrogen that is needed for the corn that follows it.

Dan grows a rye/vetch mixture which he plants in the fall, allows to mature the following summer, then combines the seed. After combining, there is enough seed left that he can disk and will get another cover crop for the winter. He'll follow this with spring plowing and a crop of potatoes, which grow incredibly well. He puts on a starter fertilizer of

200 lb/A 10-20-10 but that's all. Dan sold certified vetch seed from his farm for $0.75/lb in 1992; this is considerably cheaper than Frank gets in from Nebraska ($1.05/lb). There is hope that with more demand, the cost of seed from the midwest will go down.

b) **oat/ hairy vetch** - this is another winter cover crop mixture, appropriate for land where the crop is harvested and the land is free by early August. Growth and N fixation take place in the fall, and the oat winter-kills. Other legumes that could be used with oat include lana vetch, purple vetch, field pea and lupine (lupine has a large seed, and may be hard to use with a drill) but these don't produce as much N. The legume may survive or may winter-kill also. This also provides good weed control after harvesting an early crop, preventing growth of late-season weeds. Frank has found the oat/vetch to be very easy to manage in the early spring. He disked once, then planted. Like hairy vetch with rye, the HV/oat provided the nitrogen needed by the next season's corn, giving yields the equivalent to corn receiving 140 lb/A nitrogen fertilizer and no cover crop, and better than no cover crop with 70 lb/A added N.

With vetch/oats, you should plant as soon as you can after corn harvest (optimal time, 1st week of August, in MA); to take advantage of fall growth and gain the best vetch benefit. However, if you plant oats too early, it will form seed heads in the fall and could become a weed the following year.

Using legumes as a nitrogen source does not guarantee that leaching of nitrates is not a problem. In fact, Frank has found that nitrate leachate under vetch/rye plots was higher than under rye alone or no cover crop. He cautions that if you use a lot of N from other sources in addition to the vetch, you could have nitrate leaching. You need to account for the N contribution of cover cropping when you calculate the N needs of the crop.

Spring Incorporation

For a high-biomass crop like rye or vetch with rye, the consensus was that a sharp moldboard plow works best. Vetch and rye make quite a mat, but a plow can cut through it and turn it under. Frank used a 3-bottom plow and was able to handle rye/vetch mixtures that were 4-5 feet tall. Ken says welding a rebar on top helps to lay the top of the rye into the furrow before the plow. Dan points out that the coulters must be sharp and properly adjusted.

A Sepi flail mower can also handle rye/vetch. It pulverizes the crop, so you get a quicker N benefit. Jake finds that his flail mower misses a lot, however. Frank has used a PTO-driven rotovator, but finds it hard to put the cover crop under with it.

Disking may be enough for winter-killed cover crops like oat.

Some farmers were concerned about whether rye allelopathy would create problems with germination. According to Mary Jane and Vern, this should not be a problem with large seeded crops like sweet corn. It has been shown to be a problem with smaller seeded crops like lettuce. The exact mode of action of allelopathic compounds is not known. They may prevent germination or slow the growth of the seedling. With rye, or its extracts, there is at least a delay of germination. Rye on the surface often inhibits germination, but that is probably from a combination of physical competition, cover on soil surface, and allelopathy.

What can happen with rye plowdown is that much of the nitrogen is sequestered as the microorganisms try to breakdown the rye residue. This can cause stunted corn if another nitrogen source is not added.

When to plant after incorporation? It should depend partly on soil moisture. Cover crops can pump out tremendous amounts of water as they become larger in the spring. If it is a dry spring, the ground may be especially dry after incorporation and it may pay to wait a few days or a week before planting. Frank has found that in general he can plant immediately after incorporating a vetch/rye mix with no negative effects on germination or growth.

Mowed cover crops

a) **Mow-killed cover crops.** This is a no-till system with cover crops killed by mowing, then crop planted into the residue. Frank has compared a mowed no-till with a tilled hairy vetch/rye and did get fewer weeds in the no-till, probably both from less soil disturbance and the mulch blocking the light. In his experience, it works best with transplanted crops and those that are not hurt by cooler soil. In another experiment, mowed rye/vetch had lower soil temperature (and better weed control) than rye alone, tilled cover crops, or no cover, probably because it produced a thicker mulch.

There was also some speculation on no-till methods that would use herbicide or flaming to kill the cover crop. Jake plants corn into standing rye, then applies Round-up. He wonders if you could flame the rye, then plant corn, then perhaps the rye would come back as if you had overseeded it. Nitrogen may be a concern, but because he uses chicken manure he does not usually worry about N as a limiting factor.

b) **Living mulch.** The best choice for a non-competitive cover crop that can be managed with regular mowing seems to be Dutch white clover. In research that Vern Grubinger did at Cornell, working toward a system with corn and mowed white clover, he found that the best layout was corn-corn-clover-corn-corn-clover with corn rows 15-inches apart on 5' centers (equivalent to 30" single rows). With clover between single rows of corn, it was too tight to manage the clover well, and too competitive. The clover was established the previous year, and strips tilled before planting corn. The best nutrient contribution from the clover strips between the corn occurred when the clover strips were incorporated with a multivator about 2 weeks after the corn emerged. This was better than multiple mowings of the clover. With multivating, the clover came back late in the season, but was not competitive with the corn.

Fertility

Farmers were using a wide range of approaches to provide for plant nutrition. Here are some of their systems (NOTE: not all of these are fully organic):

1. Steve Mong: winter rye spread with 5 ton/A chicken manure (cost: $125 for 30 yd). Plowed in mid-April. Organic fertilizer in the hopper at planting, no side dress. This has given good fertility for several years, on non-rotated land (since corn takes up much of their acreage, it is impossible to rotate it all every year). (*Note on N "credits"*: if it is incorporated the same day, chicken manure should provide 30 lb N/acre, so 5 ton should give 150 lb

N/acre. However, only 75% of this is available the first year, or 113 lb/acre. Previous years' applications would also release some N.)

2. Tom Harlow: 12-15 tons of compost/A, plus cover crop (usually hairy vetch/rye).

3. George Hall: manure applied most every year, sidedress with an organic fertilizer. If it's available, he uses a custom mix of cottonseed meal, bone meal, pumice; otherwise uses a purchased mix, 3-2-2, 700-800 lb./A. Other sources of organic fertility include 3-yr.-old sheep manure (30 10-wheeler truck loads delivered to the farm), and leaves from the city of Hartford which he composts on-farm (however, this is low in N).

4. Ken Muckenfuss: band alfalfa meal at planting (analysis 6-1-2 to 4-1-1; uses 220-280 lb./A; cost: $120/ton). He believes this is a growth stimulant as well as a fertilizer, because he gets good yields even though analysis is low. His field corn yields 125 bu/A vs. a county average of 100 bu/A. He has had trouble with the alfalfa meal not flowing well in planter. Also plants corn in rotation after alfalfa (3 yr.) in long rotation: alfalfa - alfalfa -alfalfa - corn/other vegetable - rye (straw) - soybean -field corn - wheat - soybean(green manure).

5. Paul Pieri (NOTE: flint corn, not sweet corn): Soil test every 3 years; keeps Ph at 6.5, using high mag lime. Broadcasts potash (KCl, 60-100 lb/A) and uses MAP in planter (analysis 11-52-0, 100 lb/A). Takes a tissue analysis of the flag leaf and does a soil nitrate test at 6-8 " (sends it to UVM), then side dresses with urea 25 days after emergence, at 12-18" based on these tests. In 1992, convinced by the meeting that he needed to build up organic matter in his soil, Paul located manure source and now depends on this. However, he will probably continue the P and K routine.

Side dressing and the soil nitrate test

The pre-sidedress soil nitrate test was developed by Fred Magdoff of UVM and is now available from most of the land-grant universities in New England. It is taken when the corn is 12-18 inches high, and measures the amount of nitrate-nitrogen in the soil in parts per million. This is a good predictor of whether there is enough nitrogen present, or whether additional N would increase yield. 25 ppm is used as a threshold for deciding if enough N is present, but recommendations have been developed for a range of test results. This test is especially appropriate for monitoring the release of N from organic matter or organic sources of N. Soil samples need to be frozen or dried immediately to halt microbial activity that changes the nitrate content of the sample. (See fact sheet in appendices). Paul has used this test to determine his side-dress needs, very successfully.

Several of the farmers continue to use urea for side dressing. Organic options could include alfalfa meal; an organic blended fertilizer (e.g., a 3-2-2 blend); or cottonseed meal/bone meal mix (10-10-10 blend).

Corn nutrient needs

According to the New England Vegetable Management Guide, the major nutrients (NPK) removed from the soil by sweet corn (for a 250 crate/A yield) are approximately as follows:

Nutrient removal (lb/acre)

	N	P_2O_5	K_2O
ears	55	8	30
stalks	100	12	75
total	155	20	105

The largest nitrogen demand is 30-75 days after planting. When you are using organic sources of nitrogen (legumes, manures, compost) it is more difficult to calculate just how much NPK your corn is getting than with bagged fertilizer. However, it's worth a try, to be sure that your corn is getting enough nutrients, especially nitrogen. Estimates can be made of the N supplied by most organic sources. Some notes on N credits: 1) if stalks are plowed under, about half of the N they contain (about 50 lb N/acre) is available in the following year; 2) for every 1% organic matter in the soil, estimate 10 lb/acre N released during the season 3) a good stand of hairy vetch provides an estimated 100-140 lb N/acre. See fact sheet in appendices on manure credits. Manure is an excellent source of P and K, and if enough manure is applied to supply the N needs of corn, P and K will be more than sufficient. Compost may provide less available N in the first year than manure.

Insect Management

Because of the wide geographic range of these farmers, their insect problems vary quite a bit. Those near the coast in New England, and Ken from New Jersey, have heavy corn earworm flights every year, in mid to late summer, that result in wormy corn. Those in northern or mountain areas of New England get hit with earworm only in some years, and always later in the season. But for all of them, earworm is the most difficult insect pest to control and the one that most often hurts marketability and loses customers. No one in the group uses broad-spectrum insecticides in their corn; even if they are not completely organic, this is not an option they are willing to choose. Much of the discussion on insects focused on ways to control corn earworm.

European corn borer (ECB) and fall armyworm (FAW) are also a problem for some, but most felt they could control these using either B.t. or beneficial insects. Aphids were not reported to be a significant problem. Steve described how he had seen dense colonies of corn leaf aphids in the tassel dramatically reduced by natural enemies, so that neither aphids nor their honeydew made a mess of the ears at harvest. Sap beetles, wireworms and cutworms were mentioned as occasional pests.

Most of these farmers monitor their own fields for pests; some use an IPM hotline that reports on flight periods of the major moth pests; one hires a private IPM consultant to

trap and scout on his own farm. There was some discussion of monitoring techniques; for details on these see references.

The following summarizes the discussions on caterpillar controls:

Bacillus thuringiensis (B.t.)

Corn Earworm (CEW). Earworm moths lay their eggs directly on the silk, and young larvae enter the ear through the silk channel, feeding primarily in the tip. (For a short summary of CEW biology, see fact sheet in appendices) Because larvae feed very little before disappearing into the ear, and because B.t.'s must be ingested to be toxic to larvae, B.t. products are not a promising strategy for corn earworm. This was confirmed by data that Don Prostak of New Jersey showed at the 1993 meeting. He tried several B.t. products (MVP, Dipel ES and L, Biobit) are various rates and at frequent intervals (1 or 3 days) and found no less damage from earworm than in his unsprayed control plots.

However, there may be situations where B.t. is worth using even when earworm is around. Often in New England earworm arrives with fall armyworm (both are migratory and do not overwinter in New England) in late summer at the time that the second generation of European corn borer is active. In mid-Atlantic states, where earworm does overwinter in mild winters, there is a second surge of earworm flight which is a combination of migrants and second generation adults, also when ECB and FAW present. B.t.'s used in the tassel or on the silk may reduce damage from borer and fall armyworm, even if they do not control CEW. Steve Mong, in 1993, was convinced that four MVP sprays in late corn, from the pretassel stage through silking, significantly reduced his ear damage during a period when flights of all three pests were high.

European corn borer. ECB has two generations in central and southern New England, and one in northern areas. Early corn, especially if its growth is pushed with floating row cover or plastic, may become infested from pretassel through silk stage, depending on how its growth coincides with the egg-laying period of ECB females. Tom, Steve and Ken have used B.t. (Dipel ES or MVP) successfully in early corn to clean up first-generation corn borer. The second flight (late July through August) also brings a flush of borers feeding in young tassels, often in higher numbers than the first generation. Sprays applied in pretassel stage ("pretassel" = when the tassel just becomes visible down in the whorl) or green tassel prevent borers that are feeding in the upper parts of the plant from moving down into ears as they develop. Tom reported that one or two sprays with Dipel ES gives him effective control.

IPM systems monitor adult ECB flight using pheromone or blacklight traps, and scout fields at pretassel to determine the percent of plants infested with larvae. Thresholds for spray action are based on using broad-spectrum insecticides. It is possible that using B.t. requires a more conservative threshold, although Steve has used B.t. and followed the University of Massachusetts IPM thresholds with no problems. The New Jersey sweet corn IPM program uses a threshold of 12% of plants with fresh feeding damage. Massachusetts IPM uses 15% of plants with live larvae. Whichever threshold one uses, plants should be scouted at pretassel; if you wait till you see broken, dried tassels it's too late -- borers are already inside the stalk or the ear.

In trials that Ruth has done at the University of Massachusetts, three B.t. products gave equal control: MVP, Dipel ES, and Condor OF. Javelin WG was not as effective. Using a sticker (an organic option is Safer's soap or the equivalent) is probably helpful.

In general, the group did not see ECB as a big problem. This was partly because it does not always cause that much damage, partly because the damaged ears are easy to detect and cull, and partly because the B.t.'s work for them. Or, with Dan, because he finds that Trichogramma releases are helpful (see below.)

Fall armyworm (FAW) can be a problem in all stages of corn, but is the only caterpillar that causes serious damage to the whorl stage. Massachusetts uses a threshold of 15% of plants infested for treatment of whorl. There are B.t.'s labeled for FAW, and Steve reported getting control of FAW with a B.t. Good coverage is important, and B.t. should be applied at the high label rate for FAW.

Oils

Ken Muckenfuss faces CEW through most of his season, because CEW often overwinters in New Jersey. He has come to rely on an old-fashioned control that he learned from his neighbors who used to use it on 50-60 acres of corn in the 1940's, before the arrival of synthetic insecticides. His method is to apply several drops of mineral oil directly into the neck of each ear, on the silk. He applies it once, after pollination, when the silk just begins to dry and shifts from clear to cloudy (but before CEW eggs laid on the silk have time to hatch). Doing it earlier gives problems with pollination and ear fill, especially at the tip. He uses a 50cc syringe with no needle and applies two drops on each silk. He attaches a coffee can on his belt to refill the syringe as he walks through the field. It gives him complete control, and controls ECB as well as CEW. The mode of action is probably suffocation.

There was much discussion of whether the time it takes to do this is worthwhile, and how one might make it faster. Ken estimates that he can treat about one-half to three-quarters acre per hour. Ken thinks it is worth the time when CEW pressure is high, because otherwise his corn would be unmarketable or at least a whole lot less attractive to his customers. The cost of paying an employee to walk through the fields applying oil might not be more than the cost of paying someone to cut the tips off wormy corn, which people sometimes do, or the cost of reduced sales. Ken has an educated market that wants organic, but they don't want earworm either. Earworms get big and messy, and people stop buying corn. The farmers were intrigued by Ken's method, but everyone wanted to figure out an applicator that would make it possible to do oil treatments faster.

After hearing about Ken's success, which was corroborated by research done at Oklahoma State University, Ruth conducted trials in 1992 and 1993 with both vegetable and mineral oils. She reported on the 1992 trials at the 1993 meeting. Two ml. of canola oil mixed with Pyrenone was applied in late corn 48 hours after the silk was fully grown. This is when the green silk just begins to wilt at the tips. Because the stand was uneven and some plants produced silk several days later than others, early ears treated first and marked with a hole puncher on the flag leaf, and late ears were treated 3 days later. Oil was compared to multiple applications of B.t. products with a drop-nozzle sprayer, and with no treatment. Oil was used alone, or in combination with the series of B.t. sprays. The results were that oil by itself gave the same level of control as 6 B.t. sprays (<6 % damage) and oil combined with the B.t. sprays gave 100% control. The untreated had 17% damage. However, there was a 6% reduction in kernel fill in oil-treated ears, and many oiled ears had an oily feel on the kernels. The conclusion was that the amount of oil was too high.

Further trials were conducted on Steve Mong's farm in two late plantings in 1993. The first used 2 drops/silk of canola or mineral oil, applied once when most plants had silk just starting to wither. Results were: untreated, 36.6% marketable; mineral oil, 54.8 % marketable; vegetable oil, 64.6% marketable. "Marketable" meant no worm in the ear or silk and no feeding damage to the tip or filled kernels. There may have been some feeding damage to the silk, but this was not considered to affect marketability. The pest complex included primarily European corn borer and fall armyworm, with some corn earworm. We noted that all three were mainly entering the ear from the tip (rarely from the side) so that oil had an impact on all of them, not just earworm.

The second trial was in Steve's latest corn, when pheromone trap captures of corn earworm were 25-200 moths/week and FAW captures were continuous at 2-10 moths/week throughout silking. He had sprayed a high rate of MVP twice in tassel to clean up FAW and ECB, then oil treatments were applied at first-dry silk. Even though the stand was uneven, only one treatment was made. At Steve's suggestion, we included one treatment of vegetable oil mixed with MVP. Five drops, which was equivalent to 0.5 ml were applied to each neck. The percent of marketable ears in each treatment was: untreated, 48.7 % ; mineral oil 82.5 % ; vegetable oil 81.7 %; vegetable oil mixed with B.t., 95.0 %. Oiled ears did not have reduced kernel fill. The equipment used was a metal oil can with a side-projecting tip and a hand-squeezed pump, with a block under the handle to stop it at the desired amount. Ruth estimated, based on the time it took her to treat small plots, that it would take 8-10 hours to treat an acre.

In a trial at the University of Massachusetts research farm in 1993, one treatment with 5 drops of mineral oil/silk, in addition to 5 B.t. cover sprays, gave equivalent control to 5 sprays of Lannate, and better control than B.t. alone, in late corn that was subject to high FAW and CEW pressure. The percent of marketable ears in each treatment was: Lannate, 81.6 %; B.t. alone, 62.8 %; B.t. plus oil, 80.1 %

An Ohio farmer, Howard Crumb, grows 30 acres of sweet corn and though not organic was very interested in finding an alternative to hot sprays. He contacted both Ken and Ruth and in 1993 took a leap and committed himself to "oiling" all his corn. In a phone conversation after the growing season, he reported that he was pleased with the control he got. He would send a team of four of his farm helpers out together when a block was ready. It took them about 2 hours to do an acre. At $5.50 per person per hour, that's a cost of $44.00 per acre. They did not particularly like the job, especially on hot days, but then it wasn't the worst job on the farm either. They used small peanut cans with a hole punched in the plastic lid, and eye droppers refilled from the can, applying 4-5 drops of mineral oil per silk. Howard liked it because once a block of corn was oiled, he could forget about it -- instead of worrying about repeated sprays, rain, temperature, coverage, and his own pesticide exposure.

Trichogramma and other beneficials

Two farmers in the group, Dan and Steve, have purchased Trichogramma wasps and released them in their corn to control European corn borer. Dan has done this for a number of years and is convinced the wasps make a big difference in his damage from ECB. He also believes that they have an impact on caterpillar pests of cabbage on his farm. He purchases wasps from an insectary in California, which ships them as parasitized host eggs, nearly

ready to emerge, attached to cardboard. These cards can be cut into smaller pieces and placed out in the field. Dan makes releases weekly during periods of ECB flight, or from the time that his first corn is in late whorl stage.

There was discussion both years about Trichogramma biology, species, effectiveness, and availability. Unfortunately, not all species are commercially available -- including those which researchers have found to be most effective against ECB.

Trichogramma are very tiny parasitic wasps. They are egg parasites. Adult females lay their eggs in the eggs of their host, and the larvae grow and pupate inside the egg. Parasitized eggs turn black. Adult wasps emerge to search for mates and for new host eggs. Some Trichogramma species only attack a few closely-related hosts or certain types of eggs, while others are more generalist and are able to parasitize a wider range of hosts. Trichogramma species can be very confusing -- even for expert taxonomists, who argue over the names and identity of species.

For farmers concerned about controlling corn earworm and European corn borer, the following list gives some information about relevant species.

1. *T. pretiosum* (host: *Helicoverpa zea,* which is called corn earworm, tomato fruitworm, or cotton bollworm, depending on the crop.) It is adapted to search for eggs which are laid singly, as *H. zea* eggs are, as opposed to eggs which are laid in groups, such as ECB eggs. This species has been used effectively in tomato and cotton, but does not seem to be able to control earworm in corn. The reason is not clear, but it may be that *Helicoverpa zea* eggs are difficult for *T. pretiosum* to locate on the silk. Also, because it only takes one earworm in the ear to make it unmarketable, even high rates of parasitism may not be good enough if earworm pressure is high.

There are other examples a biocontrol species showing different effectiveness against the same host but on different crops. One is *Edovum putterii,* a parasite of Colorado potato beetle eggs. The NJ Dept. of Agriculture rears this wasp and has made releases in both potato eggplant fields. *Edovum* proved ineffective against ECB eggs in potato, but has been very effective in eggplant. One probable reason is that the "architecture" of eggplant is more similar to the native host plant where *Edovum* was originally found in South America.

Pretiosum is one of the few species that is commercially available (see references). It is the species that Dan and Steve have released against ECB. There are differing opinions on whether *pretiosum* is an effective agent against ECB. Numerous research studies in the U.S. and Europe indicate ECB is not one of its preferred hosts and that it is not particularly effective in the field or lab against ECB. However, one study in Yugoslavia obtained 70% parasitism with *pretiosum* releases. Dan and Steve's experiences on their farms have led them to believe it is effective, and they are convinced that the wasps are worth the expense. Releases need to be made annually, because *pretiosum* does not overwinter in temperate climates.

2. *T. nubilale.* Its primary host is European corn borer. It has been studied for several years at Universities of Pennsylvania, Minnesota and Delaware. It is very effective in the field at high release rates (at least 150,000 females/A). However, it is not commercially available at this time.

3. *T. brassicae* and *T. maidis* are two names for one species, whose host is European corn borer. *T. brassicae* was quite effective in 1992 Iowa trials, field corn (71% parasitism, 94% mortality) but performed poorly in New York State releases in 1993. There was hope that it would become commercially available in near future through a CIBA-Geigy mass rearing project, but at the time of this writing, that project has been discontinued. *T. maidis* is mass-reared and released in Europe, in commercial fields, for ECB control. It is sold as "Trichocaps", wax-coated parasitized Mediterranean fruit fly egg. These may also be the same species as *T. evanescens*, which is also an effective parasite against ECB and has been mass-reared in Europe.

4. *T. ostriniae* (hosts: Asian and European corn borer) was imported from temperate China and first released in 1990 by Dave Ferro of the University of Massachusetts and Mike Hoffman of Cornell University. It is an effective parasite of Asian corn borer in China, especially as an established, overwintering population. It is also mass-reared there and released annually as an "inundative" release. Its potential ability to overwinter successfully and become established is of special interest, although studies in 1992 and 1993 have not found evidence of survival in significant numbers at release sites in Mass. and New York. However, it has shown good ability to parasitize ECB in lab studies and field releases. It is not commercially available at this time.

5. *T. minutum* is a parasite of spruce budworm and other forest Lepidoptera, but does not parasitize ECB.

Where Trichogramma has been successful in releases, releases are begun at the time when ECB flight begins, and continued weekly or biweekly through the flight period (when new eggs are being laid.) In corn fields where there may be few sources of carbohydrate for wasps to feed upon, they live only about 48 hours. Release rates should be at least 60,000 female wasps per acre over the release period. Cards can be held for a short time in a cool place (55°F) to slow wasp emergence, but should not be kept at colder temperatures. One major concern is the quality of mass-reared insects. Rearing Trichogramma on ECB eggs is prohibitively expensive, so it is usually reared on other hosts. However, this may reduce its ability to find and parasitize ECB eggs in the field. If you purchase Trichogramma, ask your supplier about their source of wasps (many suppliers purchase biocontrol agents for resale) and their rearing procedures, and what they do to maintain quality.

6. *Other Beneficials.*

The twelve-spotted lady beetle (*Coleomegilla maculata*) is a distinctive pinkish lady beetle which is common in cornfields and preys upon ECB eggs as well as aphids. It can cause significant reduction in both pests, depending on its numbers. It also feeds on corn pollen and reproduces in corn, so the larval and pupal stages are common.

Nematodes, which can be purchased and sprayed on the whole corn plant or directly on the silk, have shown some effectiveness against larvae. Don Prostak included Biosafe at 300 million nematodes/acre in his trials and found no difference in damage from the control, but did find lots of dead larvae in the nematode plots. Possibly the nematode is simply not killing the larvae fast enough to reduce damage. The nematode *Neoplectana* sprayed directly on the silk showed some effectiveness in suppressing earworm in U. Mass trials.

Botanicals

In New Jersey, Ken finds he has regular problems with sap beetles. He tested a mixture of B.t., Sunspray oil and Pyrellin as a foliar spray and found he had good control of sap beetles and moderate control of CEW. Sunspray oil, however, may be phytotoxic and also has been placed on the prohibited list under New Jersey organic certification standards. Don Prostak included several botanicals in one trial, sprayed every 3 days or every day: Pyrenone, Pyrellin, Rotenone, and Red Arrow. CEW pressure was extremely high, with 50 moths captured in black light traps per night. None of the materials had less damage than the unsprayed control. He continued these trials in 1993, and the results will be published in Insecticide and Acaricide Tests, 1994 (see references).

Turning under cornstalks

ECB overwinters as late-instar larvae inside corn stalks. Plowing stalks under in the fall or early spring reduces their survival. Disking is not adequate because it leaves intact sections of stalks on the surface. ECB pupates and emerges in the spring, from mid-May to early June (south to north), so stalks should be plowed under before then.

Some growers were hesitant to use overseeding in their cover crop system because then stalks have to be left intact over the winter. However, early spring plowing should be effective in burying and killing the surviving ECB.

Birds

Several farmers have trouble every year with crows and other birds pulling up seeds or new seedlings. Paul reported that he has had to replant some fields because of bird damage. There was discussion of pine-tar repellents, which some farmers have used, but all such repellents have been taken off the market and even existing stocks are no longer legal to use. A brain-storming session at the 1992 meeting did not come up with any sure-fire ideas, but Paul has kept trying and in 1993 found a method that worked fairly well: planting 2-2 1/2 inches deep, then burying the plants at the spike stage. He said the birds gave up because the seeds were too deep, and it also helped with weeds. But he also points out that this was with flint corn and may not work as well with sweet corn.

Harassment and deterrence are options. This may take the form of noise-makers (shooting blanks, cracker shells, screamer rockets, and propane cannons, assuming they are legal in your town). Or, one can try to scare birds away visually, using 2-10" wide strips of mylar attached to tomato stakes or scare-eye balloons placed 3-5 feet above the ground. For balloons or mylar, make sure you move them every 3 days (or take them down for a day and then move them) – the goal is to be inconsistent so birds don't get used to them. Use 4-5 per acre. Officially, birds may be shot only if you catch them in the act of pulling up seedlings. Some farmers mentioned shooting as their major method of reducing the numbers of crows and teaching them not to hang around.

Varieties

Selecting varieties can be challenging, given the number of new choices being offered and the choice between standard varieties (Su), sugary-enhanced (SE) and supersweets (SH_2). In the 1992 meeting, farmers listed their favorite varieties, with a few comments. Note that results in another location or market might be very different.

Peter Craig:
- •Clockwork - midseason SE bicolor, Johnny's, large ear, fair taste, reliable, goes by quickly, mixed opinions from customers. Some view it as meant for wholesale market.
- •Kandy Korn - likes taste but can't sell it

Ken Muckenfuss
- •Silver Queen - name recognition, better earworm resistance
- •needs an early white with good flavor
- •his market prefers whites

Jeff Grant
- •Bodacious - yellow mid-early SE, good taste and size, keeps well
- •Sugar Buns - best early yellow, but very susceptible to Stewarts Wilt, and easy for coons to reach because it's low
- •Tuxedo - tolerant to Stewarts Wilt, good size and taste
- •Snow Belle - excellent white
- •Calico Belle - bicolor SH2, not as good flavor as SB or Bod, but finds that people like yellow after they taste it

Dan Tawczynski
- •Seneca Horizon - early yellow, good size ear, poor flavor
- •Quickie - good SE, good germination, short, high fertility needs
- •After these, moves into Sh2 -- no problem with germination, but handles seed extremely carefully
  - •Aloha
  - •Alliance (now Hudson)
  - •Starstruck
  - •Escalade
  - •Silver Queen

Tom Harlow
- •Quickie -- better than Sprite; good germination, small but that's OK for early
- •Needs SH2's for shipping (wholesale)
  - •Skyline - good germination
  - •Aloha - good
  - •Lancelot - new
  - •Diablo
  - •Sweeter by Far -- too much germination, too thick, small ears
- •No yellow corns --people won't buy
- •Does not like Clockwork

George Hall
- •Sprite -- will sell early
- •Sweet Sal -- good yellow SU
- •Cal Belle
- •Silverado -- good eating SE, white, coons like it, poor tip cover
- •Snow Belle

- Aloha -good
- Alliance (Hudson)- good

Steve Mong

- Silverado - got name recognition quickly; tassel tip problem if stressed
- Quickie - good flavor for an early corn
- Duet - small SE, uniform harvest time, medium early
- Sugar Buns -- can't grow it successfully
- Tuxedo - likes it
- Lancelot - likes it
- Sweet Sue -- this will be 1st year not growing it; narrow window to pick. late, but good eating
- Silver Queen -- keeps producing over a long period

Jake Guest

- has moved from SH2 to SE's
- Quickie -- quick early
- Sugar Buns -- grows lots
- Double Gem -- new bicolor
- Bodacious -- really good
- Gives away yellow corn to get people to try it -- then they like it
- Skyline
- Starstruck
- Diablo
- Phenomenal
- Alliance (Hudson)
- Does not like Clockwork, Silver Queen

Appendix A: University of Massachusetts Fact Sheets

University of Massachusetts Cooperative Extension System
Vegetable Integrated Pest Management Program

Managing Corn Earworm in New England Sweet Corn : Current Suggestions for Organic Growers

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Throughout the Northeast, corn earworm is a key obstacle to successful, season-long production of organic sweet corn . There have been virtually no options for controlling this pest organically. Most organic farmers find themselves putting wormy corn on the stand at some point during the season unless they are located in regions which have no corn earworm activity. This drastically reduces sales and eliminates wholesale marketing. Cutting off infested tips before sale is a time-consuming option which some growers use, but preventing damage in the first place would be much preferred. Recent research is exploring some options for control that can be used by organic growers.

Corn Earworm Biology

Corn earworm is a widespread pest which is also known as tomato fruitworm on tomato, and cotton bollworm in cotton and tobacco. It's scientific name is *Helicoverpa zea*, recently changed from *Heliothis zea.* Corn earworm moths migrate annually into New England, primarily from mid-July through September. Adult moths are about 1 1/4 inches in length, covered with light tan scales. Distinctive features are a dark dot on the forewing, a dark band near the margin of the hindwing, and bright light-green eyes.

Female moths attract males for mating by emitting sex pheromones. Pheromone traps are a good indicator of the population density of both males and females. The recommended trap that is commercially available is the *Heliothis* net trap produced by Scentry, baited with Hercon^{tm} luretapes for corn earworm. This trap should be placed with the base at about ear height in freshly silking corn. Capture numbers are a good predictor of how serious the ear damage from earworm caterpillars will be. Higher captures of males indicate greater numbers of female laying eggs (the population is usually about 50:50 male and female), and therefore more eggs and newly-hatched larvae to control.

Female moths are attracted to the odor of corn silk, and lay eggs singly on the silk as well as other parts of the plant. Females lay on the average about 5.5 eggs per day over their 7-14 day life span. After silks have been pollinated and dry up, they are no longer attractive as ovipositional sites. Eggs hatch in 2-7 days, depending on temperature. Larvae move down the silks and into the ears to begin feeding at the tip of the ear. Feeding is usually limited to the ear tip, which is why the earworm is also called "tipworm."

Silk Growth.

When corn plants begin to produce silk, the growth of the fresh silk is very rapid. Studies at the University of Massachusetts and other institutions have indicated that about 75% of the growth occurs in the first day, and growth is 95% complete in 2 days. However, not all plants in a stand produce silk at that same time. Given a relatively even stand, 60-80% of silk emergence is concentrated in a 3-4 day period. About 48 hours after growth is complete (called "full brush"), the silk begins to turn brown at the tips and dry up.

Direct Silk Application of Oils.

Corn earworm larvae enter the ear via the silk channels at the neck of the ear. Oil which is applied directly to the silks in the neck acts as a barrier and kills the larvae, probably by suffocation. This is an "old-fashioned" technique which was used before the arrival (and regulation) of synthetic insecticides. Vegetable and mineral oils are not sold or distributed as pesticides and are food products or for internal use; these characteristics appear to exempt them from regulations regarding pesticides and food tolerances. If you wish further clarification of their regulatory status, contact your state pesticide regulatory agency or regional EPA office.

Trials have been conducted at the University of Massachusetts, on organic farms, and by other Universities, examining the effect of vegetable and mineral oils on CEW damage. The results suggest that oils can reduce damage by corn earworm and other caterpillars and warrant further testing by farmers and researchers. The following results were observed:

- Both vegetable (including cottonseed and canola oils) and mineral oil effectively reduced CEW infestation. In 1993 trials conducted at U. Mass., there was no difference in the control from vegetable oil compared to mineral oil.

- To avoid tip fill problems, oil must not be applied until 48 hours after silk is fully grown. *Earlier applications can reduce pollination and result in poorly filled tips.* This timing can be determined by flagging silks on a few plants and watching them grow, or by noting when the fresh silk started to dry at the tips, which occurs at two days past full brush. In U. Mass 1992 trials, 2 ml/silk of canola oil applied at 48 hours after full brush caused a 6% reduction in ear fill. In 1993 trials, both mineral and vegetable oils applied at this time in amounts up to 0.5 ml per ear caused no reduction in ear fill.
- Too little oil may be ineffective, but excessive quantities can "pre-butter the ears"! Some growers have reported that one or two drops per ear, applied directly to the neck, was a sufficient quantity to achieve control. In 1992 trials we used about 2 ml (equivalent to approx. 20 drops). This appeared to be excessive, as oil moved down the ear onto the kernels and was still present at harvest. 1993 trials found better control with 0.5 ml (equivalent to 5 drops) than with 2 drops per silk, with no oil found on ears at harvest time. We have concluded that 0.5 ml is an optimum dose. Note that this oil must be applied directly into the hollow in the neck of the ear, not on the silk hanging outside the ear, to be effective.
- One application to each block of corn has been adequate. All ears that were close to the ideal age were treated. If the silk emergence is very uneven, it may be necessary to go through the stand twice to achieve optimal control without tip fill problems. In this case, treated ears need to be marked in some way, such as with a hole punched through the flag leaf or a thumb print from an ink pad carried on the belt.
- Eye droppers, syringes, or oil cans set to deliver a small amount have been used for the application. A can may be carried on the belt to refill whatever applicator is used. Growers have experimented to figure out the most efficient method for them. Time spent in application is the major cost of this method. In 1993 U. Mass trials, we used a metal "pistol oiler" oil can with a block under the handle to calibrate it, so that it delivered the desired amount on each squeeze. The time required for application was the equivalent of 8-10 hours per acre.
- Mixing a BT product that is labeled for sweet corn (Dipel ES™, MVP™, or Condor OF™) with the oil may increase control. In 1993 trials, adding MVP to vegetable oil increased marketable ears from 82% to 95%. Similarly, Pyrellin™ mixed with oil gave improved control over oil alone in trials at Oklahoma State Univ. NOTE: application must be made in accordance with the product label.
- Oil also prevented damage from 2nd-generation European corn borer and fall armyworm that entered through the neck of the ear. However, both of these pests also burrow through the side of the ear. Side damage, especially from ECB and FAW present in at early tassel stage, can be reduced by using BT sprays before silking.

Trichogramma Releases for CEW Control

Several species of the tiny egg parasitoid *Trichogramma* are available commercially for annual release in crops. *Trichogramma pretiosum* is mass-reared and readily available, and *H. zea* is its host. It is adapted to parasitize eggs that are laid singly, like *H. zea* eggs. It has been shown to be quite effective in reducing damage by *H. zea* in tomato and cotton. However, it is *not* effective in reducing H. zea damage in sweet corn. This may be because of difficulty in locating host eggs on the silk, or it may be because, even if the parasite is 90% effective, it only takes one caterpillar per ear to make the ear unmarketable. Growers who have released *T. pretiosum* in sweet corn report that it is ineffective when CEW is present.

Other species of *Trichogramma* have been studied for controlling European corn borer, with more promising results. *T. maidis* is mass-reared and released in commercial fields in Europe with good success. *T. brassicae* (which may actually be the same species; taxonomists disagree on this) has been mass-reared on a trial basis by CIBA-Geigy in Ontario, Canada and has been studied in field trials in 1992 and 1993. Results appear to be mixed, and the prospects for commercial availability are not promising at this time. *T. ostriniae* was imported from China in 1990, readily parasitizes ECB, and may have the important characteristic of being able to survive the New England winter. It is currently under evaluation at the University of Mass. and Cornell University, but is not commercially available. *T. nubilale* is another species that has been shown to be effective against ECB at high release rates, but is also not commercialized. *T. pretiosum* has been released against ECB by several growers in Massachusetts, who report that it is effective; however, both lab and field studies by researchers at several Universities have found poor results with *T. pretiosum* against ECB. This species has not been evaluated in Massachusetts in trials with non-release plots for comparison.

by Ruth Hazzard, Vegetable IPM Specialist
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Vegetable IPM Program
Pub. VEGICM 94-2

Pre-sidedress Nitrogen Soil Test for Sweet Corn

Nitrogen in the form of nitrate is extremely soluble and moves freely with soil water as it drains. Applying large quantities of N in the spring before planting can result in nitrate loss to ground water. Similarly, overapplication of N from fertilizer and manure can result in nitrate loss throughout the growing season and especially after crop removal in the fall. The need for a pre-sidedress N test is because farmers have no accurate way to predict N release from manure and crop residues from year to year due to climatic variability. Utilization of a pre-sidedress N test has two major benefits. First, it establishes how much, if any, N fertilizer is needed. Secondly, it would help reduce excess N loading to soil.

Sampling Procedure for Nitrogen Soil Test

1) Sample soil when the corn is 9 to 12 inches tall.

2) Collect 15 and 20 cores per field to a depth of 12" if possible. If you can't get to 12", sample as deep as you can. Sampling less than 12" may overestimate nitrate- N content and result in less than adequate nitrogen fertilizer recommendation. Avoid starter fertilizer bands or areas where manure was piled or application was unusually heavy or light.

3) Composite the cores for each field and mix completely, then dry on the same day a subsample to stabilize the nitrate. Dry in an oven at about 200°F, or in a microwave. Samples can also be air dried if spread out thinly on a nonabsorbent material. A fan will reduce drying time. Do not put wet samples on absorbent material because it will absorb some nitrate. Alternately freeze soil subsample until transporting to the testing lab.

4) Take one cup of the soil when it is dry and put the sample in bag that has your name, address, sample number and from which field the sample was taken and then send the sample together with $5.00 per sample to the:

Soil Testing Lab
West Experiment Station
University of Mass.
Amherst, Mass. 01003

or to one of the several collection sites listed on the reverse side of this page.

5) The sidedress N recommendation can be determined from the following table.

Tentative Sidedress N Fertilizer Recommendations for Sweet Corn*

Soil test level ($ppm\ No_3$-N)	Early Crop Sidedress N recommendation (lbs N/acre)	Main Crop Sidedress N recommendation (lbs N/acre)
0-10	130	150
11-15	100	125
16-20	75	100
21-25	50	75
25+	0	0

* Based on preliminary field data from Massachusetts, Connecticut, Pennsylvania and Vermont for field and sweet corn. We suggest you have a test strip following these recommendations to compare to your normal N fertilizer practice.

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Contact (413) 545-5236 for more information

Plant Nutrients From Manure

Approximately 70-80% of the nitrogen, 60-85% of the phosphorus and 80-90% of the potassium in feeds is excreted in the manure. The amount of nutrients available for recycling to plants varies widely being dependent upon the composition of the feed ration, the amount of bedding and water added or lost, the method of manure collection and storage, the method of land application, and characteristics of the soil, crop and climate. Manure contains all the plant nutrients needed for crop growth including trace elements. The availability or efficiency of utilization by a crop is determined by both the method of application and the rate of manure decomposition by microorganisms in the soil.

Manure contains stable and unstable forms of nitrogen. Unstable N occurs in urine as urea and may account for more than 50% of the total N in manure. Urea mineralizes rapidly to ammonium ions then quickly to ammonia as pH increases and manure begins to dry. Ammonia is extremely volatile resulting in N loss. Nearly all the ammonium N can be lost from surface applied manure if it is not incorporated within a few days.

The more stable organic N occurs in the feces and is slowly released. Approximately 40% of the stable organic N will be available the first year, 12% the year after, 5% in the third year and 2% in each subsequent year. These figures are approximate for New York and could vary slightly in Massachusetts due to variations in the rate of microorganism breakdown and climate. The decay series is only for the stable organic N and does not include the urea or ammonium N which is 100% available the first year if not lost as ammonia.

Manure is an excellent source of P and K. When manure is applied at a rate to supply the N need of a corn crop, the P and K will likely be in excess of the crop requirement. Essentially all of the K is available for plant growth the year manure is applied. However, some of the P may be in the form of insoluble inorganic compounds or as organic P and, like stable organic N must be mineralized before it is available. About 80% of the P and 85% of the K is available in the year of application regardless of application method.

Timing and method of manure application determine the efficiency of nutrient recycling. Incorporating manure immediately minimizes odors and ammonia loss. If manure supplies more N than needed then some ammonia loss is unimportant. However, it is better to apply manure to more acres than to apply in excess to a few acres. Manure must be spread uniformly to get consistent results. Applying and incorporating manure too early for the crop, as in the fall or early winter in high rainfall areas, could result in N loss and groundwater contamination. Likewise surface runoff and soil erosion must be controlled to protect surface waters. Effectiveness of manure as fertilizer and cost savings is based on the nutrients it contains that are deficient in the soil. These are best determined by laboratory analysis. For non-liquid systems without an analysis consider each ton supplies to be the crop approximately 5 lbs. N, 3 lbs P_2O_5 and 6 lbs K_2O. Less N if not immediately incorporated. Nutrients are supplied in the year of application and from previous years. Avoid over applications.

For more information consult "Managing Animal Manure as a Source of Plant Nutrients" by Klausner, Mathers and Sutton in the National Corn Handbook (NCH - 12).

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Revised 1993

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Nitrogen Management for Optimum Crop Production

Adequate nitrogen is essential for optimum crop production. However, applying excess nitrogen can have serious environmental consequences. Nitrogen, in the form of nitrate, is extremely soluble in water and will be carried down through the soil profile as the water drains. Overapplication of nitrogen can mean a decrease in profits and an increased potential for ground water contamination.

Nitrogen dynamics in the soil are very complex with over 98% of the nitrogen in the top 6" of soil 'tied-up' in soil organic matter and not readily available for plants. This makes it very difficult to estimate nitrogen needs for the season based on a soil test taken before planting. The largest demand for nitrogen by corn, for example, is 30 to 40 days after emergence. If soluble nitrogen fertilizer is applied at planting, much of it may have been lost from the soil root zone through leaching by the time the corn has its greatest nitrogen requirement.

In determining nitrogen fertilizer rates it is important to be aware of all nitrogen sources on the farm and to give them adequate nitrogen fertilizer credits. Below is a brief description of several nitrogen sources.

Soil organic matter - Organic matter is approximately 5% nitrogen by weight. As it decays, nitrogen will be released in a form suitable for plant use. A rule of thumb is that 10 lbs/acre of fertilizer equivalent-N will be available in a growing season for every 1% of organic matter in soil. For example, a soil with an organic matter content of 3.5% will supply approximately 35 lbs N/acre.

Manure - Animal manures supply nitrogen to crops, but the fertilizer equivalent from manures will vary greatly depending on such factors as animal species, moisture content, bedding used, handling and storage, and the elapsed time between spreading and incorporation. When manure is applied, it is important to know the analysis, the amount that you are spreading in addition and time to incorporation in order to estimate the amount of nitrogen expected in the year of application. Tables 1 and 2 are helpful in estimating manure nitrogen contribution but are no substitute for a manure analysis and a well calibrated manure spreader. These two tables can be used to estimate the amount of nitrogen that will be available to crops from manure applications. For example, 25 tons/acre of dairy manure containing 8 Lb/ton (from analysis) applied, and

Table 1. Moisture and nutrient content of manure from farm animals*

Animal	Feces/urine ratio	H_2O(%)	Nutrient Content (lbs/ton) N	P_2O_5	K_2O
Dairy Cattle	80:20	85	10	3	7.6
Poultry	100:0	62	30	14	6
Swine	60:40	85	13	7	11
Sheep	67:30	66	23	7	21
Horse	80:20	66	15	5	13

*adapted from The Nature and Properties of Soils, N.C. Brady, 1990

Table 2. Nitrogen availability as influenced by time of incorporation.*

Manure application	% nitrogen available Poultry	Other
Applied in spring (current year)		
incorporated same day	75	60
incorporated 2-4 days	45	40
incorporated 5-6 days	30	30
incorporated > 7 days	15	20
Applied in fall, no cover crop	15	20
Applied in fall, with cover crop	50	40

* adapted from the University of Minnesota and Pennsylvania State University

incorporated the same day, will give approximately 120 lbs/acre of nitrogen available the year of application. Even though 200 lbs of nitrogen would be added to the soil, only 60% of that nitrogen is available the first year with the remainder becoming available in subsequent years. However, if the manure is incorporated 7 days after applied to the soil only 40 lbs/acre of nitrogen will be available. Eighty lbs will have been loss to the atmosphere.

Crop Residues - Previous crops, including cover crops, can supply substantial amounts of nitrogen to corn when incorporated prior to planting. The amount of nitrogen will vary widely depending on the plant species. The fertilizer equivalent can be as high as 150 lbs/acre for a good alfalfa stand. Thus the percentage of legume remaining in a hay field being rotated to corn needs to be taken into account. For legume cover crops the amount of time they have been allowed to grow before incorporation, in addition to other climatic factors will influence their fertilizer equivalent. This can be as high as 100 lbs/acre for a stand of hairy vetch in combination with rye planted in late August and incorporated in late May.

Non-legumes cover crops such as winter rye and oat do not contribute nitrogen like legumes, however they are very efficient in 'mopping-up' nitrogen that is still available in the soil after crops are harvested. This conserved nitrogen will eventually be released when they are incorporated rather than the nitrogen being lost to groundwater. This emphasizes the importance of seeding cover crops soon after harvest since most of the leaching of nitrates in the Northeast occurs in the fall and spring.

Composts - Composts can also be used to add nutrients and organic matter to the soil. Composts are becoming more available due to more stringent disposal regulations, closure of landfills and high tipping fees. Research at the University of Massachusetts and other institutions has shown that the addition of certain composts can inhibit some soil-borne pathogens. Some composts can also supply substantial amounts of nitrogen without the decrease in soil pH associated with some fertilizers. This could reduce the amount of lime needed for pH correction.

Chemical Fertilizer - Most formulations of chemical fertilizer are readily available to crops soon after soil application. However, fertilizer nitrogen has a high leaching potential. Spring applications of nitrogen fertilizers coupled with the usual wet conditions at this time of the year increase the danger of leaching. Timing fertilizer applications to coincide with the time of greatest demand by the crop, 30 to 40 days after emergence, will make for more efficient fertilizer utilization.

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References

Sweet Corn IPM Guides

Adams, Roger G. and T. Jude Boucher. Integrated Pest Management for Connecticut Sweet Corn. Cooperative Extension Service, College of Ag. and Natural Resources, Univ. of CT, Storrs, CT 06268. Insect ID, monitoring methods, and thresholds used in the CT sweet corn IPM Program.

Dill, James F., D. Handley and Don Mairs. Monitoring for Sweet Corn Pests. Vegetable IPM Fact Sheet # 401, Cooperative Extension Service, University of Maine. Trapping and monitoring methods, pest identification, and thresholds for Maine Sweet Corn IPM.

Ferro, David N. and Donald C. Weber. 1988. Managing Sweet Corn Pests in Massachusetts. Guide to IPM techniques for monitoring sweet corn pest, including pheromone traps and how to use them, insect identification and biology, and thresholds. Color photos. $3.00 from Univ. of Mass. Bulletin Center, Cottage A, Thatcher Way, University of Massachusetts, Amherst MA 01003, 413-545-2717

Prostak, Don. Sweet Corn Pest Management: A Better Way. Extension Bulletin # 422, Rutgers Cooperative Extension, New Jersey Ag. Experiment Station, PO Box 231, New Brunswick NJ 08903. Sweet corn IPM system used in New Jersey.

Research reports

Hazzard, R.V., D.N. Ferro, M.J. Else, and R. Christensen. 1993. Development of Bio-intensive sweet corn IPM, Final Report, October 1993. Reports on research conducted in 1992 and 1993 on use of B.t. and oils, Trichogramma ostriniae, and weed control, including economic analysis of weed control with cultivation. Available from R. Hazzard.

-------- and Frank Mangan. 1993. 1993 Annual Report of the Vegetable Integrated Crop Management Program. Includes reports on use of hairy vetch with oat or rye, use of pre-sidedress nitrate test, and use of B.t. and oil for insect control in corn. Also includes reports on tomato, crucifer and potato programs. Available from Ruth Hazzard or Frank Mangan.

Prostak, Donald. 1994. Insecticide and Acaricide Tests. Insecticidal and Biological Control of Ear Infesting Insects in Sweet Corn, 1993; Insecticidal, Biological and Botanical Control of Foliar Sprays for Whorl-Infesting Insects of Sweet Corn, 1993; Control of Ear-Infesting Insects of Sweet Corn, 1993; Foliar Sprays to Control Fall Armyworm on Late-planted Sweet Corn, 1993.

Cover Crops

Liman, Betsy and Marianne Sarrantonio. 1993. Set of twelve Northeast Cover Crop Fact Sheets. Soil Health Series. Available from Rodale Institute Research Center, 611 Siegfriedale Rd., Kutztown, PA 19530. 215-83-1400. Cost: $0.50 per fact sheet. Series includes vetches, clovers, cereal grasses, peas, and beans.

Hargrove, W.H., editor. 1991. Cover Crops for Clean Water. Soil and Water Conservation Society, 7515 N.E. Ankeny Rd., Ankeny, Iowa 50021-9764. $15.00. A good reference book that deals with many aspects of cover crops, organized by topics such as weed or nitrogen management.

Else, M.J. and Frank Mangan. (in press). Cover Crop Manual for New England. Guide to use of cover crops in vegetable systems. Available through the authors.

Weed Identification and Management

USDA-ARS. 1971. Common Weeds of the United States. Available through Dover Publications, 180 Varick St., NY, NY 10014.

Stucky, J.M, T.J. Monaco, and A.D. Worsham. 1981. Identifying Seedling and Mature Weeds Common in the Southeastern United States. North Carolina Ag. Res. Serv. Bull. No 461.

Newcomb, L. 1977. Newcomb's Wildflower Guide. Little, Brown, and Co., Boston.

Phillips, C.E.. Weeds of the Northeast - A key to their identification by vegetative characteristics. (2 Vols.) Univ. of Delaware Ag. Exp. Sta, Newark, Delaware.

Southern Weed Science Society ID Guides. Available through WSSA, 309 West Clark St., Champaign, IL 61820.

Cramer, C., editor. 1991. Controlling Weeds with Fewer Chemicals. Rodale Institute, Emmaus, PA. 138pp. (see Rodale address, above).

Beneficial insects, including Trichogramma

1994 Directory of Least-Toxic Pest Control Products. The IPM Practitioner. Vol XV, No. 11-12, Nov-Dec 1993. An extensive, up-to-date directory listed by pest, including beneficials, microbials, botanicals, physical controls and monitoring devices. Includes an address list of suppliers and sources, including insectaries which supply Trichogramma. Available from Bio-Integral Resource Center, P.O. Box 7414, Berkeley, CA 94707. The IPM Practitioner is a subscription magazine, but single issues such as this directory are available separately.

Hoffman, Michael and Anne C. Frodsham. 1993. Natural Enemies of Vegetable Insect Pests. Cornell University. Entomology Dept., Cornell University. An excellent new guide with color photographs, life history and biology, and recommendations on using or enhancing natural enemies. Available from Resource Center, 7 Business/Technology Park, Cornell University, Ithaca, NY 14850, 607-255-2080.

Insect Identification and Management

Davidson, R.H. and W. F. Lyon. 1979. Insect Pests of the Farm, Garden and Orchard, 7th edition. John Wiley & Sons. Basic life cycles, identification, and controls for wide range of pests.

McKinlay, R.G. 1992. Vegetable Crop Pests. CRC Press. Excellent biological information on vegetable pests drawing upon recent research; lots of references. A more worldwide perspective, because written in England.

Metcalf, R.L. and Metcalf, R.A.. 1993. Destructive and Useful Insects: their habits and control. McGraw-Hill. New edition of a classic book that covers all insects that impact upon humans.

Miscellaneous

New England Vegetable Management Guide. 1994. Written by Vegetable Extension specialists from all New England states, updated annually. Includes information on crop nutrition, cover crops, soil testing, B.t. products registered for vegetables, and insect, weed and disease management. Available from Bulletin Center at U. Mass (see above), or contact your state Extension office.

Ordering Additional Copies of the Proceedings

Additional copies of the proceedings are available from the NOFA chapters listed below at $3.95 each plus shipping and in-state sales tax. Please specify which crop proceedings you are ordering (apple, sweet corn, greenhouse bedding plants, livestock or strawberries). You may also join one of NOFA's seven state chapters by including the appropriate dues listed below for your state.

NOFA/Connecticut: Box 386, Northford, CT 06472
Proceedings: $3.95 each plus 6% tax (24¢) plus $1.75 shipping for a total of **$5.94**.
Dues: Individual or household: $25, Institution: $50, Supporting: $100, Low income: $15

NOFA/Massachusetts: 411 Sheldon Road, Barre, MA 01005, (508) 355-2853
Proceedings: $3.95 each plus 5% tax (20¢) plus $1.50 shipping for a total of **$5.65**.
Dues: Individual: $25, Family: $35, Low income: $15, Supporting: $100

NOFA-New Hampshire: Jan C. LaPlante, c/o Green Pastures Estate, 38 Ladds Lane, Epping, NH 03042
Proceedings: $3.95 each plus $1.30 shipping for a total of **$5.25**.
Dues: Individual: $25, Family: $35, Student/Senior: $18, Supporting: $100

NOFA-New Jersey: 31 Titus Mill Road, Pennington, NJ 08534, (609) 737-6848
Proceedings: $3.95 each plus 6% tax (24¢) plus $2.50 shipping for a total of **$6.69**.
Dues: Individual: $25, family/organizational: $35, Supporting: $50, Sponsor: $100

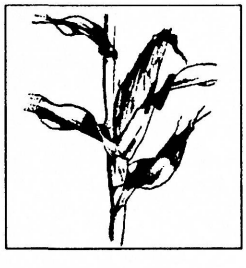
NOFA-New York: P O Box 21, South Butler, NY 13154, (315) 365-2299
Proceedings: $3.95 each plus $1.50 shipping for a total of **$5.45**.
Dues: Student and Senior (over 65): $15, Student and Senior Family (2 adults): $20, Individual: $25, Farm Listing: $30, 2 adult family: $30 (each additional adult, $5), Business: $35, Patron: $100, Corporate Sponsor: $500, Lifetime: $1000

NOFA/Rhode Island: c/o Casey Farm, 2325 Boston Neck Rd., Saunderstown, RI 02874
Proceedings: $3.95 each plus 7% tax (28¢) plus $1.75 shipping for a total of **$5.98**.
Dues: Individual: $20, Family: $25, Supporting: $50, Lifetime: $250

NOFA-Vermont: PO Box 697, Richmond, VT 05477
Proceedings: $3.95 each plus 5% tax (20¢) plus $1.21 shipping for a total of **$5.36**.
Dues: Individual or Family: $20, Supporting: $35, Sponsoring: $75

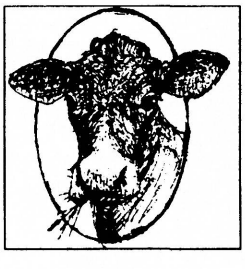
Some participants in the grower groups came from Maine, where the Maine Organic Farmers and Gardeners Association (MOFGA) performs work similar to NOFA's. MOFGA's address is Box 2176, 283 Water Street, Augusta, ME 04330, (207) 622-3118.

Apples



Sweet Corn

Greenhouse



Livestock

Strawberries