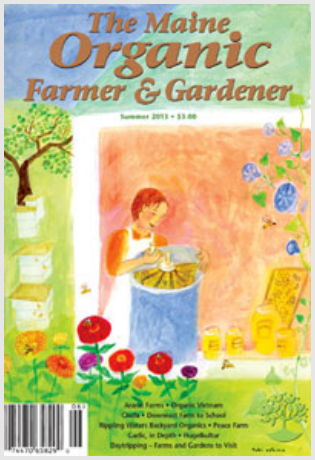
"When we see land as a community to which we belong, we may begin to use it with love and respect."

- Aldo Leopold



Garlic, in Depth

MOFGA's Spring Growth Conference in March 2013 featured David Stern of Rose Valley Farm in Rose, New York, a certified organic farm, followed by a panel of MOFGA growers. Stern is also president and co-founder of the Garlic Seed Foundation.

Eric Sideman, MOFGA's organic crop specialist, introduced the conference by reviewing the handful of diseases and insects that are increasingly problematic as more garlic is being grown. Most of these diseases tend to be carried by seed, and some could be devastating, "so be careful with what you share," said Sideman.

The diseases he covered at Spring Growth are also discussed in the new, second edition of the *Resource Guide for Organic Insect and Disease Management,* which Sideman co-authored. The guide is available as a free download at http://web.pppmb.cals.cornell.edu/resourceguide/, and a hard copy can be ordered there as well.

Resource Guide for Organic Insect and Disease Management is also sold at the MOFGA Store.

David Stern of the Garlic Seed Foundation and Rose Valley Farm (left) and Unity College professor Doug Fox at MOFGA's Spring Growth Conference on garlic. English photo.

Garlic Pests

Fusarium basal rot is fairly common. Sideman said he rarely sees it, but it's easy to see and fairly easy get rid of.

Botrytis rot is not that common. It persists in soil or on garlic as sclerotia, a compact mass of hardened, dried mycelia (the fungal hyphae or fungal body), which germinate under cool, wet weather. It spreads on planting stock but is easy to see, so people don't usually share infected cloves and this disease won't become a big problem.

Blue mold is mainly a storage problem and is most prevalent when garlic is cured in a damp area – so cure and store garlic in a dry area.

White rot is more worrisome, affects only the Allium family, and differs from the white mold that affects many vegetables. The disease can cause plants to yellow and die suddenly; on stored garlic, it forms white, fuzzy growth that begins to look like cotton on the cloves after a while. It reproduces only by sclerotia, which look like tiny pepper grains and may lay dormant in the soil for more than 15 years until planted alliums release a chemical that stimulates the sclerotia to germinate. The disease does not spread in very dry, stored bulbs, but is spread by infected seed or soil. Controls include using clean seed, avoiding transporting infected soil or manure to new fields, moving garlic to a new field once an old one is infected, and very long rotations.

Sideman described the garlic bloat nematode – a microscopic roundworm – as "really scary." Although it has been around since about 1920, it only recently became common in our area.

Growers don't see the pest but the symptoms – for example, plants without many roots, or with roots missing on one-quarter of the garlic bulb. The nematodes survive on garlic debris and seed pieces. Control includes using clean seed, sanitation, good compost that got hot and possibly biofumigation (described later). (See Bulletin #1205, *Bloat Nematode in Maine Garlic,* from the University of Maine Cooperative Extension, at http://umaine.edu/publications/1205e/.)

Bulb mite, a microscopic mite, is not as scary as some other problems, said Sideman. Cool, wet soils that are high in organic matter favor it. The mites make marks on garlic, and when they're numerous can turn a clove into brown powder. This is the same as the spinach crown mite, which, in spinach, eats leaves down in the young crowns, so when spinach grows, it already has chewed leaves. Controls include sanitation, cleaning up debris and buying clean seed.

The Alliums

David Stern said that sunlight is very important for alliums. *Allium sativum,* garlic as we know it, stops growing on June 22 – that is, as the days shorten, top growth stops and the plant puts its energy and carbohydrates into the bulb. Any shade before then – from weeds, hedgerows, planting too close together, etc. – will interfere with growth. (*A. tricoccum,* ramps, is a wild relative that emerges before leaves open on trees, lives its life cycle, dies as tree leaves are budding, and then goes into suspended animation until the following spring.)

Last year Rose Valley Farm experienced three days over 90 F in March, pushing garlic growth; this year only two days in March were over 50. March 1 had 11.25 hours of daylight; April 1 this year had 12.75 hours of daylight. Given the slower emergence of garlic this year and the fact that garlic stops growing on June 22, when daylight reaches 16 hours, "we've lost 360 hours of sun growth" this year, said Stern. "But garlic is 'incredibly elastic.' It will probably spurt and do fine."

All alliums mine sulfur (S) from the soil, and S compounds are responsible for the main medicinal and culinary factors of alliums. Because of acidic, S-containing rain that comes to New York from the Ohio Valley, garlic grown there is usually much higher in S compounds than that grown in some other states. (This difference in soil S explains why the Granex 33 strain of Vidalia onion, developed at Cornell, "will bite your face off" when grown in Maine, said Stern, but grown in red clay, low-S soils of Georgia, it is mild enough to eat like an apple.)

If garlic cloves don't get a cold period (vernalization), they won't segment and become a bulb. This is one reason garlic isn't planted in the spring.

If garlic cloves don't get a cold period (vernalization), they won't segment and become a bulb. This is one reason garlic isn't planted in the spring, although it can be vernalized in the refrigerator at 40 F for 40 days. With elephant garlic, a garlic-leek cross, often up to one-third of the cloves planted develop into rounds instead of bulbs.

Garlic is one of a few plants with three means of reproduction – cloves, bulbils and seed; another is nutsedge. Garlic is normally reproduced by cloves, because the flowers have mechanical problems related to fertility, unless garlic is grown above 4,000 feet. (It's native to the mountains of what is now Afghanistan and Pakistan.) Botanical surgery can be used to produce true seed in garlic. Maria Jenderek of the USDA Agricultural Research Service was working on garlic genetics and seed production in California, but when rust disease appeared there, the industry moved to China, which now produces 250,000 times more garlic than the United States.

Weed Control

Garlic competes extremely poorly with weeds, and weed pressure can easily reduce yields by 30 percent. Weed control starts many seasons before planting, with rotations and soil fertility, and continues until shortly before harvest. Seventy percent of the garlic grown in world today, said Stern, is processed and lacks the quality to be sold unprocessed; so farmers who sell unprocessed garlic are competing with the remainder of the crop. We must grow quality as appreciated by our customers, he said. We can get higher yield of unattractive bulbs.

An organic mulch is great for weed control and water retention in garlic plantings, and it keeps the soil cool in summer – a benefit, as garlic stops growing at soil temperatures above 92 F. But organic mulches can also keep soils too cool in spring, interfere with nitrogen (N) use and with harvest, and can encourage slugs. Growers can remove some mulch in spring, let garlic emerge, and then replace the mulch.

Stern cautioned about the source of mulch. He told of a Baltimore-area grower who planted his garlic on "double 40" raised beds, with two rows of plants per bed, rows spaced 40 inches apart, and drip irrigation down the middle of the bed. The grower used leaf mulch collected from curbsides in Baltimore; it contained petroleum distillates, and his field is now an EPA Brownfields site.

More and more growers, said Stern, are using silver-colored plastic mulch to repel thrips, keep soils cool and control weeds – but pulling weeds out of planting holes punched in the mulch is a hassle.

Stern plants garlic as a row crop. He has a Friday Wiggle Hoe cultivator (identical to the horse-drawn equipment), made by the Friday Tractor Company (now out of business), which enables him to sit directly on top of the crop and cultivate accurately, with the crop going between his legs. Cultivate weeds early in the morning, said Stern.

Stern also uses a weeding platform with a hydraulic top link. "If you're into cultivating," he said, "you ought to get a hydraulic top link; it regulates top arm length." The idea came from Michigan, where it's used as an asparagus harvesting tool; a local welding class put it together. It allows comfortable and accurate between-plant cultivating.

While no set rotation for garlic exists, everyone does some type rotation before planting, for weed control, soil fertility and to get the pH up.

Vinegar, available in strengths up to 200 grain (20 percent acetic acid), may be used for weed control, since the waxy cuticle of alliums enables foliar applications to run off. Check with your certifier before using the product, said Stern.

Flaming using a tool that shields garlic and a backpack with a 20-pound propane tank can also control young weeds easily.

Soils

Garlic grows in any soil, from bony to black muck, said Stern. He noted people's emphasis on cultivars rather than soils, but said, "It's very clear that the better your soils, the better your garlic. A mediocre garlic will do very well on a good soil; a great garlic won't do well in concrete. This is a high value crop – get a soil test!"

A low pH (around 6) is not good for garlic; raise it to 6.8 or 7.0.

This is a heavy feeder, with roots growing as deep as 4 feet. The only N fertilizer Stern likes to apply in the fall, at planting time and right in the furrow with the garlic rather than broadcast, is soybean meal, because the 7 percent-N material (protein/7 = N content) has the right carbon-to-nitrogen ratio to minimize leaching of N from the soil over winter and for the N to become available when plants need it in spring. Stern is having trouble finding organic soybean meal, but Sideman said MOFGA Certification Services allows non-organic soybean meal in crop production (but not for animal feed).

Soil fertility regimes for garlic have not been studied well. Some soil testing services use onion standards to recommend fertility for garlic, and some recommend fall N applications, which Stern advises against (except for soybean meal).

Stern discussed Angela O'Callaghan's work with garlic at Cornell. She found that the plant stopped growing on June 22, and she looked at ways to optimize N use. Sidedressing with Chilean nitrate at 45 pounds of N per acre gave the highest yield, and using a Planet Junior was the easiest way to sidedress. If you're going to sidedress, do it as soon as the plant comes out of the ground, said Stern. He believes N applied after May 1 is a waste of money; plants don't take up N after that. He thinks the 75 pounds of N that Cornell recommends is too much, and about 50 pounds of sidedressed N, right next to the plant, is actually needed. Split applications made little difference in O'Callaghan's research.

On mulched plots, N might be applied as a liquid through a drip line under mulch, said Stern. Foliar feeding doesn't work, as alliums have a waxy cuticle – except for the liquid that runs down the leaf cuticle and into root zone.

After June 21, garlic plants start to senesce, and elements in the leaves are translocated to bulbs in the ground. Potassium (K) is essential for this translocation. Materials that supply K include potassium sulfate (K2SO4), greensand, wood ashes, pig manure and Sul-Po-Mag. Stern, working with Amish farmers, is seeing "an incredible response" in garlic to applications of composted manure.

If irrigating, apply 1 inch of water per week.

Stern showed a photo of a Ferguson Ford three-point-hitch cultivator with a 55-gallon drum on it, used to apply liquefied chicken manure, Neptune's Harvest or Schaffer's fish fertilizer, chiseled in the root zone.

Pests

Fusarium

Don't mess around with *Fusarium* bulb rot and *Fusarium* basal rot, said Stern. Be aware of them, walk your fields, contact local experts, and send samples to a pathology lab.

Fusarium can blow in with the wind and is the disease he sees most. *The Compendium of Onion and Garlic Diseases,* 2nd edition, by Howard F. Schwartz, says that *Fusarium* may or may not be expressed. "You may have it and not see it," said Stern. It may appear as brown lesions on the white clove.

To control this disease, start with clean seed (although you won't know if it's clean); create a great growing environment; and cull and destroy suspicious plants during the season. When a garlic plant emerges, Stern explained, it is consuming the energy of the clove. When the second or third leaf appears, the clove sends out feeder roots – which *Fusarium* destroys. "Walk your fields once a week. If anything doesn't look up to par, have it for supper," said Stern.

Cornell University found that surface sterilization with 10 percent bleach will not control *Fusarium.* (Note that rules about using sodium hypochlorite in organic production are changing, and certifiers are interpreting those changes.) Many organic growers now use 33 percent pure hydrogen peroxide (such as Oxidate – which has additional ingredients as well), which is expensive for individuals, but $95 for 15 gallons to suppliers, so Stern encouraged group purchasing. Cutting the concentration to 3 to 10 percent (wearing gloves – the material is "hot," said Stern) gives effective surface sterilization. During planting, have two 5-gallon buckets, one with holes in the sides and bottom. Put cloves ready for planting in this bucket. This bucket must fit into the second bucket, which is half full of 3 to 10 percent hydrogen peroxide. Soak the cloves for 10 to 30 minutes, lift the inner bucket, wedge it at an angle into the top of the outer bucket so that the peroxide runs back into the outer bucket. Plant that garlic while the next batch of cloves is soaking.

Another type of *Fusarium* invades cloves but may also leave spores on the surface of the clove, so cleaning beforehand might help with this problem, too.

People in old Italian communities, said Stern, would put cloves in the sterilizing liquid, pull them out and put wood ashes on them, which provided potash and dried the cloves.

Garlic Bloat Nematode

Until recently, the garlic bloat nematode was last seen in New York state in 1966. When growers there switched to planting onions from seeds rather than sets, this nematode was no longer a problem.

However, Canadian growers found that they had bloat nematode five years ago, and now three-fourths of the garlic fields in Canada are infected. "Then they sent it to us," said Stern. "They made cheap seed available." Canadian growers, Extension in Canada, the province of Ontario did nothing about it, said Stern.

To control this pest, start with clean seed and have it tested. Create a great growing environment for garlic. Cull and destroy suspicious plants during the season – e.g., plants where only half the basal plate may have roots. Surface sterilization will not control nematodes, which run up and down the leaves as well as infecting cloves.

Often the garlic bulb becomes bloated, then wet and gooey. Unlike *Fusarium*-infected bulbs, which are dry, nematode-infected bulbs are wet, because nematodes destroy the internal systems of the plant, and then secondary pathogens attack and destroy the plants. One grower said the first symptoms in her field looked like drought stress – a general yellowing of plants.

These nematodes are extremely sensitive to cyanide and hence to biofumigation using plants that produce cyanide: 'Trudan 8' sorghum-Sudan grass and three mustards – 'Caliente', 'Pacific Gold' and 'Kodiak'. Let the mustards flower, said Stern; that is when the chemical concentration peaks. Then mow and disc the area to decimate the plants and incorporate them into the soil. Finally, seal the soil with a cultipacker. The decaying plants release cyanide, which will probably kill some beneficial soil organisms, too, but "will definitely kill the nematode," said Stern. Sideman noted that mustard meals don't work as well, because these plants release most of their cyanide-like materials during the initial breakdown of green tissues.

Botrytis

Botrytis is a fungal disease that blows in on wind, and then the spores land and grow down the neck of garlic. Infected garlic doesn't dry down or behave as it should, that is, constricting at the neck at harvest. To save your seed stock, Stern advised breaking open bulbs that aren't too infected, putting them in the sun in a greenhouse to dry, then dipping them in hydrogen peroxide to kill this surface pest. Bulbs with advanced symptoms can't be saved.

Wireworms are a secondary problem, impacting garlic after some initial injury.

Leek Moth

The night-flying leek moth came from The Netherlands to Quebec, then Ontario and then to New York state. The slender, yellow-green larvae are hard to see at the first instar stage, but they're about 1 inch long in the final stage. Each body segment has eight tiny, dark spots. The insect spends 11 to 23 days as a larva, depending on temperature. It eats leaf tissue and has great potential to be problematic but can be controlled with row covers. Look for "window-paneing" – mining of chlorophyll from the leaf.

Aster Yellows

When leafhoppers blow into an area, they can spread aster yellows, which can cause garlic to die down early and destroy the crop. While unusual, this did happen last year in the upper Midwest after the warm spring.

Other viruses may infect but not kill garlic but cause irregular growth, such as perfectly green but corkscrewed leaves. Rogue these plants, said Stern. "Once you've got virus, you've lost your seed stock."

On grower in Connecticut lost his garlic to a leafhopper-spread virus after his neighbor mowed his alfalfa, and the leafhoppers moved onto the garlic.

Penicillium Blue Mold

Storing garlic is very difficult, said Stern, noting that softneck does not store better than hardneck. Take garlic to 32 F and 65 percent relative humidity right after it's cleaned and dried. Cellular death doesn't occur until 21 F, but long before that, *Penicillium* mold – bread mold – is very common.

White Rot

Stern has feared this disease for years but hasn't had it in his crop.

Bulb Mites

Most organic farmers rotate garlic with grains, but limiting grain rotations can help curb bulb mites and wheat curl mites. These small mites chew on cloves, causing some decomposition. Growers may not see them at harvest but hear about them from customers later, after mites have been chewing and proliferating.

To destroy any diseased or infested plants, Stern recommends burning them or putting them in a tightly sealed plastic bag and taking them to a landfill.

Efficiency

With cracking, planting, weeding, harvesting and preparing the crop for market, growers touch garlic 25 to 30 times in a growing year; they must work with this labor-intensive crop efficiently, said Stern. No machinery is available to crack garlic (separate cloves for planting), so this must be done by hand. Stern said the Association for Retarded Citizens is always looking for this kind of work, and he likes the high school wrestling team's help when he harvests garlic. This is not a "skilled" job and requires hard work and teamwork.

Increasing a crop from 1/2 to 1 acre means growers will be doing each of the 25 operations at twice the scale. "Grow slowly, appropriately, as you and your market can manage," Stern advised. And try not to plant garlic unsold, because you'll have invested a lot of work, money and time.

Because he's planting in the fall on bare ground and he doesn't like to leave soil exposed to wind and water erosion, Stern sows oats at the end of August, and in October he mows, beats the oats with discs, makes furrows, plants and covers the garlic – and with the first rain, the field is green, from oats. "The only thing that kills oats is winter," said Stern. "Oats are cheap and they winterkill. Beat them up any way you want; they'll grow."

Planting Details

Stern suggests placing the tip of the clove 1-1/2 inches below the soil surface, depending on the soil type, mulch type and environment. Use a grid spacing of 6 x 6 or 8 x 8 inches; closer spacing sacrifices quality. For row crop spacing, plant garlic 4 inches or more apart within rows, with 18 inches or more between rows. Double row planting involves two rows in a 6- x 6-inch grid, with 18 inches or more between the double rows.

"If you have the land, try to spread it out a bit," said Stern. "Or experiment."

Stern has three "rules of thirds." One is that if topset garlic is planted upside-down, yield will be reduced by one-third, because the plant has to put energy into enabling the scape to grow 180 degrees until it's growing upward.

Stern will hill radically in the fall, "say 6 inches of aerated dirt on top of the furrow where garlic is 2 inches below. The air in the soil becomes your protection." (This assumes you won't be applying an organic mulch.) The first cultivation the following spring flattens the mound.

Vernalization (a cold period) is important, so don't mulch right after planting. Stern suggests planting the second week of October, letting the ground get cold, and then mulching six weeks after planting. By then the roots can grow 16 inches deep but top growth won't have emerged – which is good, to prevent deer and moose from eating the tops.

Canadian (non-organic) growers plant on bare ground and then grow wheat on top of garlic all winter, killing the wheat with an herbicide in spring.

Planting Material

Stern mentioned a Vermont seed company that sells "heirloom garlic."

"All our garlic is heirloom," he said. There are 10 classes of garlic in the world.

Botanist Gayle Volk analyzed the DNA of the USDA garlic collection in Pullman, Washington, which has 450 accessions, as well as collections from Texas, New York, Washington and Colorado. She found 10 distinct types: Silverskin, Artichoke, Porcelain, Marble Purple Stripes, Purple Stripes, Rocambole, Asiatic, Glazed Purple Stripes, Turban and Creole. Porcelain and Rocambole are the two popular ones that we grow in the East and that do well for us. All porcelains are identical, said Stern, because they "never had sex or gene mutation."

Allium sativum subspecies *Sativum* includes the softneck garlics, with two types – Artichoke and Silverskin. *A. sativum* subspecies *Ophioscorodon* includes the hardneck garlics, with the other eight types listed above. (*Ophio* is Latin for snake and refers to the scape.)

When cultivars from each of the 10 types were sent to 11 Canadian and U.S. farms to grow out, most traits were stable. Higher soil K levels produced bulbs with a wider circumference and greater fresh weight. Soil S and manganese (Mn) levels were correlated with bulb S and Mn content. Bulb wrapper color and intensity depended on location and cultivar: 'Chesnok Red', 'Purple Glazer', 'Red Janice' and 'Siberian' were more likely to have moderate or dark violet stripes, streaks or splotches, particularly when grown in northern Colorado, Minnesota, Nevada, New York, Ontario, Pennsylvania or Washington locations. (*HortScience,* Aug. 2009) This was part of the SARE grant with the Garlic Seed Foundation and USDA.

Creoles and turbans are listed as two types, but their genetics suggest that they may not be true garlics, said Stern.

'Ajo Rojo' is a Creole with beautiful purple striping when grown in high-iron soil. "It flies off the shelf." 'Purple Stripe' also has significant striping.

Among porcelains, these were all the same variety: 'Romanian Red', 'German White', 'Leah 99', 'GA Fire', 'German Porcelain', 'Music', 'GA Crystal', 'Northern White', 'German Hardy' and 'Polish Hardneck.'

Stern said that normal yield is about 1 pound of cloves planted to produce 5 or 6 pounds of bulbs.

Phil Simon, who bred 'Sugar Snax' carrot, is also a garlic expert. He brought fertile garlic from the Ural Mountains to the United States to produce seed. (See "Growing Garlic from True Seed," by Ted Jordan Meredith and Avram Drucker, at http://garlicseed.blogspot.com/p/growing-garlic-from-true-seed.html.)

"We thought we could breed away *Fusarium,* breed in colors," said Stern. "It can be done but not in our lifetime. U.S. garlic production is way down, and USDA won't support the industry as long as China is the top producer."

Selling the Oink

Scapes can also be sold. Stern said he used to leave scapes in fields until Korean grocers in New York City asked him, "Where are the scapes?" Scapes have the same beneficial chemistry as bulbs and leaves, he added.

His second rule of thirds is that if you do not remove scapes, yield will be reduced by one-third, because energy the plant puts into the scape does not go into the bulb. Stern recommends cutting scapes; he thinks pulling (to snap them off) puts too much strain on the root system. The timing depends on the year. He cuts sooner in a poor year than in a year with lots of warmth and sun, and cuts when the scapes are the diameter of a pencil. He doesn't really cut but snaps the scape over a knife blade at the bottom of the scape, where the leaves fan out. Do this between 11 a.m. and 3 p.m. to minimize the chance for pathogens to enter the plant. He gets about $1.75 per pound for scapes from a processor. Scapes grow 3/4 inch per day, said Stern.

Rinse cut scapes weekly, keep them in black poly in the refrigerator, and they will last a couple of months. They make great pesto, he added.

Grower Amy LeBlanc said she cuts scapes while they're still curled, before they straighten.

The Garlic Business Model

When Stern started growing garlic, he'd buy 2 or 3 pounds to plant but not sell, in order to build up his seed stock. Everyone grew slowly then, he said.

Then Canadians came in with big production and jobbers. A jobber is a buyer who hires 10 or so farms to grow garlic, and then sells the variable lots as his own crop.

So, said Stern, someone could buy Canadian garlic for $5 for seed and sell theirs in New York City for $15 per pound – but "as a farmer, any time you give up any part of your operation, you've lost it, because now you're dependent. Entire farms went out of production when the Canadian nematode garlic was planted. Three-fourths of all Canadian garlic fields have nematodes."

He said we need to go back to saving our own seed and selling our own crop.

"I don't recommend anyone bringing anything in from Colorado, Washington, Kentucky, New York, etc. – they all brought it in from Canada," said Stern. New York and Maine, on the other hand, are considering a clean seed program.

Harvest

After June 21 you can stop cultivating. Stern said if growers pull one garlic bulb every week between June 22 and harvest, they will see the bulb double in size each week for four weeks. If garlic is left in the ground longer, it will eventually grow out of its skin, and the bulb will bust open.

"Harvest garlic when you start to see a gap right around the stalk," said Stern; "the second or third week in July. Most of us are digging on the early side to ease cleaning. If you have good, intact leaves, it's much easier to clean by pulling back the outside leaf." (Softneck is normally dug the first or second week of July; but the only way to tell if it's ready it to dig one, cut it in half and put in spaghetti sauce, Stern said.)

Nothing above ground – e.g., one-third of the leaves turning brown – will tell you when to harvest, said Stern, as drought, disease and other factors (cultivation damage) can affect above-ground growth.

If you have been irrigating, stop two weeks before harvest.

Garlic can be dug with a fork, undercutter, potato digger, root digger, middle buster, moldboard plow or other equipment. If the crop was mulched, harvest methods are limited, because mulching material gets caught on the edges of bed lifters, and the resistance makes the bed lifter climb and cut the garlic in half. Some people do rake away the mulch in order to use a bed lifter, but that adds to the labor in growing garlic.

If you use a potato digger, Stern recommended sewing burlap to the chain so that the garlic doesn't fall through.

A mycologist from Rochester tested root zones of every vegetable crop grown at Rose Valley. The one with the highest mycorrhizal counts was garlic. Stern grows fall broccoli after garlic, because broccoli doesn't support mycorrhizae. Dave Fuller of UMaine Cooperative Extension said broccoli raab, which matures in 40 days, is also great after garlic.

Grading and Postharvest Handling

Stern strongly recommends setting up simple plywood tables in the field. "There's no other time you're going to lift garlic and have chance to look at it." After a row is lifted, put the garlic in bushel baskets, put it on the table and grade it. If roots are brown, weak and not vigorous, cull that bulb. Cull anything that is diseased, damaged or irregular. Save any large, beautiful bulbs for seed stock for the following year. "Everything in the middle – sell." All garlic for seed stock at Rose Valley Farm is hung from barn rafters.

Garlic can be washed so that it's clean for market, as long as it's kept in the sun on racks in high tunnels. The internal temperature of the garlic must be kept below 121 F to prevent the physiological process called waxy breakdown, which causes cloves to turn from white to yellow. Garlic kept at 120 or below will be fine. This (120) is also the temperature to kill bloat nematodes.

Crystal Stewart is looking at six post-harvest treatments and combinations of treatments:

- Trimming roots flush with the basal plate while the garlic was still moist
- Trimming tops to 6 inches long with a sickle-bar mower in the field
- Washing with a garden hose and nozzle (not a power washer)
- Curing in a high tunnel under shade cloth and with ventilation fans
- Curing in an open-air structure without supplemental heat
- Leaving roots and tops un-cut during curing

Results from the first year showed that garlic in high tunnels dried an average of three days faster than in open-air structures, and no tunnel-dried garlic showed damage from that treatment. Also, garlic dried in high tunnels had tighter, less discolored wrappers at one site.

Trimming tops in the field enabled a speedier harvest and reduced space taken up and moisture in the drying area, but bulbs with cut tops weighed slightly less – enough to make a difference of $1,600 over 10,000 bulbs sold at $8 per pound. However, losing 20 percent of that crop to Botrytis due to poor storage would cause greater losses.

Washed bulbs looked very good at first but became more discolored than unwashed garlic during drying and curing – and had slightly more disease. After hosing it needs to be dried well; Stern said they would look at washing again next year.

This study will continue for another year.

Stern showed a rough design for a tulip-garlic bulb dryer: Garlic is put in bushel crates on a pallet, and the sides of the setup are wrapped in plastic. A fan blows air in through the bottom pallet, and another fan blows air across the top of the crates, drying the crop in two days. This could be a portable set-up, moved from farm to farm. In humid, wet summers, a little heat could be added to help drying.

For short-term storage, Stern recommends hanging garlic in barns. Long-term storage is very hard, said Stern. Garlic needs to cure and then be kept at a constant temperature (32 F) and constant relative humidity (65 percent).

Small, unmarketable bulbs can be planted 8 inches apart in a furrow in the fall. In spring, each clove will send up green shoots. Once they're 8 to 10 inches above the ground, cut them off with a sharp knife and sell two or three bulbs' worth of garlic greens in late April for about $1.25. They make a

great addition to sauces. The greens grow back and can be cut again two weeks later and a third time after that. Stern calls this "selling the oink." By the fourth harvest, the greens are too woody to use.

Likewise, small cloves can be put in a trench, about 1 inch apart, without worrying about the orientation, spacing or fertilizing, to grow garlic scallions. These are easy to clean with a high pressure stream of water.

Stern's third rule of thirds comes from the Canadians, who looked at mechanical removal of scapes. When they tried, they also removed leaves. Loss of one leaf reduced yields 17 percent; of two leaves, 33 percent.

Amy's Adventures with White Rot

Amy LeBlanc of Whitehill Farm in E. Wilton, near Farmington, grows almost entirely in 75 4- x 10-foot raised beds, due to the slope of her land, and in assorted small hoophouses. For the last 10 or so years, 20 of those beds have been devoted to growing a total of about 2,500 bulbs of garlic per year. LeBlanc lets some scapes mature – for fresh eating "as blood pressure pills" and for pickling. She also grows garlic greens in the winter. She had been growing garlic for seed, but experienced a hiatus starting in 2007 due to disease.

Allium white rot showed up in her planting in 2004, after she bought out-of-state planting stock. In 2007 it showed up again. She diverted most of that 2007 crop to culinary use, burned the rest, and abandoned that area as a garden spot; now it's a small orchard.

In 2010 Allium white rot showed up again, in beds downhill from her original bed – possibly moved by some combination of rain, slope, chickens and tools.

LeBlanc got a SARE grant to try to reduce the pathogen through biostimulation – digging ground plant material or garlic juice into the soil to stimulate white rot sclerotia to germinate, and then planting anything but alliums in that plot that year. She used a backpack sprayer to apply garlic juice, starting with about 1 part juice to 1,000 parts water, but garlic specialist Dr. Fred Crowe, her mentor from Oregon State University, said to use more juice. "If you can smell the garlic in the water, it will be effective," said LeBlanc.

Lacking alliums to live on after germination, the fungus would theoretically be limited by the treatment. LeBlanc now has a second SARE grant to complete her 4-year experiment.

First-year results showed that one of six beds she knew were infected had only a few more sclerotia; populations dropped dramatically in other beds treated with biostimulants. In all probability some of the difference is due to variables in sampling, but the overall result is improvement. LeBlanc is planting clusters of spring and storage onions, as a final trial in the spring of 2015, to see if any Allium white rot remains in any of the six beds.

LeBlanc has been building new beds in a new area to replace the original 20 for garlic.

"Sanitation is key" to control, said LeBlanc. "Allium white rot can be moved by tools, feet, hands, chickens, equipment, mowers, anything that touches the soil. Now I have a dedicated mower for mowing between these beds, so I can't move [white rot] with a mower." She washes tools, hands and feet in water and Dawn dishwashing liquid, then dumps the wash water in a 3-foot-deep hole. She'll dig a new dump hole this spring.

For general garden sanitation, she washes stakes, towers and trellises. "You can't just power wash, as that will spread sclerotia," said LeBlanc. "A toilet brush is a great tool." Again, wastewater goes into a dump hole.

Since her old compost and compost bins could harbor white rot, she hired someone to bury that compost under what is now a new office building.

The chemicals that stimulate sclerotia are present in all parts of the onion family plants, said LeBlanc. She hopes that using garlic juice in water will be as effective as plant material – and better for larger areas. To make ground green plant material, she tops garlic just before harvesting, chops the green tops into Cuisinart-friendly pieces, grinds them in a Cuisinart, and then freezes the resulting mess for use the following spring. To make garlic juice, she has purchased organic garlic, cleaned it thoroughly and then run it through a juicer. The juice can be frozen for later use.

To prevent spreading existing disease on her farm, LeBlanc diverted any potentially affected seed to value-added products. She is just starting to sell garlic seed again, from clean beds.

To continue producing alliums when white rot is present, Eric Sideman suggested planting scallions, which mature before they develop white rot. He knows of five Maine farms that have white rot now and either stopped growing alliums or grow them in other fields.

Peacemeal Farm – New Garlic Ground and Clean Stock

Mark Guzzi of Peacemeal Farm said he plants about 650 pounds – about 2/3 acre – of garlic. He bought 30 pounds of seed at the 1998 Common Ground Country Fair, planted it, grew a crop and sold about half of it. He planted the other half, repeating this process until he was eventually planting 200 to 300 pounds.

"I saw a lot of potential for garlic back then. I thought the biggest problem we'd have was where to put all the money we were going to make, selling garlic for $5 per pound, and wholesaling to Jim Cook for $3 per pound. We got to planting about 750 pounds. Then I got a lesson taught to me."

Guzzi thinks that timing of garlic crops differs a little between New York and Maine. He usually plants garlic in the third week of October, with three rows, 15 inches between rows, and 7 inches between plants within rows. He mulches with straw, rolling out round bales and then distributing it evenly. He uses 20 5-foot-diameter bales to cover the 2/3 acre.

He moves mulch from beds into paths first thing in spring so that the ground can warm. "If anything can be detrimental to garlic, it is to come up too soon in the spring in Maine. It comes up, then we get single digits or below-zero nights, which damage the tops. But the trend has been for it to come up earlier and earlier. At least with round bales, it struggles to push itself up through the mulch – one reason we pull it off. The other reason is to warm

the soil to get garlic growing. One year we put all the mulch back on when the temperature was going down. We left a little unmulched. The

temperature got down to 9 degrees, and the garlic was unharmed in the unmulched plots."

After removing mulch, he weeds a couple of times with a scuffle hoe, sidedresses if he's going to sidedress, then puts the mulch back on for the summer. He harvests only the portion of scapes that he can sell. He starts harvesting scapes when they first pop up. "At that point they snap off cleanly and are tender and edible. When you get to the point where you can't snap the scape off, it's not that great for eating any more."

In beds where scapes were removed, the garlic bulbs get bigger quicker, but in the end, Guzzi said, it's almost impossible to see a difference in the overall size of the garlic at harvest. "Maybe our garlic isn't meeting its full potential."

His garlic seems to be finished growing by the end of July or beginning of August – a point he notes by counting dying leaves. "There seems to be a correlation between dieback of garlic and the thickness of the skin that surrounds the garlic. When we're first pulling the garlic out of the ground, there's a lot of moisture in there, and a thick skin around cloves. Toward end of its growing, that skin becomes much thinner. By the end of July or early August, we pull it all."

He used to wait until 5 p.m., when his day labor had gone home, to start pulling garlic, putting it in boxes, and throwing the boxes in a pickup around 9 p.m. He would back up to the barn, put the boxes in the barn, and stay up until 1 a.m. hanging garlic. "Then I realized maybe I should have the day laborers help pull the garlic! That really improved the situation."

He also realized that hanging garlic in the barn right out of the field was probably the most difficult way to dry it. "The year we planted 750 pounds of garlic and brought it into the barn, we were at maximum capacity for our area to dry garlic; it was a very wet August; we ended up throwing away half our garlic. We easily threw away $20,000 worth into the compost pile."

He sent samples for testing and found they had Botrytis, so now he pulls all his garlic within a few days, puts it in black bulb crates (from Fedco or other sources) and brings it into a greenhouse with the garlic standing upright, the bulbs at bottom of the crate and the leaves hanging over the crate. He sets the crates on greenhouse benches that have 12-inch air tubes running underneath, with holes all around tubes. Fans blow air through these tubes, and box fans blow air above and below the garlic. Exhaust fans suck air out of greenhouse. "I do this until the green moisture is out of the tops of the plants. Then we tie all of our garlic into bundles and hang it in the barn to finish drying. Basically there is almost no moisture left in leaves when we're hanging it."

He had heard of people cooking their garlic when drying it in a greenhouse, but he thought that if the bulbs were shaded by the tops of the plants, the crop would be OK.

He grows 'Russian Red', 'German Red' and 'Rocambole'. When he breaks it up to plant, sometimes the peels come off, sometimes they don't. "I have no idea what's under the peel. To make sure I'm not planting diseased garlic, I thought I had to start peeling it all." He's been doing that since 2008, and is finding much less disease every year as a result of better culling. "The first year we were discarding buckets and buckets of garlic. We split open the garlic, and if there's any sign of disease, we chuck it aside. The rest, we peel. Now we get not even half a 5-gallon bucket of culls. My long-range thinking is to do this with a much smaller subset of garlic that we raise specifically for our seed."

Guzzi didn't think his crop had nematodes, as he'd been saving his own seed since 1998. But someone who bought seed from Peacemeal and submitted it to Steve Johnson of UMaine Cooperative Extension for testing told Guzzi it tested positive for the nematode. Guzzi then "struggled to find sick-looking garlic," finally found some, had it tested, and was told it had nematodes. "So we couldn't sell that for seed. Typically we sold 30-plus bushels at Common Ground for consumption, with a sign saying it was not for planting. That really cuts down on sales at Common Ground."

So next, when saving seed, he put anything that was not sound in a bag. He found only four or five bad cloves in his 'Phillips' and 'Russian Red' but about 20 in his 'German Red'. He sent these to Johnson, separated by variety, and learned that only the 'German Red' had nematodes.

"Because of *Botrytis* and possibly other diseases, we had been thinking we needed to expand onto new ground that hadn't grown vegetables or garlic in a long time. We're taking old fields in our neighborhood with the idea of moving garlic off the farm – luckily, because now we find we have garlic bulb nematode. We're still hoping to save our own seedstock, to get some clean subset, and at least start raising all my own seed off the farm, if not all the production."

Guzzi wonders if *Botrytis* came in on purchased compost, because when he harvested one field where that compost had been applied, sclerotia were pervasive. Now he spreads dairy manure before planting garlic.

Kiwihill Farm: Storage and Planting Tips

Tom Vigue of Kiwihill Farm in Sidney, Maine, grows garlic in a 3-foot-wide bed with 5- x 8-inch spacing. When he tried a 6- x 8-inch spacing, the bulbs were slightly bigger but total yield in pounds was lower. Spacing closer than 5 x 8 inches produced smaller bulbs and a smaller yield.

Vigue applies leaf mold made on his farm at a rate of 20 cubic feet per 100 square feet of garlic bed, as well as one or two 5-gallon buckets of on-farm-made vermicompost broadcast over 100 square feet. The vermicompost "has quite a large effect on the crop," he said.

He mulches with about 8 to 10 inches of hay, which compacts to 2 to 3 inches by spring. The crop doesn't have much trouble getting through the hay, nor through ground leaves when he's used them; but it did seem to have trouble getting through whole leaves (maybe because of the oak leaves).

His tight crop spacing makes removing and reapplying mulch difficult; and his very light, sandy soil is prone to drying and would need irrigation if he removed mulch, so he leaves it on. In cold wet springs, that may lower N availability. He applies soy meal in the fall and believes it usually releases N around the right time for garlic emergence.

Vigue has found that scape removal produces larger bulbs and earlier sizing up, but he wonders about its effect on long-term storage. "If you're trying to store garlic to eat or to sell into [late March] or later, scape removal reduces long-term storability. I believe there is a hormonal relationship between what's going on in the scape and what's going on in the bulb. When you remove the scape as soon as it appears, the bulb is on its own to become the next generation. From the bulb's perspective, it's going to stay in the ground and propagate there. If you leave the scape on, the scape tells the bulb, 'It's time to get tough.' When you can no longer snap [the scape] with your fingers, the bulb is getting that message to get tough." Vigue has seen that waiting to remove scapes can increase storage life by up to two or three months.

With the 'Bogatyr Marble Purple Striped' variety, "if I snap the scapes off as soon as they appear, it stores until about now [late March]; ones I left scapes on until two weeks before harvest are still much harder and will keep until the next crop is ready to harvest in July. So I leave scapes on about 20 percent of the crop; the rest is used for seeding and early eating."

Vigue has had thrips in his onions but not in his garlic growing alongside the onions. [See Vigue's Onion Thrips article in the June-August 2013 issue of *The MOF&G*.]

Vigue has also looked at the effects of temperature on planting stock. A friend stored her planting stock indoors, where it was warm, and it produced bulbs that were larger but had more cloves and decreased storability. Vigue had stored some garlic outdoors in an open woodshed and didn't plant it until November, so it was subjected to more cold before planting – and it produced bulbs with just two or three cloves each. Exposing seed stock to 40 to 50 F for a couple of weeks can solve both problems, he said. "So keep it in a shed, then bring it indoors for a couple of weeks, then plant it." (See So When Is the Right Time to Plant Garlic? by Tom Vigue, *The MOF&G,* Sept.-Nov. 2012)

Discussion

Asked about the ideal storage temperature for garlic, Guzzi said 32 F.

Asked about cloves that break in half, Vigue said those are double cloves, which happens in some cultivars more frequently than in others. "If you plant double cloves, you get double plants growing adjacent to each other. You won't increase the likelihood of double cloves in a future crop. Breaking them apart often compromises their ability to survive."

Stern said he sees double cloves as a mutation, not a genetic inheritance, and as occurring mostly in 'Rocambole' and not in 'Porcelain' or 'Purple Stripes'. He removes them because they tend to produce bulbs that are too small.

LaBlanc uses them for dyeing, because they're big and easy to cut.

LeBlanc uses them for drying, because they're big and easy to cut.

Regarding soil fertility, Guzzi said he spreads all his fertilizer for garlic in the fall – including Sul-Po-Mag or whatever a soil test calls for, then he spreads dairy manure, and then he plants. He does not sidedress in the spring.

To trim and clean garlic, LeBlanc said she dries garlic, trims tops so that about 3/4-inch of stem remains, trims roots and removes any remaining soil with gloved hands.

Guzzi said he trims "as we go, for selling," using green scrubby pads to brush off dirt and loose skin, obeying the 5-second rule: "You get 5 seconds with it."

Sideman warned not to cut the stem too close to the clove during harvest, because that can open the clove to infection.

Stern said he washes and then hangs bulbs in a greenhouse to enable the skin to begin to shrivel and loosen; then it's easy to grab the outside leaf and strip it down to clean the bulb. He also said many farmers are buying large dairy fans to dry garlic. "Consider hanging garlic in a small hoophouse or other small structure that can be covered with old greenhouse plastic. Put a large fan at one end and a pull fan at the other end to pull air through the garlic. Normally the crop will dry in 10 days to two weeks and will lose 20 percent of its weight.

Stern added that you can determine the size of the crop in the field from the size of the neck. A thicker neck means a larger bulb.

Asked whether the market is saturated, Vigue said natural food stores are. Others pointed out that the United States is still importing garlic from China. LeBlanc said that hot, sweet, sour pickled garlic is a great farmers' market product. She also said that if someone could store garlic longer, more markets would be available. Another grower said that Chinese garlic is all softneck. "If you want quality stiffneck, you have to get it from a local farm, and "the buyer in Maine is more sophisticated than in other places." Stern noted that softneck garlic doesn't have to be oriented any special way at planting time, so it can be planted mechanically; also, California growers use high pressure air to clean garlic. They run garlic through rollers going in two directions to break it apart for planting. China makes machines to peel garlic, and simple, small-scale machines are available to peel cloves (not bulbs); growers can check YouTube and should be able to duplicate them.

Stern mentioned applying liquid chicken manure as a sidedress. He said a certified-organic chicken farm in New York puts composted manure in 50-pound bags and mixes it in water. This is applied to the field from a hose and a 55-gallon drum on a tractor. LeBlanc said she is going to try making manure tea with Chicken Doo Doo (a commercial organic amendment).

Asked if a lack of mulch will create a problem with frost heaving, Sideman said it depends on how much soil is on top of the garlic. "Hilling with soil is essentially mulching," he said. With a 4-inch planting depth, Sideman said he wouldn't worry about mulching.

Vigue said that planting in time to ensure good root growth in the fall will enable the roots to keep the plant from heaving.

Stern noted an Iowa grower whose mulch blew off during a -25 F day (with the wind chill); the 6-inch-tall tops "burned" to the ground, but the garlic grew back and the crop was OK.

Another grower said that mulch protects against soil erosion; he had some garlic wash away in torrential rains this winter. Vigue said that when he harvests, he leaves the mulch in place to protect against late summer and fall rains.

Regarding varieties, Vigue said there are hundreds of heirlooms. "Although they are genetically, apparently, identical, if you grow them side by side, there are some differences … It's worth paying attention." LeBlanc grows 'Phillips', a Rocambole from Phillips, Maine, that tends not to make twin double cloves. It's shaped like 'Red Russian' but is more pungent, and is purple and brown striped. Vigue added that 'Phillips' stores well into the next growing season, while most Rocamboles reputedly store for only four to six months, which, he said, is more or less true.

"Garlic is pretty adaptable," said Vigue. "There are differences growing the same cultivar in different locations. That adaptability leads to having many heirloom cultivars."

Stern agreed, saying, "The only garlic that has identical DNA are the Porcelains." Others have numerous subspecies that do not have identical DNA. "There are probably 30 or 40 subspecies of Rocambole; nobody knows what to call them. Find something you like, something your market likes, something that grows well in your ground."

Regarding taste tests, Stern said not to put out 10 kinds of raw garlic and expect a reliable evaluation. "Once your tongue touches raw garlic, you're done. To taste garlic, take the raw garlic, take a crusty bread, cut the garlic in half, rub it on the bread and eat the bread. Or make a hummus or pesto without garlic, add various garlic varieties, and try that."

To have garlic tested for nematodes, contact Steve Johnson of UMaine Extension, $20 per sample, or for six and above, $15 each. He will look for other diseases as well. Contact Johnson at stevenj@maine.edu or 207-554-4373 for directions on how to mail soil and/or garlic samples. The Pest Management Office in Orono does not test for nematodes but does test for other pests. Other grower said that Johnson says an entire crop would have to be tested to be sure it's nematode-free. Even with one clove, he can miss the pest if he samples the wrong part of the clove. This grower puts any new garlic he brings onto his farm in a special spot, away from other alliums.

LeBlanc said she will not buy garlic from another farm unless she's seen it growing in that field.

Sideman said some people, including Steve Johnson, are pushing for a garlic certification program in Maine. Growers can push for this, he said. Bruce Hoskins from the UMaine Soil Testing Service said Johnson is working on indexed tissue culture material that could be certified as nematode-free.

Asked if nematodes attack bulbils, Sideman said that's less likely but no one knows yet.

Stern noted that the garlic bloat nematode can live on more than 120 alternate hosts. Sideman said it can survive in the soil but doesn't disperse, unless soil, debris, garlic or water moves it.

– J E