NEVF

New England Vegetable and Fruit Conference

2003 Proceedings

Tuesday, December 16, 2003

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Grapes

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New England Vegetable and & Berry Growers Association

and

Massachusetts Fruit Grower's Association

and

Maine Organic Farmers and Gardeners Association (MOFGA)

Strawberry Production Basics: Matted Row

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The matted row production system for strawberries has been successful and profitable in cold growing regions for many years. Despite some recent adoption of other production systems adapted from warmer climates, the matted row system has remained widely planted in northern regions because of its proven advantages. These include relatively low initial investment costs, adaptation to cold climates, and the ability to maintain the planting for several years. The matted row system remains popular because it exploits the natural growing habit of the strawberry plant in New England, optimizing both its vegetative characteristics and its fruiting potential to produce a profitable crop with a relatively low level of inputs.

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

Selecting A Planting Site

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

Preparing the Soil

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

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

Planting and First Season Care

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

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

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

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

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

The new planting should be irrigated after planting and regularly thereafter to insure optimum growth. One to two inches of water per week is ideal.

Mulching

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

Strawberry plants are good indicators of when mulch should be applied. After a few hard frosts the leaves turn reddish and collapse down around the crowns. This is a sign that the plants are dormant (usually late November). Mulch should be applied anytime after that, but before the ground freezes. Two to five tons of straw per acre is recommended (approximately one ton of straw provides one inch of coverage per acre). Use the higher rates if your fields are exposed and do not get consistent snow cover. The mulch layer should be 3 to 6 inches deep over the plants. Be discriminating about your source of straw. Straw from weedy fields will result in weed infestations in your strawberries.

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

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

Frost Protection

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

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

Renewing the Planting

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

1. Broadleaf Weed Control: If perennial broadleaf weeds (dandelion, daisy, etc.), and/or a high population of emerged annual broadleaf weeds (lambsquarter, pigweed) are present 2,4-D amine

(Formula 40) can be applied for control. 2,4-D is a post-emergent herbicide, which is effective on broadleaf perennial weeds. It will not control grasses, nor does it offer any pre-emergent control. If 2,4-D is not applied all broadleaf perennial weeds should be removed by hand.

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

3. Fertilization: Apply fertilizer according to soil test recommendations. Soil testing kits and information are available from your county Cooperative Extension office. Typically about 40 pounds of actual nitrogen per acre is applied at this time (e.g. 87 lbs. of urea), with another 20 pounds of actual nitrogen applied four to six weeks later. Balanced fertilizers, such as 10-10-10, containing phosphorus and potassium may be used if soil tests indicate a need for these nutrients. Avoid over-fertilization with nitrogen. The resulting excessive growth on plants can lead to problems with winter injury, spider mite infestations and fruit rots, in addition to potential water contamination problems from soil leaching. Tissue nutrient analysis of leaves after renovation can offer more precise guidance to appropriate fertilizer rates for each field. Contact your state Extension specialist for information on tissue analysis. A very light application of nitrogen is often applied the following spring after removal of the mulch. Ten to 15 pounds of actual nitrogen at this time can help to stimulate early plant growth. Heavier applications should be avoided because this could cause excessive vegetative growth and increase the likelihood of fruit rot. Light applications of boron (1 to 2 lbs. per acre) and calcium may also provide some benefit to fruit development in the spring.

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

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

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

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

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

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

Pest Management

Numerous pests can potentially cause problems to strawberry plantings. Consult local University Extension recommendations for the best management techniques for problems in your area. It is important to note that weed infestations are the most common cause of poor production in matted row strawberry plantings. This is due to the fact that the plantings are in place for several years, allowing weed populations to build up, and the relatively small selection of chemical weed control options available.

Good pre-plant weed control is essential for the successful establishment of a profitable strawberry planting. Strawberry growers should develop a planting rotation, which includes the use of cover crops and/or alternate cash crops for which herbicides different from those used on strawberries can be utilized. Crop rotations should allow fields to have at least three years between strawberry plantings. This will prevent the build up of weed species that defy strawberry weed management programs and will also help to renew the soil, so that the next planting of strawberries will be as good as or better than the last.

There are several types of cultivators that will provide good control of weeds between the rows of strawberries. Multi-head rotary tillers; spring-tooth harrows; and basket, finger and rolling cultivators can all be very effective, depending on the soil type, weed species and frequency of use. Weeds emerging within the strawberry rows will not be controlled. However, in combination with good pre-plant weed control and some hand-pulling of weeds within strawberry rows, cultivation can form the basis of an effective weed management program.

Production Basics – Strawberry Plasticulture

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A lack of adequate weed control options for 1st year strawberry beds has stimulated interest in the annual hill system for strawberry production. This system as used in California and Florida is dependent on soil fumigation as a key element while in New England, growers use a combination of crop rotations, black plastic mulch (vs. the clear plastic used in CA and FL), and raised beds to help in management of weeds and soil diseases. In addition, trickle irrigation tape is placed under the black plastic.

There are two basic options for use of this system in New England: plant dormant crowns into black plastic covered raised beds in late spring/early summer or plant live plug plants into similarly prepared beds in late summer/early autumn. It is the fall planting option that has generated the most interest. For the fall plant option, the basic calendar looks like this:

1) Summer soil preparation. Usually, this consists of growing a vegetable crop like sweet corn, summer squash, beans, or some other crop that will be maintained relatively free of weeds and can be turned under by late August. Alternatively, a summer cover of Sudan grass or Japanese millet could be grown for mid-August soil incorporation. During this summer, soil drainage, pH and nutrient deficiency issues need to be addressed.
2) Prepare the beds. Usually a bed shaper/former that forms a 6 inch high, flat topped bed and lays both the trickle tape and black plastic mulch is used. It is critical that the soil be properly moistened before beds are formed. Dry soil covered with plastic mulch is difficult to wet and plant growth will be compromised, perhaps severely, if attention to this important detail is deficient. I typically use 4 foot wide plastic, 1.25 or 1.5 mil and hopefully manufactured with high levels of UV inhibitors (this is especially important when pulling mulch). 5 foot plastic is a bit easier to put down, but removal is more difficult. I space rows 5 feet on center, requiring about 17,000 plants per acre. Be sure the trickle tube is centered on the bed.
3) Late summer/early autumn – plant. Plug plants are set about September 1 in Durham although we have had good response planting as late as September 15. In colder areas of interior northern New England, planting a week or so earlier is desirable. A cautionary note is in order – plug plants sell out quickly so make the decision to plant and order early – you will not be able to get what you want at the last moment.
   Planting is generally done by hand. Many growers use a water wheel or similar device to punch holes. We want to set plants in a double, staggered row with one row down each side of the plastic covered bed. Plants within each of the two rows are set 12 inches apart. Select a punch slightly smaller than the plugs you are setting to insure tight soil contact with plug when it is jammed into the planting hole.

4) Care during September and early October. If runners emerge in substantial numbers, run through the bed once in early October and remove them. An early October application of nitrogen at the rate of 5-7 lb/acre through the drip system can be made if growth is not adequate. In some 10 separate plantings, I have yet to determine that this nitrogen was necessary (because I took care of soil fertility pre-plant). One final touch I suggest – mulch the bare soil aisles with straw to help keep fruit clean in spring. Some fruiting clusters will contact soil.

5) Apply floating row cover in mid-October. Use a floating row cover of medium to heavy weight. It is worth the effort to purchase wide covers fitted to your field. This floating row cover will create a warm, lighted environment that will promote growth and development into December and more importantly in late winter as soon as snow cover is gone. No additional winter protection is needed; however, plants wintered under floating row cover will fruit at least 10 days to 14 days ahead of those covered with organic mulch such as straw. This means growers must be prepared to fight frost earlier and perhaps more often than with plants in the matted row system and must have access to early markets.

6) What about straw mulch? Some growers choose to use organic mulch for winter protection, primarily to delay harvest in the spring to more a "normal" harvest window. The floating row cover is still applied in mid-October. It is removed a few days ahead of mulching with straw in December. While this will delay harvest in the spring, it will also reduce yield potential as the largest impact of floating row cover is the result of light exposure and environmental modification in late winter/early spring.

7) Spring – harvest. Expect large crops of exceptional quality fruit, free of major insect and disease problems.

8) Post harvest – renovate. Rip off runners and mow foliage 2-3 inches above crowns. Plants will re-grow quickly – you will need to remove runners again in late September or early October. Apply floating row cover, again in mid-October. Fruit a second spring but with this harvest delayed a week or two due to the increased plant cover shading the black plastic mulch, reducing its effect on soil warming. Post harvest, plow it down.

The second major option is to plant dormant crowns into black plastic covered, raised beds mid to late June. The same basic system is used. Raised beds, complete with trickle tape are formed and covered with black plastic. Planting again is done in double, staggered rows with plants 12 inches apart within each row. Planting is a bit more labor intensive as dormant crowns are simply more difficult to set in the punched planting holes. I trim roots of dormant crowns to a uniform 4 inches or so in length to facilitate planting. How does the time table flow for this method of planting?

1) Soil preparation is again critical – I like to select a site where a good cover crop or sweet corn or pumpkins were grown the previous summer.

2) You will be planting dormant crowns into black plastic during the hot part of the summer – set up the solid set (overhead) irrigation system for plant cooling, especially the first 3 weeks from planting.

3) While runner development will be less than for plants set in May, there will be some and they should be removed.

4) Cover with floating row cover (early harvest) October 1 or with straw in late November/early December (late harvest).
5) Fruit in spring, then plow planting down.

What About Varieties?

Without a doubt, Chandler has been the most productive variety in our fall plug plantings. Typical yields in Durham, NH are 11,000 lb/A in the first spring after planting and 12,000 lb/A in the second. Other varieties have done well. Cavendish has been almost as productive and Northeaster, Jewell, Seneca and Allstar have produced well, but none of these has yielded as well as Chandler in this system. In addition, Chandler fruits have been flavorful and very uniform in shape and size. Cavendish will produce some extremely large fruits, but its lack of uniform ripening of individual fruits is still an issue. And Allstar color is definitely a weakness in this system. The following table shows yield data collected in 1999-2000 – it is representative of the yield response we see with use of the annual hill system using fall planted plugs. These are 2 year yields.

VARIETY	Lb/A
Avalon	12,279
Northeaster	17634
Chandler	23185
Seneca	13630
Jewell	14126

For early summer plantings using dormant crowns, Cavendish was extremely productive among the many varieties we have looked at, producing over 17,000 Lb/A in the first year and an additional 6,000 plus pounds in year 2 for a total of over 23,000 Lb/A over the life of the planting. Interestingly, fall planted Cavendish plugs in the same trial yielded almost 23,000 Lb/A as well, 11,000 in the 1st year and 12,000 in the 2nd. Seneca in the same trial performed better when planted as a fall plug – almost 18,000 Lb/A vs. 12,000 for dormant crowns planted a full growing season earlier.

Why are yields for these early summer dormant crowns significantly lower in their second harvest when compared to fall planted plug plants? Simply put, the plant develops a complex of many branch crowns but due to the plastic mulch system, has no way for new plant/soil contact needed for new root development to occur. A second interesting piece of information relates to the level of pest injury in unsprayed plots. Tarnished plant bug injury represented the bulk of injury seen. That level was about 15% for fall planted plug plots but exceeded 40% for early summer dormant crown plots. Why? Plant debris was distinctly more dense around these latter plants and offered excellent hiding places. Additionally, the fall planted plug plants began fruiting a full 8 days ahead of the early summer dormant crown plants, offering both early harvest and the potential of being developmentally ahead of the insect pests.

There are several variations to these systems in trial in grower plantings around New England. Several growers are established living mulches in aisles to reduce weed management inputs and provide a clean harvest environment. In colder areas, the system is being used without the use of 6 inch raised beds to reduce risk of cold temperature injury to the plants. But all have the use of black plastic, trickle irrigation, and establishment of the final field plant population at harvest as common characteristics. Given the current and likely future herbicide outlook, this trend is likely to continue. And the use of fall planted plugs offers growers several distinct advantages:

- The field is available for other cash crop production the season before planting; if dormant crowns are used, actual yields per year are much lower due to a "down" grow year
- Pest pressure is reduced, offering organic and reduced pesticide growers a viable production option
- Growers can select a winter protection system, organic mulch or floating row cover, to affect harvest date
- Growers can quickly respond to changes in market demand or poor plant performance in other strawberry plantings
- Labor on most veg/berry farms is more available for fall planting than for late spring/early summer plantings

The use of intensive management systems for strawberry is constantly evolving. More changes are likely, and the best ideas for manipulating strawberry plasticulture for maximum benefit will likely come from you, the grower.

Strawberry Weed Management Update

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Introduction

The 2003-2004 version of the New England Small Fruit Pest Management Guide is available and all small fruit growers should have a copy of this publication. There were many revision made to the strawberry weed management section. The major ones are explained below. In addition, there is a narrative on weed management during the summer months. All other information that will be presented in this talk can be found in the Small Fruit Guide. I expect that some copies will be available for sale at the Conference and copies are available from all 6 New England Extension services.

Major Herbicide Label Change

2,4-D Formulation Change: Amine 4 is the new formulation of 2,4-D amine (salt) available for use in strawberry. Formula 40 will no longer be available. There are many ester and low-volatile ester formulations on the market for other uses of 2,4-D. Be certain to NEVER use ester or low-volatile ester formulation of 2,4-D on vegetable or fruit crops. Both ester and low-volatile ester formulations of 2,4-D can move from the target area after application under warm weather or low humidity conditions. They have the potential to damage crop far from the site of application and their movement is unpredictable.

Gramoxone (paraquat) Formulation Change: Gramoxone Max 3S has replaced Gramoxone Extra for all uses. Label rates are generally lower than the old formulation since Gramoxone Max contains more active ingredient per gallon. As with the old formulation, the use of a non-ionic surfactant is still required. With Gramoxone, always remember that better weed coverage through the use of more water per acre will result in better weed kill.

Dacthal 75WP (DCPA): Dacthal herbicide was back on the market during 2002 and 2003 with all the previous labeling. The price of this product has more than doubled, however, rising to approximately $14 per pound. One critical uses of this product is on newly transplanted strawberry. The revised Sinbar label, described below, has somewhat lessened the need for Dacthal for broadleaf weed control but does not replace Dacthal for control of annual grasses. Because of the expense of this product, it will not be commonly used.

Sinbar 80 WP (terbacil): The supplemental label for strawberries has been revised to allow use during the transplant year as well as on soils with between 0.5% and 2%

organic matter. During the planting year, Sinbar may be applied at 2 to 3 ounces per acre after transplanting but before new runners start to root. If strawberry plants have developed any new foliage prior to application, irrigation or rainfall (0.5 to 1 inch) is required to wash the Sinbar off the strawberry plants. In late summer or early fall, a second application may be applied at 2 to 6 ounces per acre to control winter annual weeds. This application must also be followed by 0.5 to 1 inch of irrigation or rainfall to wash the Snbar off the plants. A third application of 2 to 4 ounces per acre can be applied, as usual, after the strawberry plants are dormant and just prior to mulching.

For soils with at least 2% organic matter, there is no maximum amount per application; however, no more than 8 ounces of Sinbar can be applied per year. For soils with between 1 and 2% organic matter, a maximum of 4 ounces of Sinbar can be applied at any one time with an annual maximum of 8 ounces per acre. For soils with between 0.5 and 1% organic matter, a maximum of 3 ounces of Sinbar can be applied at any one time with an annual maximum of 6 ounces per acre.

Following the establishment year, applications can only be made just after renovation and just prior to mulching. Applications are now allowed, however, on soils with between 0.5% and 2% organic matter using the same guidelines for rates as above. As always, be careful with Sinbar in strawberries, especially with potential overlap of sprayer passes which will double the rate and increase the potential for injury in some varieties. Please consult the new supplemental label for addition information, rates, precautions, etc.

Strawberry Renovation Weed Management Advice

Following are weed management suggestions for strawberry plantings at renovation. Emerged broadleaf weeds can be controlled with 2,4-D (Amine 4) at 2 to 3 pts./acre applied immediately after the last harvest. Amine 4 is the ONLY 2,4-D formulation labeled for use in strawberries. Be extremely careful to avoid drift when applying 2,4-D. If this application is delayed, some damage to strawberries is also possible. Read and understand the label completely before applying Formula 40. If grasses are present at this time, sethoxydim (Poast) will control both annual and some perennial grasses. However, do not tank mix Poast and 2,4-D. Check the product label for rates and especially for precautions. Three to five days after the 2,4-D application, strawberry plants should be mowed.

Preemergence weed control should begin immediately after the plants are mowed and the soil is tilled to narrow the crop row. The most common practice at this time is to apply half the annual rate of terbacil (Sinbar at 4 oz/acre). It is essential that the strawberry plants are mowed, even if 2,4-D was not applied, to avoid injury from Sinbar. If regrowth of the strawberry plants has started, significant damage may result. Some varieties are more sensitive to Sinbar than others. If unsure, make a test application to a small area before treating the entire planting. Sinbar should not be used on soils with less than 0.5% organic matter or on reportedly sensitive varieties such as Guardian, Darrow, Tribute, Tristar and possibly Honeoye. Injury is usually the result of too high a rate or overlapping of the spray pattern. If Sinbar is not used, napropamide (Devrinol at 4 lb/acre) or DCPA (Dacthal at 8-12 lb/acre) should be applied at this time. Dacthal is preferred over Devrinol if the planting is weak. If Sinbar is used, napropamide (Devrinol at 4 lb/acre) should be applied 4 to 6 weeks later. This later application of Devrinol will control most winter annual weeds that begin to germinate in late August or early September. Devrinol should be applied prior to rainfall or it must be irrigated into the soil. During the summer, Poast can be used to control emerged grasses. Cultivation is also common during the summer months. Cultivations should be shallow and timely (weeds should be small) to avoid root damage to the strawberry planting. The growth of strawberry daughter plants will also limit the amount of cultivation possible especially near the crop row.

Using Fungicides to Control Strawberry Fruit Rots in Ohio

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The most common fruit rots on strawberry in Ohio are: Botrytis fruit rot (gray mold), caused by *Botrytis cinerea*; anthracnose fruit rot, caused by *Colletotrichum acutatum*; and leather rot caused by *Phytophthora cactorum*. Especially in wet growing seasons, successful strawberry production may depend on the simultaneous control of all of these diseases. Generally, all three diseases do not occur simultaneously in the same planting, but this can occur. Botrytis fruit rot or gray mold is the most common disease and generally requires some level of fungicide for control each year. Anthracnose is a problem in years with warm to hot temperatures combined with prolonged rainfall prior to and during harvest. Anthracnose is generally not a problem in most plantings; however, when it does develop, it can be devastating. New fungicide chemistry with good to excellent activity against anthracnose has recently been registered for use on strawberry and should be helpful in providing effective control. Leather rot is a problem in years with excessive rainfall or in fields with poor drainage that have standing water (all of these diseases are a problem in situations such as this). Many growers do a good job of controlling leather rot by planting on sites with good soil drainage and maintaining a layer of straw mulch to prevent contact of berries with soil. In years with excessively wet weather or on sites with problem soil drainage, fungicides may be beneficial for leather rot control.

As previously mentioned, Botrytis or gray mold is the most common disease and is probably the easiest to control with effective fungicide use. Most fruit infections by Botrytis occur only during bloom. Therefore, most growers that apply fungicide during bloom generally do a good job of controlling Botrytis and do not need to apply fungicides pre-bloom or during harvest. If anthracnose and leather rot **are not a problem**, fungicide sprays during bloom only are generally all that is required. Obviously this is an ideal situation in relation to reducing costs and overall fungicide use.

In plantings and in growing seasons (warm and wet) where anthracnose or leather rot are problems, the need for a more intensive fungicide program is greatly increased. The following information provides guidelines for developing an effective fungicide program for control of the major fruit rots in Ohio.

Prebloom

In most years, there is generally little or no need for fungicides prior to bloom for control of Botrytis. If weather is exceptionally wet from rain or overhead irrigation from frost protection, some early season fungicide may be required prior to bloom. If anthacnose is a concern, especially in plastic culture berries, prebloom applications of fungicide may be beneficial in reducing the buildup of inoculum in the planting. This is especially true if prebloom temperatures are abnormally warm and conditions are wet. Applications of Captan or Thiram alone at the highest rate (Captan 50WP, 6 lb/A; Captan 80WDG, 3.75 lb/A; Captec 4L, 3 qts/A, Thiram 75WDG, 4.4 lb/A) should be effective in reducing inoculum buildup of all three diseases. A seven day application interval should be sufficient.

During Bloom

This is the critical period for control of Botrytis. In addition, in fields infested with Colletotrichum (anthracnose), the fungus may be able to build up inoculum on symptomless (apparently healthy) foliage during warm, wet weather. Increased inoculum could result in increased fruit infections if weather remains favorable for disease development. The main fungicides for control of Botrytis are Topsin-M 70WSB, Elevate 50WG, and Switch 62.5WG. All of these materials have excellent efficacy for control of Botrytis, but only Switch has efficacy against anthracnose. This is an important point to remember if anthracnose is a problem in the planting. I also recommend that all of these materials be tank-mixed with Captan or Thiram during bloom. Captan and Thiram are protectant fungicides that provide some additional control against Botrytis (gray mold), anthracnose fruit rot, and leather rot. In addition, mixing the materials should also aid in reducing the risk of fungicide resistance development.

Topsin, Elevate and Switch are all at high risk for development of fungicide resistance in Botrytis. None of these fungicides should be used alone in a season long program for Botrytis control. They all have different chemistry so they can be alternated with each other as a fungicide resistance management strategy. It is wise not to apply any of these fungicides in more than two sequential sprays without alternating to a different fungicide.

For successful Botrytis control, it is important to provide fungicide protection throughout bloom. Remember that early blooms (king bloom) may be your largest and best quality fruit, so protection needs to be started early (at least 10% bloom). The number of bloom sprays required depends upon the weather. If it is hot and dry, no fungicides are required. All of the fruit rot diseases discussed here require water on the flowers and fruit in order to infect. If it is very dry and overhead irrigation is used for supplemental water, irrigation can be applied in early morning so that plants dry as fast as possible. Keeping plants dry reduces the need for fungicide application. Fortunately, most years are not this dry and fungicides are generally applied on at least a 7-day schedule through bloom. If it is extremely wet, a shorter interval (4-5 days) may be required in order to protect new flowers as they open. Although Botrytis is the primary pathogen we are trying to control during bloom, the selection of the proper fungicides should also aid in reducing the buildup of anthracnose as well. This is important to remember in plantings where anthracnose is a problem or threat.

Post Bloom Through Harvest

As bloom ends and green fruit are present, the threat from Botrytis infection is generally over. Green fruit are resistant to Botrytis. If you got fruit infection by Botrytis during bloom, the symptoms (fruit rot) will not show up until harvest as fruit start to mature. At this point, it is too late to control it.

As new fruit form through harvest, the threat of anthracnose fruit infection increases. In many plantings, anthracnose is not present or is not a problem. In these plantings no additional fungicide should be required after bloom through harvest. Unfortunately, you cannot determine if anthracnose is a problem until you see it. Often, this is too late to control it. In plantings with a history of anthracnose fruit rot, or if the disease is identified in the plantings, fungicides with efficacy for anthracnose control may be required from the end of bloom through harvest. Remember, anthracnose is favored by warm to hot wet weather. In addition, anthracnose appears to be a greater problem in plastic culture plantings.

Quadris 2.08F, Cabrio 20EG, and Pristine 38WG are the most effective fungicides currently registered on strawberry for control of anthracnose fruit rot. These fungicides are also registered for control of powdery mildew and they also provide good suppression of Botrytis fruit rot (gray mold). All of these fungicides are at high risk for fungicide resistance development in the anthracnose fungus. In addition, they are all in the same class of chemistry; therefore, they cannot be alternated with each other as a fungicide resistance management strategy. In order to delay the development of fungicide resistance, the label states that no more than four applications of Quadris or five applications of Cabrio or Pristine can be made per season. In addition, the label states that no more than two sequential sprays of each fungicide can be made without switching to a fungicide with a different type of chemistry. For anthracnose control, the only fungicides that currently can be used in such a rotation are Captan, Thiram, or Switch.

The following are suggestions for developing a fungicide program for simultaneous control of strawberry fruit rots.

Fungicide and (rate/A)	**Comments**
<u>Prebloom</u> Captan 50 WP (6 lb) or Captan 80WDG (3.75 lb) or Captec 4L, 3 qt or Thiram 75WDG (4.4 lb)	Prebloom applications should be required only if excessive water from rain or irrigation is a problem early in the season. Fungicides here could help reduce build-up of Botrytis and Colletotrichum inoculum. In dry or more “normal” seasons, fungicide is probably not required until bloom starts.

<u>During bloom</u> Switch 62.5WG (11-14 oz) or Elevate 50WG (1-1.5 lb) or Topsin-M 70WSB (1 lb) plus Captan 50WP (4-6 lb) or Captan 80WDG (3.75 lb) or Captec 4L (2-3 qt) or Thiram 75WDG (4.4 lb)	This is the main time to control Botrytis and if temperatures are high, Colletotrichum could build up in the planting. Switch is excellent for control of Botrytis has been reported to be good for control of anthracnose. Obviously, this is ideal. The addition of Captan or Thiram provides additional protection against both diseases and may aid in reducing fungicide resistance development. Topsin-M and Elevate are both excellent for control of Botrytis, but have no activity against anthracnose. Where anthracnose is not a threat, these fungicides will provide excellent Botrytis control. When combined with the high rate of Captan or Thiram, the combination should provide some level of anthracnose control. If anthracnose is a concern, Switch would be the fungicide of choice. None of the fungicides (Switch, Elevate or Topsin-M) should be applied more than twice before alternating with a fungicide of different chemistry. This is to aid in reducing fungicide resistance development. Quadris, Cabrio, and Pristine are the fungicides of choice for anthracnose control, and all of them provide some control of Botrytis. Although they could be used during bloom, I prefer to use them after bloom when the threat of anthracnose fruit infection is greatest.

Post bloom Through Harvest	
Quadris 2.08F (6.2-15.4 fl oz) or Cabrio 20EG (12-14 oz) or Pristine 38WG (18.5 - 23 oz) or Switch 62.5WG (11-14 oz) tank-mixed or alternated with Captan 50WP (3-6 lb) or Captan 80WDG (3.75 lb) or Captec 4L (1.5-3 qt) If more than two applications of Quadris, Cabrio, or Pristine are required, Switch can be considered as an alternating fungicide.	As green fruit develop, the threat of anthracnose infection increases, especially under warm, wet conditions. Quadris, Cabrio, or Pristine are the most effective materials for anthracnose control. If anthracnose is a problem, the highest label rate should be used. This may be the best time to use Quadris, Cabrio, or Pristine. Switch also has some activity for control of anthracnose. If the risk of anthracnose is high or the disease has been observed in the planting, Quadris, Cabrio, or Pristine plus Captan should be applied 7 days after the last bloom spray for Botrytis. If anthracnose remains a threat, sprays should probably be repeated on a 7 day interval through harvest. As harvest approaches, Captan should be removed from the program. Captan applied close to harvest could result in visible residues on fruit and this can be a big problem. Quadris, Cabrio, Pristine or Switch applied alone should result in minimal visible residues on fruit and can be applied on the day of harvest (0-day PHI). Remember, **these preharvest sprays are required only if anthracnose is a threat or problem.**

The extensive use of Captan in this program could result in problems with visible residues on fruit. This needs to be considered, but under heavy disease pressure for anthracnose a high level of Captan usage may be required. The Captec 4L (flowable) should result in less visible residue than the Captan 50W (wettable powder) or Captan 80WDG formulation. The use of Quadris, Cabrio, Pristine or Switch alone in the last spray or two before harvest should aid greatly in reducing visible residues.

Leather Rot

As mentioned previously, leather rot should be controlled by good soil drainage (no standing water) and a good layer of straw mulch to prevent berries from soil contact. If leather rot is a threat or a problem, fungicides may be required. Quadris, Cabrio, and Pristine have excellent activity against Phytophthora diseases on other crops. Although not on the label, Quadris, Cabrio, and Pristine should have good activity for control of leather rot in addition to anthracnose and Botrytis gray mold. If applied at the time suggested here (green fruit through harvest) for anthracnose, Quadris, Cabrio, and Pristine may be beneficial for control of leather rot as well. Recent research at Ohio State indicated that these materials have good to excellent activity against leather rot.

Fungicides for Leather Rot Control

As previously mentioned, emphasis for leather rot control should be placed on the use of cultural practices such as planting on well drained sites or improving water drainage in the planting and a good layer of straw mulch to prevent berry contact with the soil. When needed, the following fungicides are labeled specifically for control of leather rot.

Ridomil Gold is labeled for control of Red Stele (caused by *Phytophthora fragarieae*) and Leather Rot (caused by *Phytophthora cactorum*). The label for perennial strawberries reads as follows: "Established Plantings: Apply Ridomil Gold EC at 1 pt. per treated acre in sufficient water to move the fungicide into the root zone of the plants. Make one application in the spring after the ground thaws and before first bloom. A second application may be applied after harvest in the fall. **Note:** Although not labeled for leather rot control, the early spring application for red stele control should provide some control of leather rot. **For supplemental control of leather rot**, an application may be made during the growing season at fruit set. This application at fruit set (as green fruit are present) has been very effective for leather rot control.

Aliette 80WDG is labeled for control of Red Stele and Leather Rot. For Leather Rot, apply 2.5 to 5 lb/A. Apply as a foliar spray between 10% bloom and early fruit set, and continue on a 7-14 day interval as long as conditions are favorable for disease development. Applications can be made the same day as harvest (PHI=0 days). Do no exceed 30 lb product per acre per season.

Phosphorous Acid (Agri-Fos) is labeled for control a Red Stele and Leather Rot on strawberries. This material has essentially the same active ingredient as Aliette and the use recommendations for red stele and leather rot are very similar to those of Aliette; however, Aliette is a wettable powder and Agri-Fos is a liquid. Agri-Fos is recommended at the rate of 1.25 quarts per acre in 90 gallons of water or 2.5 gallons per acre in 200 gallons of water. For leather rot, apply at 10% bloom and early fruit set, then at 1 to 2 week intervals as needed. Several Phosphorous acid fungicides are currently being registered for use on several crops in the U.S. and others will probably be registered for use on strawberry in the near future.

Remember these are only suggested guidelines for a fruit rot control program. It is always the growers responsibility to read and understand the label. For the most current pesticide recommendations in Ohio, growers are referred to Bulletin 506-B "Ohio Commercial Small Fruit and Grape Spray Guide".

If growers have questions regarding the information covered here, they should contact:
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Field Tomato Trials in Maine

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Materials and Methods

We selected 16 varieties of open field, determinate tomatoes ranging in maturity from 66 to 79 days. One indeterminate variety, New Girl was inadvertently planted along with the determinate varieties. New Girl was staked using a basket weave while all other varieties were grown on the ground Three plots of each variety were transplanted in a randomized design, and data from the plots were combined for analysis. All tomatoes were seeded into trays on April 30, grown in the greenhouse and transplanted in the field on June 10, 2003. Each plot consisted of 8 plants planted 18" apart within rows and rows spaced 6' on center. Rows were covered in embossed black plastic mulch. Prior to forming the beds 10-10-10 fertilizer was incorporated into the soil at a rate equal to per 500 lb per acre. The plants were fertilized with a starter solution at transplanting.

Harvest began on August 17 and continued until September 11. The first four harvest dates were combined to measure early yields. No sprays were applied for disease or insect management. Fruit from each plot was harvest at red ripe stage, counted and weighted. The fruit were graded in to selects, marketable, and culls. Selects were large fruit with no cracks, blemishes and small blossom scars. Fruit larger than 4 oz (112g) with some scaring or cat-facing considered marketable. Small, diseased or otherwise deformed fruit were graded as culls.

Results

Most of the varieties performed well despite the cool wet spring (Table 1). However, compared to previous years harvest was delayed by approximately 7-10 days. First Pik was the top producer in 2003. Sunshine was the top early variety producing 4.04 lb (2 kg) of fruit per plot in the first four harvests. Sunshine was also the second best for total season yield and produced the greatest amount of culls. Redstone and New Girl were also top early producers, however production fell off as the season progressed. Redstone fruit were pinkish-red, uniform, round and were easily distinguished from the other varieties in the trial. New Girl was the least productive and smallest fruited of the varieties evaluated. Fabulous had the largest fruit size averaging 12.1oz (343g) while overall yields ranked in the middle of the pack. Red Sun, Empereador and BHN 543 all produced fruit averaging over 10oz (284g).

Table 1. Performance of tomato varieties evaluated in Monmouth, Maine 2003.

Variety	Total Yield (lb. / Plot) [1]	Early Yield (lb. / Plot) [2]	Culls (lb. / Plot) [3]	Fruit Size (oz.)
FirstPik	91.11	12.19	26.70	6.84
Sunshine	89.32	35.41	47.16	8.78
Valley Girl	66.02	14.55	22.34	8.93
Royal Mountie	63.59	14.49	17.04	7.73
Sun Chief	61.41	10.32	12.97	9.35
Red Sun	60.53	5.03	9.81	11.68
Fabulous	60.33	4.56	14.31	12.10
BHN 543	58.74	6.57	12.83	10.02
Sun Guard	57.04	6.09	15.28	8.54
Empereador	55.06	2.23	10.41	11.47
Red Pride	51.33	4.50	11.80	9.88
Sunbrite	48.29	6.68	8.82	9.49
HMX 2807	47.28	5.58	11.25	9.91
Redstone	47.03	21.90	12.90	8.26
Sunrise	38.12	7.01	9.88	7.48
New Girl [4]	32.30	18.28	5.89	4.73
LSD 0.05 [5]	28.44	12.01	9.83	0.93

[1] Plots were 12 ft with 18" between plants, 6' between rows, and 8 plants/plot.
[2] Early yield was the sum of the first four harvests: 8/17, 8/20, 8/23, and 8/26.
[3] Culls included fruit that were too misshapen, small, or diseased to be considered marketable
[4] New Girl is an indeterminate variety and was grown on stakes using basket weave.
[5] Data within each column must differ by this much to be considered statistically different.

It's All About Flavor

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Why grow heirloom tomatoes? Heirlooms represent a slice of history including people's personal memories of "the way it used to be" or "...my grandmother used to grow..." Even though tomatoes come in an incredible array of colors, textures, shapes, and flavor, there is only an ounce of actual genetic diversity among those varieties. But that is enough to start a dialog with customers and provide a jumping off point for marketing.

Heirloom tomatoes have been in the news for years, and with good reason. But after all the conversations about genetic diversity, the history and stories, it all boils down to one word - flavor. The home gardener is growing heirlooms for their flavor. The market customer comes back again and again for the "good old tomato flavor" provided by heirlooms. My seedling customers send me out to find "that tomato my grandmother grew" or "the perfect sandwich tomato". My personal search has been for the "perfect, no nonsense paste tomato" that tastes so good we can eat it fresh as well as consign it to the sauce pot!

Sometimes the subject of heirlooms and poor disease resistance comes up. I have to say that, in my experience, most heirlooms can be grown well and will be disease free if good conditions are provided. Ample spacing to provide plenty of air drainage, mulch to prevent splash from the soil, steady moisture, appropriate support, and minimal pruning will all contribute to a good harvest. Other folks maintain that heirlooms may bear fewer fruits than hybrids. In some cases this IS true, but in my experience well grown plants will bear well as a general rule. And it IS true that some heirloom tomatoes will crack on the shoulders. One of the factors that makes the heirloom tomato so appreciated is the tenderness of the skin. And it is that tenderness that makes many heirlooms vulnerable to cracking. The "secret" to limiting cracking is providing even moisture. Since the skins lose a lot of their elasticity as they approach maturity, a heavy rain (or drip irrigation left on too long) will swell the fruits and cause cracking. With heavy rain in the forecast it is sometimes wise to pick ripe and almost ripe fruits to protect them!

Market growers sometimes experience the "it looks funny" reaction to some heirlooms, but a tasting plate will take care of doubters! From a practical standpoint, a great market display should have a good mix of hybrids, standards, and heirlooms. There will always be the customer who can't possibly eat a tomato that isn't round and red! But that's where the tasting plate comes in - even dyed-in-the-wool red tomato folks can be challenged to try something new! In addition to direct market sales, the connection to chefs and fine restaurants provides another valuable outlet for an unusual and beautiful crop.

Trials of heirloom tomatoes can be a real adventure. I try to plan at least three years for a realistic trial, as the results I need are complex. I need to know if the variety will produce at all in my niche of New England. I need to know how the variety will produce in the widely varying growing seasons in New England. I need to know the growth habits of the plant. It is amazing what differences of opinion there are when describing "healthy", "sprawling", compact", or "vining" plants! I also need to know if the variety is sensitive to particular locations (mini-climates) on my property. I need to know when I can expect the first ripe fruits. I need to satisfy the question of whether this variety is actually unique. And last but not least, I need to know if it tastes good!

So my trials include several widely spaced plantings of at least 3-4 plants each as well as side-by-side plantings with suspiciously similar varieties. The true test comes in the second and third years when I grow out seedlings from saved seed. I carefully select fruit that meets the description and save seed to see if the variety will breed true.

As complicated as trailing might seem, it is still very subjective! The bottom line is still the flavor! I market my trials at farmer's market right next to the tried and true favorites. The customers are very good at letting me know which ones they like!

The following is a list of some of my personal recommendations of heirloom tomato varieties. This list is based on both spring seedling sales and farmer's market sales later in the season. The codes in bold refer to the list of sources which appears at the end.

REDS

* Box Car Willie (80-I) Abundant crop of medium to large size globes. Named after the country singer, Box Car Willie, who regrettably passed away in 1999. Not just the hobos' favorite tomato - market customers will come back for these!
fest TGS Mari

* Delicious (77 - I) One of the early standard setters, Delicious was selected from Beefsteak aka Red Ponderosa, and introduced by Burpee. Fruits are a deep red, meaty, and can easily average 1 1/2 to 2#. Good old-fashioned flavor. A favorite among sandwich lovers. fest TGS SEx sand

* Mortgage Lifter (90-I) "Radiator Charlie's Mortgage Lifter" was named after a man who sold his tomato seedlings and the resulting crop to pay off the mortgage on his shop! This is a wonderful firm pink/red beefsteak...great flavor...great story!
fest TGS SEx Mari terra

* Red Brandywine (90-I) Scarlet red, rounded, gourmet version of Brandywine! Regular foliage plant. Red Brandywine is a consistently good seller as both seedlings and at market. fest TGS Mari terra sand

* Cosmonaut Volkov (72-I) Round, slightly flattened red fruits. Prize winning fruits can weigh up to 2#. Named for a famous Russian cosmonaut who was killed while landing. fest F

PINKS

* Brandywine - OTV Strain (78-I) Dr. Carolyn Male, tomato specialist, researcher, and author of "100 Heirloom Tomatoes for the American Garden", has selected seed from an old strain of Brandywine which she believes to be the sweetest and creamiest of all. The fruits are a rich pink/red with an orange undertone. Fruits are 12-16 oz. Very productive and more heat tolerant than other strains. fest TGS SEx Mari sand

* Cherokee Purple (80-I) Cherokee Indian origin, introduced in Tennessee. Bears 10-12 oz dusky rose/purple fruits that are delicate and a true taste treat. Vines should not be pruned as the delicate fruits sunburn easily. The flavor is excellent and makes the effort to take good fruits to market well worth the time. Customers will come back for more!
fest F TGS SSE SEx J Mari sand
* German Johnson (pink) (70-I) Pennsylvania Dutch heirloom. One of the "parents" of Mortgage Lifter, this is a deep pink, rich-tasting, medium-sized tomato. Large yields.
fest F TGS SEx Mari

BI-COLORS and GOLD
* Earl of Edgecombe (golden) (73-I) This tomato came from New Zealand with a sheep farmer who went to England to claim his title as the 7th Earl of Edgecombe! The round fruits are firm, absolutely smooth and defect free, and have a well-balanced sweet/tart flavor. Better flavor than Golden Boy, and a market favorite.
fest SEx Mari sand
* Hillbilly (yellow/red) (85-I) Heirloom from West Virginia. Large beefsteak type fruits average from 1 to 2#! Unique orange and yellow flesh streaked with red and pink. Flesh is firm, meaty and juicy! Rivals Pineapple! fest TGS
* Pineapple (85-I) Unique red and yellow striped huge fruits. The rich, fruity, sweet flavor, and dense juicy flesh make this an exquisite salad tomato. fest F TGS Mari

BLACKS
* Black Brandywine (80-I) Large, oval, well-formed fruits are DARK, almost black and full-flavored. Regular foliage. mari
* Black Krim (80-I) This is a medium sized slicer, with dark maroon to black flesh and distinctive green-black shoulders! Originally from Krymsk, on the Black Sea. Seed was originally smuggled to the US before the breakup of the Soviet Union.
F TGS SSE Mari Tur terra

* Black Prince (70-I) An old-fashioned slicer saved in Irkutsk, Siberia. Garnet-red outside and red to chestnut-brown on the inside. Some strains of these oval fruits will crack in rings on the top but a strain that doesn't crack is available from Tomatofest.com. The flavor is a complex mix of sweet and acid with mellow overtones. Customers need to taste these to be convinced - and then they come back for more!
fest TGS SEx sand

CHERRIES
* Broad Ripple Yellow (75-I) This little gem was literally found growing in a sidewalk crack in Indianapolis! A Seed Savers Exchange member saved the seed! A VERY prolific plant, bearing hundreds of 1/2" round, incredibly tasty pale yellow fruits. SSE
* Matt's Wild Cherry (60-I) Incredibly high sugar content gives this little cherry tomato a wallop of flavor! From the Hidalgo region in Eastern Mexico, where they are found growing wild. Great for fresh eating and salsas. Will self seed! J Ch Mari terra
* Tommy Toe (70-I) Hundreds of apricot-sized bright red fruits per plant, bearing right till frost. Very sturdy plants are disease resistant. Tommy Toe won taste tests in Australia and at the Rodale Institute. TGS SSE Mari sand

PASTE

* Amish Paste (74-I) This one has been handed down for generations in Amish families. It is recommended as a "perfect" paste tomato! Good tasting too, so it can double as a slicer. Averages 7-8 ozs TGS F SSE SEx Mari terra
* Corne de Bouc (mid) Stunning and delicious! The flavor is almost as fine as Hogheart, but the fruits ripen much earlier (long before the Common Ground Fair!) and are virtually blemish-free! 5" long, fat sausage-shape and intensely red/orange. Tur
* Hogheart (75-I) This is originally from Italy, and for my money, the best paste tomato going! These are huge, often 12 oz! They can make twin fruits, really heart shaped! F
* San Marzano (80-I) Sets the standard for sauce tomatoes! Rectangular pear-shaped, red, meaty, and averaging 3 1/2 inches. From the San Marzano region in Italy where the San Marzano tomato is a treasure...lifestyle...and heritage! TGS Mari Tur terra sand

SEED SOURCES

fest www.tomatofest.com is a good source of organic tomato seed, mostly heirlooms, all open pollinated.
F FEDCO Seeds. P.O. Box 520, Waterville, ME 04903 www.fedcoseeds.com
TGS Tomato Growers Supply, P.O. Box 2237, Fort Myers, FL 33902 www.tomatogrowers.com
SSE Seed Savers Exchange, 3076 North Winn Road, Decorah, IA 52101 www.seedsavers.org
SEx Southern Exposure Seed Exchange, P.O. Box 460, Mineral, VA 23117 www.southernexposure.com
J Johnny's Selected Seeds,955 Benton Avenue, Winslow, ME 04901 www.johnnyseeds.com
Ch Seeds of Change, P.O. Box 15700, Sante Fe. NM 87592 www.seedsofchange.com
Mari Marianna's Heirloom Seeds 1955 CCC Road, Dickson, TN 37055 www.mariseeds.com
Tur Turtle Tree Seed, Camphill Village, Copake, NY 12516 turtle@taconic.net
terra Terra Edibles, Box 164, 535 Ashley St., Foxboro, Ontario KOK 2BO www.terraedibles.ca
sand Sand Hill Preservation Center, 1878 230th Street, Calamus, IA 52729 sandhill@fbcom.net

EXCELLENT REFERENCES

100 Heirloom Tomatoes for the American Garden, by Carolyn J. Male, Workman Publishing, 1999.
Heirloom Vegetable Gardening, by William Woys Weaver, Henry Holt and Company, 1997.
Heirloom Vegetables, by Sue Strickland, Gaia Books Limited, 1998.
Livingston and the Tomato, by A.W. Livingston, foreword by Andrew F. Smith, Ohio State University Press, 1998.

Effect of Shade on Quality of Greenhouse Tomato

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What amount of shade is optimal for the production of high quality tomatoes in a greenhouse? Horticultural science and plant physiology suggest that when grown in a greenhouse, the quality of tomato fruit may benefit from some shade. High light and temperature can induce the skin of the tomato fruit to crack, and alter metabolism leading to uneven ripening. On the other hand, the rate of production or total yield typically increases with the amount of available sunlight. Is there a level of shade that increase fruit quality more than it decreases the rate of production? This critical amount of shade likely will depend on more than ambient sunlight. In terms of greenhouse microclimate, it is likely to depend on air temperature, humidity, and day length, as these all influence aspects of plant physiology related to fruit development and composition.

In previous years, I noted that the quality of greenhouse tomato fruit depended on whether the greenhouses were shaded during the summer months. Tomatoes were grown in a similar way in the years from 1999 through 2002, except that in some years the greenhouses were covered with reflective aluminized cloth that provided 30% shade, and in other years the greenhouses were unshaded. In years when the greenhouses were covered with shade cloth, the fraction of a fruit that was marketable was 10 to 20% greater than in years when the greenhouses were not shaded (Table 1).

The planting in 1999 was late, summer was hot and sunny, and there was no shade cloth on the greenhouses. This combination resulted in the poorest fruit quality of any year of these trials. The incidences of fruit with cracked skin, green shoulder, or blossom end rot were higher in 1999 than in any other year. Seedlings were not set at the final spacing until 20 May and plants did not start to produce until mid-July. This trial also had the lowest yields, in part because the rate of production was slowed by decreasing light intensity in September.

In 2000 and 2001, shade cloth was applied to the greenhouses in mid June. The spring of 2000 was warm and sunny, but summer was cool and wet. Plants were set at the final spacing on 23 Feb and fruit production commenced on 12 May, earlier than in other years. The final harvest was 15 Aug 2000. The summer of 2001was warm. Plants were set at the final spacing on 7 March and fruit production commenced on 1 May. The yield characteristics were similar in these two years, except fruit size was one ounce larger in 2001 than in 2000. Because of the difference in fruit size, the incidence of fruit with cracked skin was slightly greater in 2001 than 2000. Nevertheless, this was a much lower incidence of fruit with cracked skin, green shoulder or blossom end rot than in 1999.

Shade cloth was not applied in 2002, and summer temperatures were average. Plants were set at the final spacing on 20 March, fruit production began on 4 June, and picking continued to 26 August. Although the highest yields were achieved in 2002, only 44% of the total yield was marketable, compared to 56 to 58% in 2000 and 2001. Thus marketable yield in 2002 was reduced due to a lack of shade, primarily due to a greater incidence of cracked skin and green shoulder or uneven ripening.

This last summer, I attempted to determine the effects of shade more precisely through simultaneous comparisons among greenhouses covered with different amounts of shade, varying from none to 50 percent shade. The houses were either uncovered, or covered with reflective aluminized shade cloth that provided 0, 15%, 30% or 50% shade. The shade was applied at the start of the first warm weather in early June corresponding to the start of fruit production. The houses remained shaded for the rest of the summer, and fruit was picked until late August. Plants were set at the final spacing on 24 March, fruit production began on 9 June, and picking continued to 29 August 2003.

This comparison demonstrated some interesting points. First, the rate of fruit production did not respond immediately to the amount of shade applied. There was essentially no difference in the production in June, and yield in July was reduced in only two of three shaded conditions. However in August, the reduction in yield due to shade became obvious. Thus the effect of shade on the yield of fruiting tomato plants developed gradually. It took more than one month to have an obvious effect.

Second, shade affected fruit size immediately following the application of shade to the greenhouses. The size of fruit decreased with the amount of shade, for the tomatoes picked within two or three weeks of application of shade. However, this effect was not so clear in the following month, and the 30% shade treatment produced the largest fruit. In August, there was a trend towards larger fruit in the unshaded house, although this trend was smaller than in June. The rapid effect of shade on fruit size probably resulted from the fact that the number of ripening fruit was fixed. These had to compete for a reduced supply of carbohydrates. Later on the plants probably adapted to a change in carbohydrate supply by altering the number of fruit set.

A Farmer is more interested in marketable production rather than total production. Shade tended to increase the fraction of fruit that was marketable, so although total yield was reduced by shade, marketable yield was affected less. In the comparison of different levels of shade in 2003, the 15% shade treatment had the highest marketable yield in June. The treatments with more shade yielded less marketable fruit that the unshaded treatment. In August, there was a more obvious trend towards lower marketable yields in houses with more shade. Over the entire 2003 season, the unshaded greenhouse produced the highest total and marketable yield.

Cracked skin was the defect most affected by shade. About 35% of the fruit produced in unshaded greenhouses had cracked skin, whereas only 25% of tomatoes in greenhouses with

50% shade had cracked skin (Table 2). Some 6 to 8% of fruit had blossom end rot. The fraction with this defect declined slightly as more shade was applied. Very few fruit had uneven ripening or green shoulder, as all the cultivars used in 2003 had the even ripening gene.

The summer of 2003 was relatively cloudy. It is likely that there were more deleterious effects of shade, and less of beneficial effects than would be seen in a summer with more normal weather. Averaged over the entire season in 2003, there was no benefit of any degree of shade compared to no shade, because total yield was decreased more than fruit quality was increased. In previous summers it seemed that the increase in fruit quality due to shade outweighed the decreasing yield or fruit size. I am planning to continue these experiments in future seasons, to look more closely at cultivars that tend to have poor quality in unshaded greenhouses.

Table 1. Yield characteristics of tomato that varied from year to year depending on whether shade cloth was applied to the greenhouses in the years 1999 through 2002.

Year	Shade	Total pounds/ plant	Market pounds/ plant	Market fraction weight%	Fruit size ounce	Percent of total: Cracks in skin	Percent of total: Green shoulder	Percent of total: Blossom end rot
1999	None	8.7	2.7	32	4.2	40	13	9
2000	30%	14.1	8.1	58	4.5	15	5	1
2001	30%	13.7	7.6	56	5.8	21	5	1
2002	None	15.7	7.1	44	6.2	30	14	4

Table 2. Yield characteristics of tomato in 2003 as a function of different amounts of shade provided by reflective aluminized cloth applied to the greenhouses.

Shade	Total pounds/ plant	Market pounds/ plant	Market fraction weight%	Fruit size ounce	Percent of total: Cracks in skin	Percent of total: Green shoulder	Percent of total: Blossom end rot
None	14.5	7.8	54	7.4	34	1.5	7.6
15%	13.4	7.6	57	7.2	29	1.5	6.2
30%	13.0	7.1	54	7.3	30	1.0	7.2
50%	11.2	7.0	63	6.8	25	1.1	5.9

Tomato Grafting

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Just a few years ago, when I began to tell my grower friends about tomato grafting, they looked at me a little funny. They wondered if I was trying to produce a tomato with seven different varieties on one plant. Most of them had not been raising tomatoes in the greenhouse for more than three or four years and were so far experiencing no serious soil disease problems. Unfortunately, I had been growing in the same soils for considerably longer, up to twelve years in one structure, and my tomato plants were starting to collapse faster than the Red Sox in September. It didn't help that we grew the variety 'Buffalo', consistently one of the wimpiest of the dozen or so greenhouse types we've trialed over the years yet also the hands-down best tasting variety we've ever raised. It also didn't help that we grew organically so we were limited in the amendments that we could add to combat the Evil Empire of soil pathogens that sucked the life out of our healthy green vines. Something had to be done short of hiring a Chinook helicopter to relocate our greenhouses to healthier soils.

We didn't always have soil disease problems. When we first started with Jetstar tomatoes in poly-tunnels in the mid-eighties things went just fine. The tomatoes were big and red, the birds were singing, the cotton was high. Of course Jetstars are field tomatoes and total yield fluctuated with the temperature and weather. One day you picked a load, the next day you had nothing. Then we discovered the magical world of greenhouse tomato types and realized that we could achieve our goal of having red-ripe fruit consistently from the opening of our seasonal farmstand to closing time at Thanksgiving. For a few more years the plants grew fine all season to a length of 14-16' and other than the 'May check' problem when blossoms took a break after four or five cluster sets, plant health was superb. After experiencing only a couple of 'yellowing' plants each year, we suddenly had a season where we lost about twenty-four plants just about the time they began to bear fruit. After talking with other growers and extension agents I found that some greenhouses were experiencing up to fifty percent mortality. One organic Canadian grower had even tried removing his greenhouse soil and replacing it with fresh, healthy soil.

We were determined to solve the problem and hoped that some new products out on the market that contained pathogen fighting organisms might help us stave off the diseases. One season we trialed several of the biological fungicides including 'Backpack' and 'Plantshield'. These materials contained the beneficial microbe *trichoderma harzianum* which when applied as a drench provides prolonged protection against pythium, rhizoctonia and fusarium. These drenches helped dramatically for a while but we knew we needed something more to boost production back to the good old days of fresh, new soil. We heard rumors that other growers were having excellent results combating disease problems by grafting their favorite varieties onto disease resistant tomato rootstocks. The idea of grafting tomatoes seemed a little odd but I remembered how surprised I was a number of times when after accidentally snapping the growing tip of a tomato plant while pruning and then setting the partially severed tip back upright on the stem, I would return a few days later to the same plant and find the tip had reattached itself and the cut had calloused over. We needed to find out more about this mysterious grafting process. It was time to hit the Internet.

We found a 1996 article written by Andre Carrier, a Canadian agronomist, detailing the methods and advantages of tomato grafting. In the article he stated that the main purpose of grafting "is to obtain a better root system that will last longer". Further research found that the Japanese and Koreans because of their intensive cultivation of land over many years and the corresponding buildup of soil disease had been forced to develop grafting techniques to ensure continued crop production. Not only had they experimented with tomatoes but also had grafted peppers, eggplant and various vine crops. Japanese researchers concluded that "Since soil sterilization can never be complete, grafting has become an essential technique for the production of repeated crops of fruit-bearing vegetables grown in greenhouses." Sounded good to us, now all we had to do was fuse two plants together.

The first method we tried was the side-by-side method in which the rootstock and scion stem are planted at the same time in a 4" pot. The rootstock top was cut off with a diagonal cut and stuck into an upward slice in the scion stem. Moisture proof tape was wrapped around the cut to prevent the graft from drying out. Unfortunately it was hard to see if the graft was successful since it was hidden by the tape. Mortality rates were high for us with this method. Friends of mine had tried top grafting by cutting the rootstock stem in half and placing a portion of the scion stem over a small porcelain pin that joined the two together. The plants were then put into a misting chamber to facilitate the graft healing process. The success rate of this method was not too impressive either. Finally, we were shown a method in which two similar sized young plants from square 128 plug trays were laid down side by side. An upward cut was made with a very sharp razor blade into the scion stem an inch or so above the soil line. The cut was made at about a 35 degree angle cutting halfway through the stem. Another cut was made in the rootstock stem at about the same height and stem thickness downwards at about a 35 degree angle and halfway through the stem. The two stems are then joined and held together by the flaps of tissue. We use a small plastic clothes pin from Japan specifically designed to hold the graft together. The English translation for the Japanese name of the clip is 'the Tomato's Friend'. The clip protects the graft from separating during misting or watering. The grafted plant is placed in a compost mix in a 4.5' pot. After four or five days, we cut the rootstock top off a little above the graft, leaving the scion stem root so there are now two roots powering one plant. In a couple of more days, we remove the clip. It seems to take a week to ten days for the plant to outgrow the shock of the transplant process but when it does, the growth really takes off. Plants are generally ready to put in the ground at 6-8 weeks.

Presently, we are using a rootstock from De Reuiter Seed called Maxfort. Previously we had good results with Kyndia and Beaufort.

For a while, the grafted plants are pretty much indistinguishable from non-grafted plants after they are planted. However, once the rootstock gets a firm foothold, the Jack-in-the-Beanstalk effects begin to take over. First, there is no more 'May Check" on the blossom clusters. The yellow flowers maintain a steady appearance so the plant will be producing consistently. Second, the plants show steady vigor and growth even after picking begins. This translates to larger fruit and more of them, increasing the yield per plant dramatically. Third, loss of plants due to soil disease is relatively non-existent.

Tomato grafting may not be necessary for everyone, especially if fresh soils are available. Organic growers know that rotation of crops is an important step to prevent disease and insect build-up. However, due to the major investment in the greenhouse structure and the fact that tomatoes are an important economic crop, tomato grafting may be the answer to soil fumigation or chemical control. Even if soil disease is not presently a problem, grafted plants can allow growers to harvest a larger crop without significant investment in more structures. An experienced worker can graft 60 to 100 plants per hour, so even with the extra cost of the rootstock, the eventual yield increase makes grafting profitable. There is also an economic opportunity to provide custom grafted plants for other growers.

Don’t be scared by the grafting process. It’s been done for centuries and is relatively easy with a little patience. Who knows, maybe we will have seven varieties of tomatoes on one plant fairly soon?

Soil Health, Tillage and Compaction

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Healthy soil is the foundation of sustainable crop production. It is the result of a combination of factors. While this presentation will focus mostly on how tillage affects soil health I first want to briefly go over the "bigger picture" of soil health.

A key concept for managing soil health is recognizing the interaction between the biological, chemical, and physical aspects of soil. **Biologically** healthy soil has low pest populations, or the ability to suppress pests, and is fully functional with respect to nutrient cycling and producing plant growth promoting compounds. From the **chemical** perspective, healthy soil has adequate levels of available nutrients, but not so high that there will be a lot of leaching; an optimal pH for the planned crop rotation; and low levels of toxic or disruptive substances such as heavy metals, aluminum, or salts. The **physical** characteristics of healthy soil include good tilth, water infiltration, aeration, and water retention.

The biological, chemical and physical properties mutually influence each other, and if we ignore one, the other will be affected. For example, aggregation of soil particles is influenced by the types of cations (e.g. Ca, Mg, K) and amount of organic matter present in the soil. The types of organisms present can be influenced by compaction and availability of food sources, and soil drainage influences the amount of nitrogen available to plants because saturated soil can lose nitrogen through denitrification, and well drained soil can lose nitrogen through leaching. In the past decades, agriculture has too much focused on the chemical aspects of soils and insufficient attention has been given to the physical and biological (especially) functions.

The key management approaches that can positively influence soil health are organic matter additions, reduced tillage, and compaction prevention. Adding organic matter to the soil increases biological activity and diversity, which in turn releases plant-available nutrients and holds them in the soil, increases soil aggregation, pore structure, and tilth, produces humus and other plant growth promoting substances, and reduces soil-borne diseases and parasitic nematodes (Fig. 1). At least one long term cropping experiment has shown a yield increases related to increasing organic matter levels, especially in dry years when higher organic matter levels can improve water retention.

Now we'll move on to tillage. One question we can ask ourselves is why we till in the first place. The plow, which was invented in the England in the mid-1700's, revolutionized agriculture. It provided unprecedented control of weeds, allowed for a more stable food supply, and was a critical tool in the development of virgin lands in North America. Plowing the soil incorporates residue from the previous crop, weeds, and amendments. It's the first step in seedbed preparation, increases the conversion of organic matter to plant-available nutrients, and reduces compaction, at least temporarily. So, the first experience with the plow was very positive, mainly because the destructive qualities didn't manifest themselves until after several decades.

In that respect, it is interesting to study the contributions of the eighteenth-century English agriculturalist Jethro Tull. Tull made an everlasting contribution to the worlds by inventing the seed drill, as he recognized that good seed placement improved germination and plant population over the conventional broadcast seeding (of small grains). Now, we recognize that the mechanical seeder is an essential agricultural tool, especially for conservation farming because no-till planters allow us to place seeds with very minimal tillage. Tull, however, also appears to have done an unintentional disservice to the land. He believed that plant roots absorbed nutrients as tiny soil particles (rather than as ions as was established in the following century). He therefore tilled his soils over and again to pulverize the it. Sure enough, he was able to feed his crops for many years without the use of manure or other forms of fertilizer. But what was he doing? He oxidized the soil organic matter and released nutrients for his crops. In time, however, he mined the soil of its nutrients and food source for soil organisms. In the long run this is not sustainable, and we have seen similar problems with modern farming methods. One interesting lesson learned from Tull's work is that short-term research does not always provide the right picture.

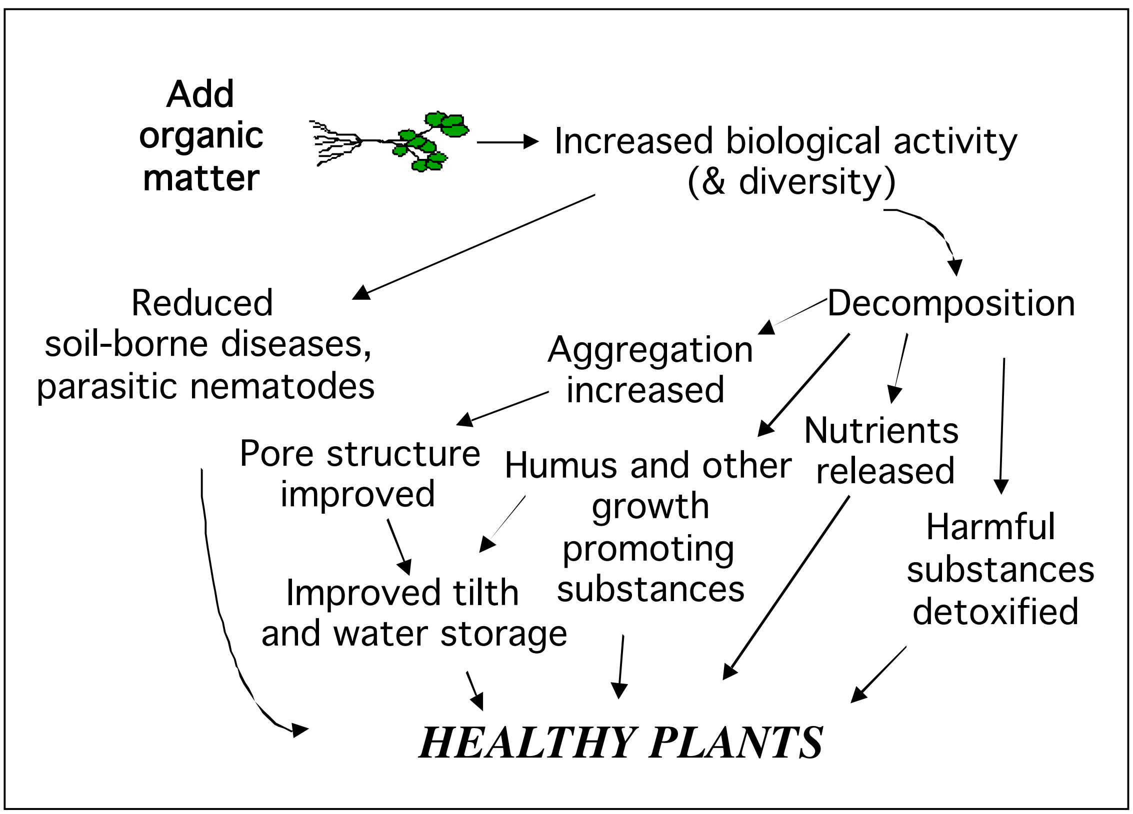

Fig. 1. Why adding organic matter benefits soils.

There are also other negative aspects of plowing. It uses a large amount of energy, and repeated plowing destroys soil aggregates, which increases compaction and the potential for crusting, resulting in low water infiltration, increased erosion, and the development of a zone of low microbial activity near the soil surface. Intensive soil tillage exposes the soil to the elements and causes temperature and heat extremes near the surface, creating an environment that is uninhabitable for soil organisms. In that respect, we need to start changing our somewhat romantic image of clean tillage, which we often associate with goodness and tradition. What could be better than a beautiful, aromatic freshly-plowed field? In fact, we are actually doing something very unnatural, because soil is not naturally exposed to the elements and we are creating an ecologically unfavorable soil environment. A field covered with residues may not have the aesthetics of a plowed field, but it is a lot more ecologically compatible. Farm ugly, as they say. Another factor associated with increased soil degradation is driving heavy farm equipment on a field. The weight of heavy equipment is concentrated in a small area underneath the tires, and can certainly increase soil compaction, especially if the soil is wet. The level of compaction is greater and extends deeper into the soil when it's wet than when it's dry, reminding us of the importance of staying off fields when the soil is wet.

The notions of water availability and compaction are brought together in the concept of the “optimum water range”. Highly compacted soil has a smaller optimum water range than a well-structured soil. (Fig. 2). During wet periods, compacted soils experience prolonged water saturation and aeration problems, because they do not have the large pores that readily drain and allow air into it. When the soil dries, compacted soils more readily experience drought stress, which is actually caused by hard soil not allowing for root penetration. So crops growing on compacted soil are “happy” only when the moisture conditions are “average”. During prolonged dry or wet periods, however, the plants quickly become stressed and have decreased yield or quality. A well-structured soil will not show drought or aeration problems unless the conditions are very extreme.

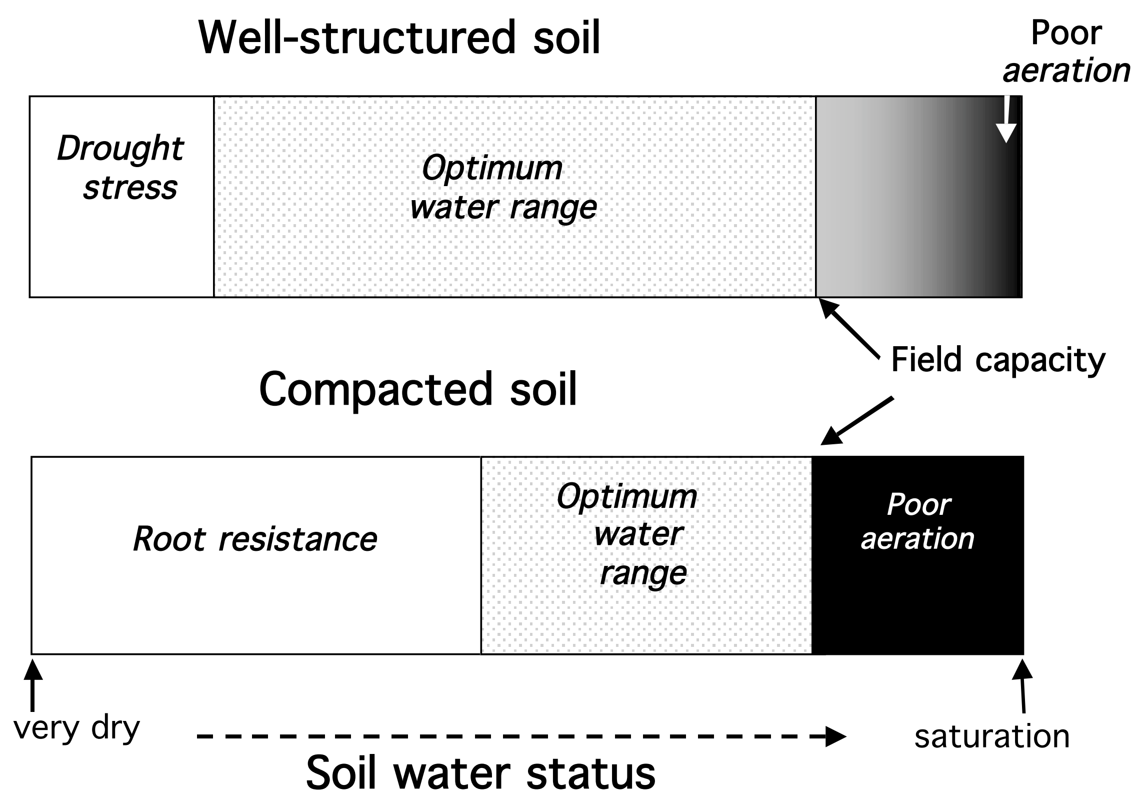

Fig. 2. The optimum water range explains the effects of compaction on plant growth

So how do we improve soil health? First, we have to recognize that some soils have become "addicted" to tillage. Depletion of organic matter over time has resulted in soils that are so compacted that multiple passes are needed to break up clods to create a good seedbed. The relief is only temporary, however, as these soils usually settle back down and form crusts after the first good rain, inhibiting seedling emergence and root growth. What can we do to remediate such soils or prevent them from occurring in the first place?

Building Healthy Soils

In general, the following practices will help build soils:

1) Organic Matter Management
   - Add organic matter to the soil regularly. Use different types of organic materials.
   - Use different sources of organic materials
   - Reduce organic matter losses
   - Keep soil surface covered with living vegetation as much as possible
2) Improved tillage
   - Minimize tillage intensity
   - Optimize timing
   - Maximize surface cover
3) Minimize soil compaction
   - No traffic on wet soils (by far most important)
   - Minimize soil loading by reducing equipment weight and spreading the load with multiple axles and large tires
   - Use controlled traffic lanes, and take advantage of ridges and beds

Reducing tillage results in many changes in the soil including higher carbon (organic matter) levels, better structure, better water availability, more biological activity, and reduced erosion. Other changes to keep in mind are that soils may also stay cool later in the spring, nutrients may become stratified (higher levels near the surface) because they are not being mixed into the soil profile, and the pH of the surface soil will change more rapidly after applications of lime because the lime is not being mixed with a larger amount of soil.

There is a range of options for reduced tillage, including no-till, strip till, ridge till, and zone till. The cooler soils associated with no-till can be a challenge in the Northeast. Strip, zone, and ridge till are adaptations of no-till that can overcome some of the cool soil problems. The narrow tilled zone warms up faster due to the removal of a small amount of residue, and is loosened and aerated, creating more favorable conditions for germination and growth. My research program has shown that no till is most successful when used with crop rotations rather than in monoculture. Also, we found that using ridges or beds, which force controlled traffic, are very attractive for our climate conditions, especially on medium and fine-textured soils. No-tillage is generally very successful on sandy and gravelly soils, which have lees compaction problems and are more drought sensitive.

We have learned that a good no-till seeder is a critical piece of equipment, because it allows for good seed placement under a range of conditions. Many times, farmers perform intensive tillage just to create a seedbed, while fine tilth is only needed in the soil immediately surrounding the seed. With a no-till or zone-till planter, tillage options are much more flexible. If serious cover cropping is part of the management of the farm, a no-till drill is essential. There should be no tillage prior to cover crop seeding, because that mostly negates its benefits.

Recent studies conducted in Michigan and New York suggest that even when cover crops or manure are used in a rotation, soil organic matter levels don't increase when a moldboard plow is used for tillage. Tillage practices such as no-till, zone-till, strip-till, and ridge-till do result in an increase in organic matter, even when cover crops are not used. In other words, the less the soil is disturbed, exposing organic matter to the air, the less organic matter is oxidized and lost to the atmosphere.

Mulching is another practice that can benefit soil health by providing cover for the surface of the soil and providing a source of organic matter. The use of mulches enhances water availability by improving infiltration into the soil and reducing evaporation from the soil. Mulching provides weed control by shading the soil surface and inhibiting weed germination, reduces splashing of soil and disease inoculum onto leaves and fruit, and reduces infestations of certain insects (i.e. Colorado potato beetle) on plants grown in a mulch system. Also, the temperature and moisture moderation from a covered soil promotes biological activity.

While bringing cut mulch into a field is feasible on a small scale, a different approach is needed for using mulch on a larger scale. Steve Groff, an innovative farmer in southern Pennsylvania has adapted a technique for planting into standing mulch that was developed by USDA researchers. Steve uses a no-till seeder or transplanter to establish a crop into the mulch from a killed rye/vetch cover crop that was planted in the fall of the previous growing season. The cover crop is killed either with herbicides or by a piece of equipment that rolls down and crimps the cover crop just as it starts to flower. You can learn more about this technique from Steve's web site: http://www.cedarmeadowfarm.com/.

What type of tillage makes the most sense on any particular farm? It depends….on the type of operation, the soil types, and the climate. What works for one grower in one part of the state may not work for another grower in another part of the state. Choose a system that is most efficient in terms of energy use and passes across the field, can handle organic matter additions in the form that is available to you, and is appropriate for your management style and operation. Be aware that a there is often a yield reduction that lasts 2-3 years when changing to minimal tillage systems on unhealthy, degraded soils. Start small and develop a system that works for you before using it on your entire farm..

A good resource for learning more about soil health is: *Building Soils for Better Crops* by Fred Magdoff and Harold van Es. It's available from the Sustainable Agriculture Network: http://www.uvm.edu/~nesare/news_BSBC.html, call 802/656-0484 or send e-mail to sanpubs@uvm.edu.

A Permanent Cover Cropping System

Steve Groff, Cedar Meadow Farm
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I started no tilling in the early '80s on about 15 corn acres because we had some erosion problems and I didn't like having to fill in gullies before harvesting corn and I felt that wasn't right. In 1991 I began using a rye cover crop as another soil-conservation measure. In 1994 we stated no-tilling tomatoes and in 3 years, all of our 175 acres of 15 different crops were no-tilled. This "Permanent Cover Cropping System" is done successfully by using cover crops, intensive crop rotation, and long-term no-tillage. I can't say enough how these 3 components are the foundation to make this system work. No-till is not the "magic bullet". It is an equal partner with cover crops and rotation. I use this system for 3 reasons:

- Increase profits
- Enhance soil quality
- Reduce pesticides.

Increase profits

The economics of this system are positive. Total savings when no-till transplanting tomatoes amounts to $675 per acre. Nearly $500 of the cost reduction is from material, labor, and time savings when eliminating the use of plastic mulch. Bear in mind that plastic mulch would still be needed for early-season tomatoes. I have erected a Haygrove multi-bay high tunnel to get the early plantings off to a good start. A saving in tillage is $50/A and $125/A for pesticides (average over 5 years). Increased costs are $50/A for establishment and seed of a cover crop, and $10/A for controlling the cover crop. It's hard to put a dollar value on the other benefits cover crops give such as erosion control, better soil quality, and increased organic matter, but it has to be factored in at least indirectly. On my farm I've been able grow my own cover crop seed and use a rolling stalk chopper to control the covers. This allows me to further reduce expenses. Our yields have increased the last several years and this adds to the profit.

Enhance Soil Quality

Soil erosion is one of the most detrimental aspects of agriculture. We can't turn our backs on soil erosion and call ourselves sustainable! No-till has some very attractive attributes especially when combined with cover crops and crop rotation. SOIL IS MEANT TO BE COVERED! Soil erosion on Cedar Meadow farm has been cut from 14 tons per acre per year to almost nothing. With the ground covered by plant residues and not loosened by vigorous tillage, the soil stays rather than getting washed away during heavy rainfall. With an average soil loss in Lancaster County of 9 tons per acre per year on the typical farm, you begin to realize the importance of keeping this valuable soil resource in place. The combination of cover crops and no tilling does more than cut erosion -- it improves soil tilth, increases organic matter levels, enhances water infiltration and lessens pest problems. Organic Matter has gone from 2.7% to 4.8%. Soil aggregate stability in fields tilled recently (less than 10 years) is 16% and fields that have not been tilled for over 10 years is 67%. Soil microbial biomass has tripled. These results are proof to me that this system is working. Yields have increased 10% over the last several years.

Reduced Pesticides

A good thick mulch helps control weeds and has really cut down on my herbicide bill. It's very important to have a consistent cover crop to make this work. Total pesticide use on tomatoes has dropped from $200/A to $75/A. This is mainly due to fewer fungicides for early blight and insecticides for Colorado Potato Beetle. Consistent with what Dr. Aref Abdul-Baki (USDA Researcher) and Dr. Ron Morse have found, as well as others who have tried no-till tomatoes, the onset of early blight has been delayed. Penn State has a weather station (FAST system) near Cedar Meadow Farm that forecasts favorable early blight susceptibility. I usually am able to wait 3-7 weeks to spray after the FAST system recommended a protective fungicide although this year with constant moisture it didn't make much difference. We've experienced years of extremely different weather conditions -wet, dry, and near normal. In every year, early blight has been delayed with this system. I've also noticed healthier plants even to the end of the season. I've planted a cumulative total of 175 acres of no-till tomatoes the past 9 years and have yet to spray for Colorado Potato Beetles! I haven't used Admire at transplanting. A good thick mulch helps control weeds as well and has really cut down on my herbicide bill**. It's very important to have a consistent cover crop to make this work**. Herbicide use for corn and beans has dropped from $25/A to$18/A. Total pesticide usage on the whole farm has decreased 30%. Beneficial insects have increased.

How the System Works

The foundation of this system is the establishment of a cover crop in the fall. My favorite for transplanted vegetables right now is a mix of hairy vetch (25 lbs.) and rye (30 lbs.). I have successfully no-tilled vegetables into corn and soybean residue with excellent results, however more herbicides, fungicides and fertilizers are needed to control weeds and diseases. I credit rye/vetch giving #50lb. of N and straight vetch #75lb. of N. Vetch seed is expensive so I grow my own with rye. I also have seed to sell.

I wanted to control covers mechanically and in a way that flattens them near the soil to help their decomposition. I ended up buying a 10-foot Buffalo Rolling Stalk Chopper in 1996. It's designed to flatten and chop cornstalks, on a scale between a flail mower and a disk. The machine has two rows of rollers, four in front and four in back, with eight 23-inch blades per roller. The turning rollers crimp up the cover and push it right down. It can be run at 8-10 miles per hour, so it's fast and economical. I added parallel linkage so each roller floats independently. The versatile machine has been used on over 1,000 acres in 8 years. I roll the covers with it, and get good control of hairy vetch and rye if it has flowered. Vetch that hasn't bloomed yet will give some regrowth and needs a low rate of post emergent spray. **It is important to roll the cover before wind blows it in various directions so it is laid parallel to the direction of planting.** I always roll soon after the rye is 4 feet tall, which is around May 10th unless the cover is thin, and will not blow down. If I need to plant before the cover is 2 ft tall I will spray with Roundup 3 days before planting instead of rolling. A cover that is rolled before or during flowering will regrow somewhat and then I spray with 3 ounces of Sencor and 1/2 ounce of Matrix at least 10 days after transplanting tomatoes. Occasionally I will need to do a follow-up spot spray with this same rate. If grasses break though Poast is used to control them. I've successfully eliminated all herbicides when I have a good thick mulch cover and it is fully matured when rolled. This system does have potential for organic growers when a heavy cover is achieved. After harvest, I use the rolling stalk chopper to roll the plant residues and then immediately plant another cover crop.

I've customized an RJ Equipment carousel no-till transplanter for no-till transplanting of tomatoes into killed cover crops. This transplanter has a spring-loaded 20-inch, turbo coulter, followed by a double disk opener and a short shoe to place the transplant in. Angled press wheels tuck the soil firmly around the plant. The package leaves virtually no soil showing after the crop is planted, giving good full coverage mulch for the whole season. RJ Equipment is now manufacturing no-till transplanters on custom order basis. Phone: 519-676-4110

Fertilizer management evolves, as you have become more committed to the use of no-till, cover crops and the overall concept of sustainable ag. Any synthetic N I use is mainly ammonium sulfate as I need the sulfur it supplies, as well as its low volatility. A 30% N blend of ammonium sulfate and Super U is used in side-dressing by broadcasting 40 - 80 lbs. of dry N (depending on contribution of cover). I've found that you need to get N on earlier with the no-till system. I credit my higher organic matter soils of giving me 25lb of N or so from release of additional N and do some foliar feeding as well.

Soil Compaction is to be avoided at all costs! However, once you've no-tilled for several years the soil becomes noticeably less susceptible to compaction. Cover crops are key to this in building soil structure. I'm real fussy about when lime and manure trucks can get on my fields. If you ever need to alleviate compaction, do so with as little surface disturbance as possible. I have a customized 2 shank Unverferth ripper/stripper to go through my field driveways after harvest. This tool has a 3/4" narrow shank that penetrates 12 inches deep and has a 2-inch wide wavy coulter on either side of the shank. This keeps soil from being thrown away from the shank and chops it up a bit. A 12-inch wide rolling basket follows to further break up clods. I am able to plant behind this without needing to disk.

Controlling perennial weeds can be a challenge in no till but I have found that with intensive crop rotation and occasional spot spraying, weeds can be managed effectively. Perennial weeds are not a problem on our farm.

In wet years, you might notice more slugs, but they haven't chewed our fresh-market tomatoes unless the crop is in contact with the soil. I am concerned though with the potential of slug damage and have begun to collaborate with researchers in establishing biological and chemical controls of this pest. Deadline MP has been effective in reducing slugs as well as applying liquid N when they are exposed. Aphid pressure has remained the same.

Video and Web Site

We have produced a video titled, "Cedar Meadow Farm, A Model for Clean Water and Healthy Soil". It shows how our farm handled hurricane Floyd which dumped over 8 inches of rain in 12 hours. Cost is $21.95 each plus $3.00 S/H. To order call (717) 284-5152, e-mail: sgroff@epix.net, or web site: www.cedarmeadowfarm.com. The website also has more information about our farm and the research results that were conducted there.

These examples of the use of cover crops, crop rotation, and long-term no-till are what sustainable agriculture is all about. Don't try and adopt exactly what I have done. You need to adapt these principles to your operation in accordance to the resources, equipment, and experience you've attained. Start small. Learn as you go. Network with researchers, extension agents, and other growers who have been successful. Go to field days or research tours. At the very least, think of one idea you can implement on your farm to make it more environmentally friendly, yet still maintain profitability.

Cover Crops For Soil Health

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Cover Crop Resources

Northeast Cover Crop Handbook, 1994
Marianne Sarrantanio
Rodale Institute

Managing Cover Crops Profitably
Bowman, Shirley and Cramer
Sustainable Agriculture Network
www.sare.org

Building Soils for Better Crops 2nd edition
Fred Magdoff and Harold van Es
Sustainable Agriculture Network
www.sare.org

Sustainable Vegetable Production
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NRAES 152 Riley-Robb Hall
Ithaca, N.Y. 14853

When defining soil health, most scientists will now describe chemical, physical and biological properties as key parts of a productive sustainable soil system. A key component of a health soil cropping system includes ways to increase and manage soil organic matter, by either additions to the system through diverse organic amendments and cover crops or methods to reduce losses of organic matter through conservation practices that reduce erosion or minimize tillage. Cover crop systems work to do both in a well-designed system.

Traditionally, cover crops are delineated in three ways:
Green Manures –Crops for soil improvement including organic matter additions and/or nitrogen fixation with legumes.
Catch Crops –Crops for retaining nutrients after the cash crop has been harvested or after nutrient applications (primarily nitrogen)
Fall Cover Crops –Crops for reduction of erosion from bare or fallow soil.

For this presentation, I have will categorize cover crops by their impact on improving soil health.

Soil and Water Management: When selecting cover crops for soil and water management, one should always consider the impact of rainfall events on bare soil. When soil erodes, it not only represents a loss of soil and nutrients, but also a loss of organic matter as this component of soil is easily detached and lost. Having a crop to intercept rainfall and improve water infiltration is extremely important to long-term soil health. Physical damage to soil structure is prevented with the use of cover crops (improved aggregation and a reduction in soil crusting). Since heavy rainfalls often occur in early spring and late fall, winter cover is extremely important to maintaining soil quality. Cereal Rye (*Secale cereale*) is the most common fall cover crop due to its ability to germinate and grow in cool weather. Heavy soils also benefit from a rye cover crop in the spring, as these soils will dry out faster than bare ground due to the root system of the rye and evapotranspiration by the plants. Many producers choose Oats (*Avena sativa*) as an alternative to rye due to its lack of winterhardiness. It too will grow well in the fall, but will be a dead matt of organic matter in the spring and will facilitate soil preparation for early small seeded crops.

Soil Organic Matter: Growing and incorporating material back into the soil will improve organic matter levels, increase soil biological activity and increase nutrient holding capacity of the soil (Cation Exchange Capacity or CEC). Cover Crops vary greatly in the amounts and types of organic matter they add to the soil system. Buckwheat (*Fagopyrum esculentum*) will produce much less biomass then most other cover crops and also contain very little lignin. Its rate of decomposition in the soil is rapid, so the change in organic matter is small and short lived. Sorghum-Sudangrass or Japanese Millet on the other hand produce copious volumes of carbonaceous material that can be highly lignified if left until maturity before incorporation and can add significantly to the active carbon pool in the soil. When choosing cover crops or rotations that include long term soil cover (sod), it is important to realize the impact of the carbon source, the nitrogen content and the volume and type of root mass on long term organic matter improvement. Sod crops, such as grass legume mixes can significantly improve organic matter in soils due to the large root system these crops develop over the course of one or two years.

Physical Enhancement of Soil: Growing and utilizing cover crops can alter many physical properties of soil. Parameters such as water holding capacity or drought tolerance (organic matter), soil structure (aggregation due to biological activity), improved drainage (organic matter), and reduced compaction (organic matter and plow pan disruption) are all qualities potentially impacted by cover crops. Soils high in organic matter can withstand stressful periods and abuse better than low organic matter soils. Cover crops with deep taproots such as alfalfa (*Melitotus satvia*) and Sweetclover (*Melitotus officinalis*) have the ability to disrupt compacted soils or plow pans and leave large pores in compacted soil layers when the roots die off.

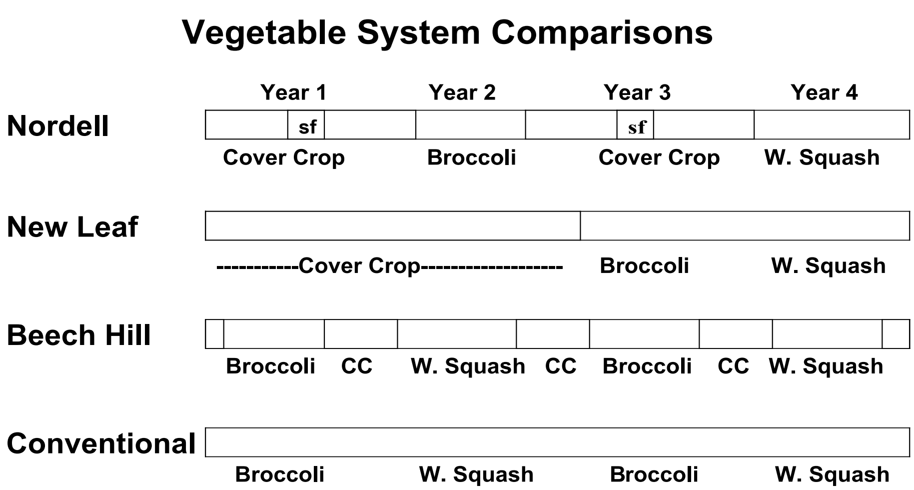
Soil Fertility: Cover crops add and retain plant available nutrients in various ways and forms. Legumes and their ability to “fix” atmospheric nitrogen through a symbiotic relationship with rhizobia bacteria will add nitrogen to the soil when the crop is incorporated. The amount of N can vary greatly depending upon how much biomass is included when the cover crop is turned into the soil. Legume cover crops have also been shown to help promote the development of mycorrhizal fungi in the following crop. These fungi help plants take up nutrients, improve nitrogen fixation, and help to form and stabilize soil aggregates. Roots with large amounts of mycorrizae are better able to resist fungal diseases, parasitic nematodes and drought.

Any cover crop that is incorporated when green (green manure) will provide a flush of plant available nitrogen. The rate and amount of nitrogen release will depend on several factors, including the maturity of the crop (carbon to nitrogen ration increase with increasing maturity), the time of year and the soil temperature when it is incorporated. Highly carbonaceous crops (mature rye for example) will actually cause a period of “nitrogen lockup” due to immobilization of the nitrogen by microorganisms consuming the carbon.

Cover crops are also useful in “catching" excess plant nutrients, especially nitrogen, in the fall to avoid losses due to leaching during the winter. Cereal rye and oilseed radish seem to be the most effective at scavenging nitrogen with cereal rye potentially capturing up to 70 pounds of N per acre in a September seeded crop. Other traditional fall crops such as oats that are winterkilled, loose their ability to hold nitrogen as they die and 'leak" nutrients as cell walls deteriorate. Capturing of N in the fall is increasingly important to organic growers who may be applying manures in the fall to vegetable ground to meet harvest restrictions under the new National Organic Program (NOP).

<u>Weed Suppression:</u> Although not directly related to soil health, cover crops do play a role in weed suppression. Competition for nutrients and light, smothering by cover crop residues and allelopathy all can play a role in reducing weed pressure in succeeding cash crops. No-till vegetable systems use smothering as a key part of weed and moisture control. Fast growing crops such as buckwheat out compete weeds for light. Various cover crops release chemicals during decomposition that inhibit small seeded weeds from germinating. This allelopathic effect is most common in cereal grains, but research is on going with other cover crops as well. A Maine study by Dyck and Liebman (1994) demonstrated that crimson clover residue was able to suppress lambsquarter emergence by 27%. More recently, researchers have turned their attention to the use of brassicas as crops to reduce weed seed viability.

One of the issues related to soil health and cover crop systems is the impact of tillage operations. Often, growing a cover crop will mean additional tillage, which may have negative impacts on soil quality. Currently in Maine, researchers Gallandt and Sarrantonio are conducting a SARE project entitled "Diversity and Intensity of Cover Crop Systems: Managing the Weed Seed Bank and Soil Health." This project is comparing 3 different cover crop systems currently being used by farmers in the northeast with a conventional rotation to evaluate the impacts on weed seed bank changes and soil quality over a three-year period. One of these systems includes a period of summer fallow (Nordell system).



Shaded areas denote cover crop; "sf" denotes summer fallow

Another area of research in Maine with cover crops and soil health is focused on the role of brassicas and their potential impact on weeds (Haramoto and Gallandt), and their role as a "biofumigant" for soil diseases (Griffin, ARS). Brassicas contain glucosinolates, which are responsible for the potential beneficial effect. Research in Aroostook County has shown promise that brassica crops (canola) in rotation with potatoes reduce the severity of Rhizoctonia infection during the potato rotation. Ida Gold, a yellow condiment mustard seems to have one of the higher glucosinolate concentrations among the brassica species. Researchers are also investigating the potential negative impacts that these cover crops may have on beneficial soil microorganisms.

Cover crop systems must be chosen with numerous parameters evaluated in the decision. Producers should choose a system that meets their production schedules, matches their rotations and equipment and helps them improve soil quality over time.

Mineralization of Nitrogen from Compost

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Introduction:

Compost and other amendments play several roles in vegetable production systems. Most often, they are applied as "soil conditioners;" because they contain stabilized carbon (C), they can improve many physical properties of soils, including water-holding capacity, aeration, and aggregation. They also contain a broad range of nutrients, including macronutrients like nitrogen (N), phosphorus (P), and potassium (K). We have had a difficult time predicting the rate and extent (i.e. when, and how much) of N release from compost. These characteristics are affected by compost characteristics, maturity, soil type, and environmental conditions. We also need to be aware of the fact that N is released from current *and past* compost applications. In the following, we summarize some results of lab, greenhouse, and field research on the availability of N from composts.

Compost Effects on Soil Properties and N Release:

The Potato Ecosystem Experiment, developed and managed by the University of Maine at the Experiment Station Farm in Presque Isle, ME, offers a good chance to look at the impacts of long-term compost application. This experiment was started in 1990, and includes amended and non-amended plots in a 2-yr barley – potato rotation. Soil samples were taken in 1999, following eight consecutive years of compost + beef manure application. A number of soil properties were measured, and several are summarized in Table 1. Clearly, the application of these amendments greatly increased the amount of C in the soil. This is true for "total" C (a big pool of C), particulate organic matter C (which is easily degraded and releases N), or the amount of C tied up in soil microbes. This, in turn, improves the physical properties as discussed above.

Table 1: Changes in soil C as a result of eight years of compost + manure application. (Griffin and Porter, unpublished data).

	Total Carbon (%)	**Particulate Organic Matter C** (% of total C)	**Microbial C** (mg per kg of soil)
Amended	2.20	39.3	454
Unamended	1.58	24.3	252
% increase from amendment	39	62	80

These annual amendments have resulted in consistent potato yield increases, ranging from 0 to 25%, depending on climate in any particular year. The amendments have also almost completely eliminated fertilizer application in the 2-yr rotation (except from some N applied at potato planting).

Greenhouse Experiment on Compost N Release for Lettuce:

During the winter (2002-2003), we conducted a greenhouse experiment with lettuce, in an attempt to answer grower questions about the availability of N from composts, and from the raw stock materials used to make the compost. Specifically, the grower had access to by-products from a baked bean processor ("bean waste") and from a fish processor ("fish waste"). One option would be to use these materials raw, and presumably they would have a large amount of rapidly available N. Alternatively, each of these materials could be stabilized by composing with sawdust, horse manure, or some other C-rich material. The grower had also tried simply mixing the fish waste with sawdust, allowing the mixture to sit for 2-3 days, and then spreading it. The grower thought that the sawdust would tie up the N, and that this N would be released later. We included all of these options, along with an un-fertilized treatment, in the greenhouse experiment. Some initial assumptions had to be made regarding N availability, in order to calculate application rates. This information is summarized in Table 2.

Table 2. Characteristics of amendments used in greenhouse lettuce experiment.

Amendment	**Dry Matter**	**Organic N**	**NH_4-N**	**Target Application**
	--------------------	%	---------------------	
Bean waste	36	1.49	0	100 lb PAN, 80% avail.
Bean compost	100	1.36	0	100 lb PAN, 10% avail.
Fish waste	12	1.07	0.15	100 lb PAN, 80% avail.
Fish waste + sawdust	50	0.25	0	100 lb PAN, 80% avail.
Fish compost	100	0.79	0	100 lb PAN, 10% avail.

Amendments were stirred into 400 g of sandy soil, and packed into 4 inch square pots. Lettuce (3 leaf stage, variety 'Winter Density) was then transplanted into each pot, and all pots were well watered for duration of experiment. An additional set of pots, treated the same way except *without plants*, were used to monitor soil N level after amendment application. In these plots, soil samples were taken every 7-14 days, and soil NH_4 and NO_3 were measured. Lettuce was harvested after 45 days. Leaf material was weighed wet, then dried and re-weighed. It was then ground and analyzed for N concentration. Immediately after harvesting lettuce, perennial ryegrass was planted in each pot, and harvested after 28 and 56 days, to evaluate residual N availability.

Both composts clearly increased lettuce growth and leaf N concentration at harvest (see Table 3). This was not surprising when compared to an unfertilized pot, as this was a sandy soil with relatively low organic matter. What was surprising is that the raw bean and fish wastes did not *appear* to affect lettuce yield; at first glance, it looked like they did not supply any N to the lettuce. However, the fact that raw stocks increased N concentration in the leaves is the first indication that N was released. The other indication comes from the second set of pots without plants. As shown in Figure 1, raw fish waste with or without sawdust released N very quickly, before there was any significant plant demand, while the bean waste released very little N.

Table 3. Greenhouse lettuce yield and leaf N concentration from addition of fresh and composted bean and fish wastes.

Amendment	**Leaf Dry Weight**	**Root Dry Weight**	**Leaf N Conc.**
	----- grams / pot ------		%
Control	0.80	0.52	1.52
Bean waste	0.72	0.58	2.68
Fish waste	0.81	0.68	3.03
Fish waste + sawdust	0.87	0.63	3.01
Bean compost	2.32	1.44	3.24
Fish compost	2.40	1.15	4.64
LSD	0.51	0.28	0.39

The composts, in contrast, released N for the duration of growth. The high level of N in the soil also indicates that all application rates were probably too high. Both composts used here were not fully mature, as indicated by ammonia smell from both. This results in more rapid N release than with fully mature materials. This was confirmed by the growth of the two subsequent ryegrass crops, shown in Table 4. Fresh weight of the ryegrass was roughly three times greater in compost amended pots amended with fresh materials. This again points out the need to account for nutrient availability from the composts, which are certainly variable, rather than following the "more is better" line of thinking.

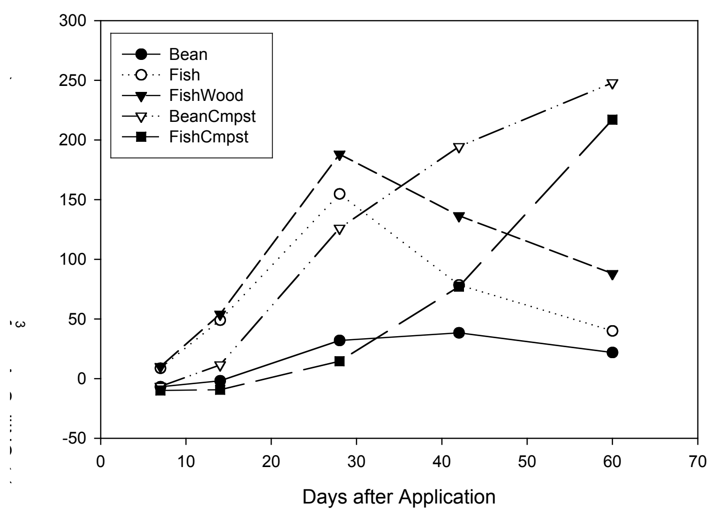

Figure 1. Changes in soil N level after application of fresh and composted bean and fish wastes.

Table 4. Growth of ryegrass in pots amended with fresh and composted bean and fish wastes, after removal of lettuce crop.

Amendment	First Ryegrass Cutting	Second Ryegrass Cutting	Total Yield
	-------------grams / pot -------------		
Control	1.4	1.1	2.5
Bean waste	3.2	2.1	5.3
Fish waste	4.2	2.5	6.7
Fish waste + sawdust	6.8	3.4	10.2
Bean compost	11.5	7.8	19.3
Fish compost	14.1	9.8	23.9
LSD	2.1	1.1	

<u>Followup Field Evaluation of Compost N Availability:</u>

In Spring/Summer, 2003, we conducted a small plot field experiment to followup on some of the lessons learned in the greenhouse. This experiment had only four treatments: an unfertilized control, fish compost applied at rate the grower had previously used (40 lb total N acre) and twice grower rate, and a 10 day old mixture of fresh fish waste and sawdust. Plots were amended on May 16, and lettuce seedlings were transplanted at a 12 inch spacing on May 30. Lettuce was harvested on July 16. Soil samples were taken periodically from each plot to measure soil NO_3 level.

Lettuce yield was identical for the unfertilized control and both compost application rates, indicating that either the rates were too low (and no N contribution was realized) or N was not limiting in the control plots. The soil NO_3 levels again provide some clues on the response; soil N levels in roughly the last month of lettuce were slightly higher with compost (1x) and higher still with compost (2x). In general, however, soil NO_3 levels were in the range of 20-30 mg kg^{-1} soil (ppm) during this period. This means that some N was released from the compost applications, but there was also significant N available from soil organic matter. The field used for this experiment was consistently cover cropped with hairy vetch pus winter rye, and received small amounts of compost (as were used in this experiment), and provided more N than would be expected from a very sandy soil.

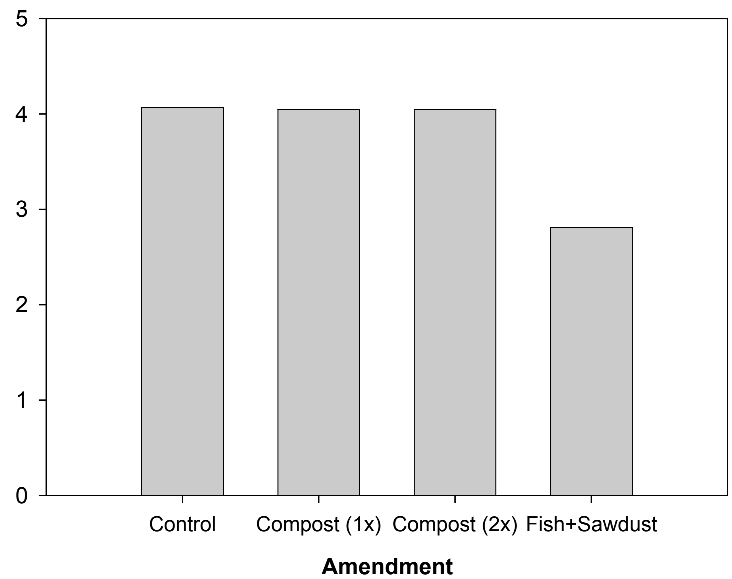

Figure 2. Lettuce yield following amendment with compost, from field experiment.

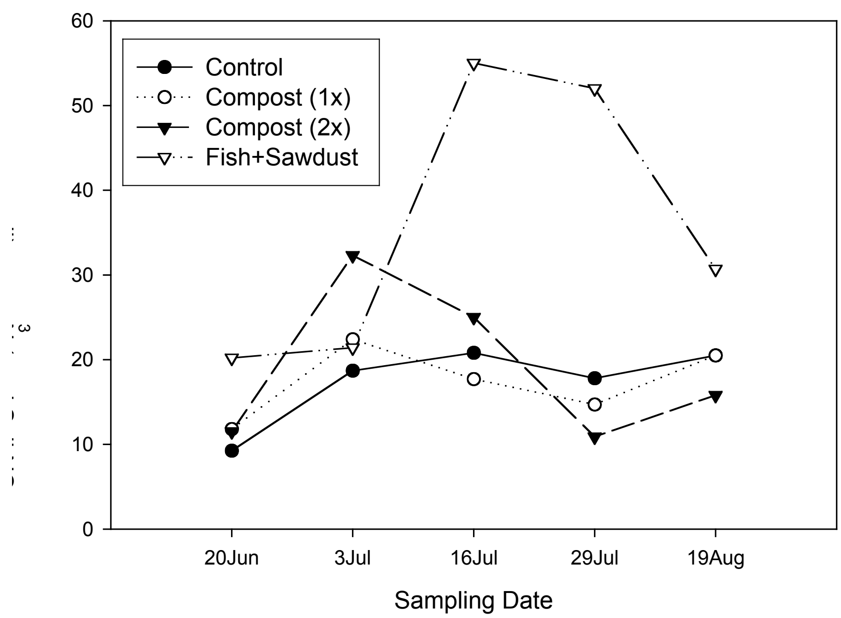

Figure 3. Changes in soil NO_3 in field experiment evaluating fish compost N release.

The effect of applying freshly mixed fish waste and sawdust is interesting. There was a yield reduction of about 40% from this treatment, which could have two causes. First, it could be that the sawdust caused a short-term immobilization of soil N. From June 20 onward, the level of soil NO3 was similar or higher than the other treatments, but may have been lower initially. Many crops are particularly sensitive to N shortage early in the season, and reductions in growth rate early can not be overcome later. By the time lettuce was harvested (July 16), soil NO_3 levels in this treatment were more than three times *higher* than other treatments, in the range or 50 mg kg^{-1} soil, and this N is almost certainly going to be lost if there is no plant demand. The other possibility, which is less likely, is that there is a phytotoxic effect from the fish and sawdust mixture. However, the mixture was made almost a month before lettuce transplanting, so water-soluble phytotoxic compounds would have been lost in the interim.

Lessons Learned:

The results of these simple experiments are reminiscent of Goldilock's; we started with too much available N (greenhouse), moved to too little available N (field). Can we define the "just right" available N scenario? Maybe not precisely, but in general. We learned that the availability of N from immature compost is higher/much higher than our initial assumption of 10%, and could be more like N availability from manures of 25-35%. The mature material used in the field experiment (produced in Fall, 2002 and applied in Spring, 2003) is more representative of soil conditioning composts, and it does appear that N available is fairly low. Even though we did not see a yield response in the field, we also did not see dramatic differences in soil NO_3 levels for several months after application. If availability of N from this material were at the 25-35% level discussed above, we would have observed elevated NO_3 levels, especially in the month after the lettuce crop was removed. We also confirmed, from the long-term potato experiment in Presque Isle, that consistent compost application adds significant amounts of C and N to the soil, and can displace synthetic fertilizer as a result.

Nutrient Status of Organic Vegetable Fields in Northeast US

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Introduction

The fertility of organic vegetable fields often is maintained by additions of organic amendments. Maintaining optimum levels of nutrients, especially N and P, is difficult when organic amendments are the primary source of nutrients. The objective of this study was to survey the fertility status of organic vegetable fields in Northeast US.

Methods and Materials

Soil samples were collected from 153 organic vegetable fields in 5 states: Maine, New Hampshire, Massachusetts, Connecticut and New Jersey. One set of samples was collected in May, June or July from the surface foot of soil for soil nitrate. We used these samples to document the nitrogen fertility of the soil. Another set of samples was collected in October or November from the surface 6-inch layer of soil for pH and macronutrient (Ca, Mg, P, and K) fertility. We collected samples from 31 farms. We did not randomly choose the farms. Farms were chosen to provide a distribution of factors thought to affect fertility, such as length of time in organic production, and type of compost or manure used to maintain fertility. The modified-Morgan extract was used to categorize the macronutrient fertility of the soil. Soil pH was measured in a 1:1 soil:water mix. Soil nitrate was extracted using 0.01 M $CaCl_2$ and measured using the cadmium reduction method.

We collected information about the history of the field management from each farmer. The type of information collected included: type of nutrient applications, frequency of nutrient applications, tillage, cover crop use and cropping pattern, etc.

Results and Discussion

Selected information about the management of the fields is shown in Table 1. Most of the farms use compost and some use manure. All of the farms use winter cover crops (data not shown) and about half of the farms use season-long cover crops. These practices reduce erosion and nutrient losses from fields.

Table 1. Selected management information about the fields and farms[1]

	% of fields	% of farms
Use compost or manure	87	17
Don't use compost or manure	13	83
Type of raw manure used		
Don't use	73	75
Chicken manure	9	8
Cow manure	11	12
Poultry ranging in fields	8	8
Type of material used to make compost[2]		
Don't use	27	33
Chicken manure	10	17
Dairy manure	11	12
Horse manure	16	17
Leaves	7	8
Mushroom soil	23	17
Don't know material	5	4
Use of season-long cover crops		
Use	46	52
Don't use	54	48
Type of tillage used		
Rotovator or rototiller	47	48
Other tillage (plow disk, etc.)	53	52

[1] Based on a total of 128 fields and 25 farms.
[2] Primary type of material used. Most compost made from more than one material.

A summary of the soil test categories is shown in Table 2. Heavy rainfall shortly before planting probably reduced soil nitrate concentrations. Spring rainfall is known to affect PSNT values (Balkcom et al., 2003, JEQ 32:1015-1024). For this reason, the PSNT categories may not accurately represent the nitrogen fertility of the fields.

The high percentage of fields with P values above optimum are mostly due to long-term applications of manure, manure-based compost or mushroom soil. The fields testing below optimum for P may not show P deficiencies due to the more efficient cycling of P in organic vegetable fields.

The high percentage of fields with Ca and Mg values above optimum are mostly due to long-term applications of poultry manure, poultry manure-based compost or mushroom soil.

Table 2. Summary of soil test values on 153 organic vegetable fields in 2002.

Nutrient	% below optimum	% optimum	% above optimum
PSNT	58	14	28
P	27	12	61
Ca	19	11	70
Mg	10	12	78
K	32	22	46
pH	3	65	31

Categories based on modified-Morgan soil test critical concentrations
pH below opt=<6.0; above=>7.0

Conclusions

Organic vegetable growers could improve the sustainability of their farms by developing and implementing nutrient management plans. Implementation of nutrient management plans should minimize over and under application of nutrients and improve the profitability of organic vegetable farms.

Connecting to Your Markets – The Other Half of your Job

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If you grow it, they will not (necessarily) come.
All of us in business today face a constant challenge – our customers have multiple choices for everything we could possible offer them. So just because we're very good at creating, building growing something, that in and of itself is no guarantee that anyone will buy it or will buy it in volumes that enable us to enjoy a thriving business.

The challenge for all of us, therefore, is the other half of our job – connecting to our clients. But like every other aspect of your operation, effective marketing is a complex function that takes the same level of skill and dedication as it does to manage your orchard or farm. My task this morning is to in 30 minutes provide an outline of how you can more effectively connect to your customers, and share some knowledge that may help you enhance your business success.

What do your customers want… that you have?
Some years ago we conducted a study which focused on identifying ways to increase the volume and value of processed agricultural products produced in the Connecticut River Valley . This was a classic marketing study because very little data existed regarding the channels available to you through which to market your products, and the needs that each of the "multiple customer" in these channels have that you need to know and address.

In our short time together this morning I'd like to look a two fundamental channels – direct to consumer and wholesaling.

First, let's look at direct to consumer marketing.
You can market directly to your end customer or consumer in a number of different ways – pick your own, a farm stand, direct mail, web marketing. In each of these channels you directly control the relationship – the most advantageous position for any marketer to be in. Yet it also means you now have responsibility for identifying, understanding, and fulfilling the needs of these customers if your are to be successful.

So what do they want? We conducted a number of focus groups with consumers to identify their knowledge and needs of locally grown or produced foods. The most important – the story behind the product. They indicated they could get jams and jellies at any grocery store, but locally (or regionally) produced items gave them a chance to connect to something larger than the product – an experience that provided them with something that they themselves could not provide themselves, but was seen to be of value for many reasons (historical, cultural, environmental, etc.).

Interestingly, the second most important need was knowing how best to use what you offer. For processed foods (jams, jellies, etc.), consumers are accustomed to knowing how to use the brands from their supermarket (the market power of the familiar). What they do not know is how to use your processed food – how it will taste, cook, what recipes it will work best in, other tips. Sampling was seen as a key enhancer of sales, even if your products were available in the local supermarket.

Other key concepts we learned about consumers included:

- Consumers are willing to pay a premium for a product if they perceive that they are getting a better value; however, the consumers in one focus group indicated the need for competitive pricing if specialty foods are to become more widely accepted and purchased;

- The brand of a product is less important than the fact that it originated in New England. When buying a product from New England, the consumer transfers the characteristics of the region to the product. There also is a connected feeling when a consumer buys a product that is locally produced, as well as a feeling of contributing to one's own community;

- Over and over, the participants in our focus groups stated that they read the packages of food products, either in the store or while they cook. From the labels, they enjoy learning about the story behind the product and finding the producer to be "a real person." By knowing more about the person and the history behind the product, they feel connected with the product and this connection adds the critical value to their purchase. The participants' desire to understand the product's story was a common thread woven throughout the focus group session in their understanding and perception of the products themselves, as a critical part in effectively positioning the product in a market overflowing with national brands. These consumers consistently expressed their desire for creative packaging representative of the story, more effective presentation and display in the retail outlet, and suggestions for promotional efforts;

- Because of the customary pricing of specialty items above the cost of national brands, consumers value the opportunity for samplings. They feel there is a measure of risk in buying an untried brand, and this precludes many initial purchases without prior sampling;

- Suggesting low-prep methods of experiencing a specialty food item takes the preparation risk out of the purchase and the item becomes more accepted for everyday use;

- Packaging is critical to the consumer, to catch their attention and set the product apart from its competition. The history and the story of the products has to be a part of the packaging to entice the consumer to notice it and to make the personal connection with the product;

- Specialty products are currently bought on special occasions, when entertaining guests, on weekends, for a treat and when there is more time to prepare food;

- While on vacation, consumers are not as cost-driven as during routine periods of time; they are more willing to splurge while on vacation. This is the "prime time" to sell more locally produced specialty foods, and to begin a “direct marketing” relationship with that customer where repeat sales of your product enable them to have this experience the other 50 weeks of the year.

Beyond these specific needs, consumers identified several broader issues that can be part of you connect to them:

- **food safety and source** – in this era of many choices, people have been disconnected from any relationship or knowledge as to the source of the food they consumer, and this concerned many we talked with. This need has further been exacerbated by 9/11;
- **community connection** – in our highly mobile society, you are one of the most stable business segments, you offer connection to members of your community that very few institutions can match. Creatively building this into your marketing strategy can offer a very strong appeal.

With all of your marketing information, it is important that it be obtained and updated regularly to understand consumer's changing needs.

So how can you address these notions in an organized way? Below is an expanded Marketing Mix borrowed from the tourism industry that we call the 9 P’s of Agri-Marketing:

- Product
- Place
- Packaging
- Production
- Presentation
- Positioning
- Partnerships
- Pricing
- Promotion

Here is a brief definitions of each – consciously considering and building each one of these into your marketing efforts, specifically those aimed at your direct customers – will strengthen your results.

Product – Look at and consider all aspects of what is being produced – not just ingredients or contents or the generic category (jams or jellies) but all aspects of your unique “story. Producers should develop this expanded sense of their product to meet not only the needs of the end consumer, but every “customer” in any distribution channel.

Place - Place plays an important role in marketing a value-added food product. Producers should be aware of how and how not to capitalize on it. Local and state history, the history of their family and /or farm, geography, culture, lore are all critical aspects of place that offer rich ways to expand how your consumers relate to your products.

Packaging - Packaging is one of the most important features of the product because it is sometimes the consumer’s first (and only) exposure to the product and producer. Once attention is captured, the packaging can also determine the level of interest maintained by the consumer. Packaging must also be designed to capture the interest of every entity in the chosen distribution system.

Production - The "what & how" of creating your products – both from a process, systems, compliance and financial standpoint offer potentially strong "story" points. Creating and sharing a story of how you produce your product can be a strong way to connect this aspect of your product with your customers, particularly from a health and wellness standpoint.

Presentation - Both verbally and visually, your "presentation" is the single most important factor in gaining market access and acceptance. A producer's presentation of the product secures the sale to the next customer downline in the chosen distribution system, as well as to everyone in the system.

Positioning - Value-added products should not all be positioned the same. Doing the hard work of understanding how and why your product is different, and translating this into messages and benefits customers will value is an essential part of any marketing effort.

Partnerships - Partnerships could be made with retailers in the form of providing demonstrations, with local tourist businesses, or with other producers in joint promotion efforts. Identifying and building effective partnerships are ways to further expand the value of your product, and increase your marketing reach and impact.

Pricing - It is clear that many producers are not familiar with pricing strategies. With pricing being impacted by the market, production costs, channel selection and cost, this is an area where formal training is highly valuable.

Promotion - Producers should be aware of the various levels of promotion available, so that they can make an educated decision about what is best for their budget and most effective in reaching their target markets.

Wholesale or indirect Marketing
For the remaining few minutes of our presentation I'd like to focus on other channels we've studied and some of the considerations for producers when looking at various wholesale channels out there. Wholesaling offers the option of moving larger volumes of product, though at reduced prices because of the channel costs associated with other channel members moving your product and needing to make a profit as well.

First, in this same study mentioned above, we interviewed a number of major wholesalers and retailers in the food service and grocery industry regarding their inclusion of locally grown or produced foods. This included Associated Buyers, C&S Wholesale, KDI, Stow Mills, Grand Union, Shaws, Bread & Circus, Trader Joe's, Vermont Roots, Cricenti's Markets and others. Here are some of our key findings:

Retail Buyer Perceptions
Like the producers, no two retailers are quite the same. All recognize the importance of fresh and locally produced agriculture to their customers, and most try to support local producers when they are

not bound by corporate procedure. Buyers for retail stores, not surprisingly, look for the same qualities in a product as their customers:

- Retailers will not pick up a new product, regardless of how innovative or unique, unless they believe the producer will be able to meet consumer demand. Producers must demonstrate that the product will be available in quantities which meet the buyers needs while maintaining consistent quality;

- Uniqueness and "stand-alone" quality came up repeatedly in conversations with retailers. The term "stand alone" refers to the product's ability to fulfill consumer expectations based on the taste, texture, versatility of the product itself, aside from its attachment to promotional hype. As an example, while retailers acknowledged that Vermont's image is strong in the promotion of Vermont products, they also caution that it could evolve into a diluted notion if over-emphasized and the products this notion is attached to have few unique, redeeming qualities of their own;

- Buyers and retailers expressed a desire for the producer to promote their products. While this is most commonly done through demos, buyers also look for the producer's ability to ultimately engage in advertising and other product promotional activities. This also may mean being flexible about giving price breaks for special promotions. At a minimum, a producer must be versed in educating a buyer to the unique benefits of their product so that the buyer can in turn express this to their consuming public;

- Packaging and presentation are critical components of the product for each entity in the distribution chain. Shelf space is too precious and products with unfinished or unsophisticated packaging won't be considered;

- Because of the increased competition among retailers, featuring unique products is a way to differentiate and remain competitive. Retailers concur that part of a product's notability comes from its connection with the local area or region, as well as from knowing about the producer. In this sense, retailers also try to establish connections between the products they sell and their customers who also happen to live in these same regions;

- The buyers we interviewed spoke favorably of the aggregated "selling power" of produce co-ops. Buyers consistently referred to the capacity of these co-ops to help buyers by reducing the effort it took to get the products they need when they needed them. In contrast, almost all buyers stated that this is lacking in the specialty foods industry, where there are few specialty food distributors who can meet their needs with this same consolidated "selling power." The Hanover Co-op is one of the few retail stores who deals with each producer individually, but has expressed the difficulty in doing so as well as the desire for an aggregated system of purchasing local products. Bread & Circus and Shaw's will handle some relationships with producers on an individual basis, but have difficulty in managing a large number of these singular contacts;

- On a positive note, retailers, buyers and distributors all believe the demand for specialty – gourmet, natural and health foods – will continue to grow.

Distributor Perceptions
Distributors we interviewed had many of the same comments as retail buyers. Most did not want to deal with a wide range of single, small producers, but again preferred to work with larger, integrated efforts such as production cooperatives or producers represented or aggregated by a broker. There also appeared to be a clearer distinction between produce and processed or specialty foods. C&S in Brattleboro indicated a strong desire to buy as much local produce as possible from the Connecticut River Valley, while having very little interest in distributing processed or specialty foods.

Many commented on the lack of understanding of market distributions systems exhibited by producers. Some had producers approaching them before they have finished their packaging and before they have done their pricing homework. From their perspective, producers do not understand the role that distributors play in the system, and are not prepared to price their products accordingly. Like the consumer and the retailer, the distributor wants the product's packaging to be complete by the time the product reaches their hands.

Concluding thoughts.
Marketing – like production – can be a complex and sophisticated process. Yet its principles are common-sensed based, and when creatively applied from a basis of knowledge, can generate the results you desire and deserve for your operation. To help re-energize or refocus your marketing efforts, I would propose the following definition of effective marketing:

Marketing is a good story, well told.

And, in telling your story, one of the best ways to do is to follow the counsel of one of the leading markets in the US:

Marketing is everything and everything is marketing.

Every contact, every interaction with any of your customers, or those who influence your customer, is a marketing opportunity. Make the most of them to tell your story well, and connect to your markets.

Thank you.

The Uphill Adventures of Red Tomato

Michael Rozyne
NEVB Presentation *December 16, 2003*

An outline to guide the presenter (not necessarily to aid the general reader)

INTRO

• personal intro: my people, in the blood, re: Poland

• story begins, not in New England, but in Peru (though it ends in Poland); who would have thought the simple task of growing/selling food...soooo much risk

• the fair trade formula: addressing human rights, survival through trade: price, credit, democratically-run co-ops, business transparency

• BRIDGE to the home turf: FSC; met Shirley Sherrod in 1999; civil rights work

(LOST IN) TRANSLATION: FROM COFFEE TO STRAWBERRIES

• QUESTION: how to conduct business as if farmers mattered...a lot

• lost in translation: product stability (nonperishability) and the margin or profitability

• RT differences: nonprofit; product quality; social/enviroinmental benefits□icing vs. cake

FALSE PEAKS IN THE UPHILL ADVENTURES OF RED TOMATO

• 1997 a marketing and promotion campaign *(limitation: no distribution)*

• 1998 distribution pilot *(limitation: no truck)*

• 1999 one truck; 1-man-show; FSC watermelons at S&S
(false peak: no infrastructure: QC, refrig, staging, database/technology)

enter: EE & Oxfam & indiv: infrastructure June 10

• 2000 & 2001 significant growth; working systems; QC success; melons
(limitation: competition; customers morph into competition; labor costs)

• 2002 new facility *(limitation: cost of distribution)*

crash of June 2002

• 2003 brokering/wo/ the overhead

INTENTION--IN TENSION

- constant reinvention: slogan/way of life
- surrender□it_sthe journey
- Is there a model here? new business□training/consulting/coaching
- financial health and sustainability

FINAL CREDITS

- FSC: steady growth; **Shared Interest loan**; stable secondary supplier
- no reinvention: MISSING LINK□the brokerage direction; improved productivity
    - S&S 2003; one step forward, one step backward
    - SHAPIRO/ Donelan_s/ Harvest
- TCC program to be launched
- END: back to Poland

Marketing Trends: Specialty Vegetables & Fruits

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SUMMARY NOTES
NEW ENGLAND VEGETABLE & BERRY CONFERENCE

- **ROOTS**
- **FOOD SAFETY & HACCP CERTIFICATION**
- **FOOD TRENDS & PRODUCT DIVERSITY**
- **GROW IT LOCALLY**
- **TAKING ADVANTAGE OF YOUR NATIONAL ENVIRONMENT**
- **PROPER PRESENTATION & QUALITY STANDARDS**
- **SUSTAINABLE AGRICULTURE**
- **INNER CITY FARMING**
- **SALES & DISTRIBUTION**

Strawberry Variety Update & Review

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Strawberries are one of the most variable and temperamental of the fruit crops and many varieties are available because individual varieties are often adapted to a relatively small growing region. June-bearing types are most commonly grown in north-central and northeastern North America, but interest is growing in day-neutral types grown on plastic. If you are looking to try a new variety Darselect and Cabot produce high yields or if you want to see the latest thing, L'Amour (NY1829) and Clancy (NYUS304B) are new releases from Cornell with great promise. No variety will be perfect so try new ones on a limited scale to determine how they will perform in your operation.

A replicated trial with 10 varieties, each with three 7.6 m (25 ft.) plots, was established in 2001 in Geneva, NY. A standard matted row system (Pritts and Handley, 1988) with an initial plant density of 17,940 plants per hectare (7,260 plants per acre) with overhead irrigation was used. Bare root plants were planted at 46 cm (18 in.) spacing in rows with 1.2 m (4 ft.) apart. Napropamide (Devrinol) was applied at the labeled rate in the establishment year for weed control followed by supplemental hand weeding later in the season. During the harvest seasons weed control was accomplished using napropamide and sethoxydim (Poast) in the spring and 2,4-D at renovation and in the late autumn after dormancy had set. This was supplemented with hand weeding as necessary. No fungicides or insecticides were used during this trial.

The soil type in the field was Honeoye fine sandy loam with approximately 2% slope. After the establishment year, calcium nitrate was applied at the rate of 140 $kg•ha^{-1}$ (125 $lb•ac^{-1}$) in April. During renovation, ammonium nitrate was applied at 202 $kg•ha^{-1}$ (180 $lb•ac^{-1}$), and SulPoMag (22%K_2O-11%Mg-22%S) with 28.8 $kg•mt^{-1}$ (70 $lb•t^{-1}$) of 15% borate was applied at 252 $kg•ha^{-1}$ (225 $lb•ac^{-1}$) in late autumn.

The plots were harvested three times per week during the summer and total yield per hectare extrapolated from the plots. Harvest on each variety ended when the average fruit weight on a harvest day fell below 8 g per berry. Samples of 10 fruit were taken from 6 of the varieties during the 2003 season for storage trials and 5 varieties were included in a blind taste test with growers during a field day in Geneva. Total yield, percent marketable yield, and average fruit weight over the season were calculated (Table 1). Average harvest dates from 2002 and 2003 were recorded (Table 2), and results from the storage test and taste test are in Tables 3 and 4.

Table 1. Total yield, percent marketable yield and mean fruit weight for 10 strawberry varieties in Geneva, NY. Fruit was harvested until the mean weight was below 8g/berry. Fruit over 8g with no rots, deformities, or damage were considered marketable. Yield was extrapolated from three 7.6 m plots planted at an initial density of 17,920 plants•ha^{-1} in a matted row system. (1 kg/ha=0.89 lb/ac)

Variety	Total Yield (kg•ha^{-1})		% Marketable Yield		Mean Fruit Weight (g)	
	2002	2003	2002	2003	2002	2003
Cabot	29,070	17,380	79	76	17.7	15.5
Brunswick	20,060	21,690	66	73	10.8	12.2
Darselect	23,530	16,120	74	76	11.5	12.0
Clancy (NYUS304B)	15,240	18,680	78	85	12.3	13.9
Honeoye	18,280	14,470	70	84	10.7	12.4
Jewel	20,250	11,650	77	87	10.5	12.9
L'Amour (NY1829)	15,930	14,950	80	77	12.3	11.4
Eros	22,340	6,680	77	68	12.6	10.9
Sable	12,650	10,330	51	75	8.7	10.2
Earliglow	13,040	8,160	60	75	8.6	10.2

Table 2. Average harvest dates for 2002-03 for 10 strawberry varieties in Geneva, NY. Presented in order of 50% harvest date.

Variety	**First Harvest Date**	**50% Harvest Date**	**Final Harvest Date**	**Harvest Length** (days)
Earliglow	June 13	June 18	June 22	10
Sable	June 13	June 19	June 22	10
Honeoye	June 14	June 21	June 25	12
Brunswick	June 15	June 22	June 27	13
L'Amour (NY1829)	June 17	June 23	June 29	13
Jewel	June 17	June 24	June 28	12
Darselect	June 16	June 24	July 1	16
Eros	June 21	June 27	July 3	13
Clancy (NYUS304B)	June 18	June 28	July 4	17
Cabot	June 21	June 29	July 6	16

Table 3. Mean storage ratings for 5 strawberry varieties in Geneva, NY. Ten fruit samples were taken at 3 harvest dates during the season and stored for 6 days at 1°C. (Scale 1-5; 5=best)

	Firmness		**Bruising**		**Sepal Appearance**		**Overall Appearance**	
Variety	Day 1	Day 6	Day 1	Day 6	Day 1	Day 6	Day 1	Day 6
Honeoye	3.7	2.7	3.7	2.3	4	3.7	4	3
L'Amour (NY1829)	5	3.7	4.7	4	4.7	3.7	4.7	4
Jewel	4	3.2	5	4.3	3.7	3.2	4.7	4
Darselect	4	2	3.5	2.5	3	3	3.5	2.5
Earliglow	4.7	2.7	3.7	2.7	3	2.7	3.7	2.3
Clancy (NYUS304B)	5	4.3	4.7	3.7	4	2.8	3.7	3

Table 4. Blind taste test results from 11 growers attending a field meeting on 6/24/03 in Geneva, NY. (Scale 1-10; 10=best). (Average rank is in order of preference.)

Variety	**Flavor**	**Texture**	**Exterior Color**	**Interior Color**	**Appearance**	**Average Rank**
L'Amour (NY1829)	6.5	8.2	8.4	8.2	8.1	2.6
Jewel	6.7	8.3	8.5	8.0	8.2	2.8
Darselect	6.3	7.9	7.9	7.6	7.8	3.1
Clancy (NYUS304B)	5.3	6.9	7.7	7.8	7.2	3.6
Earliglow	7.0	7.1	7.9	7.9	7.1	3.8

The following descriptions are based on published reports and trials at Cornell University's New York State Agricultural Experiment Station in Geneva, NY. They are organized by harvest season and include the majority of varieties grown in the north-central and northeastern growing regions of North America.

Early Season

Earliglow is still considered the best tasting berry around. Primary berries are large and attractive and are suitable for retail or wholesale. Berry weight drops off quickly after the primary berries and yields are relatively low.

Honeoye has reigned as the yield king for many years and produces an abundance of large, attractive, firm, berries that are suitable for all markets. Closer to an early mid-season, the look of this berry sells it, but taste is the major drawback as it can be tart and can develop disagreeable aftertastes when over ripe or in heavy soils. It is susceptible to red stele disease but is manageable.

Northeaster was billed as a replacement for Earliglow and out performs it in all ways except flavor. Yield is higher and fruit weight and attractiveness are equal to Earliglow but the grape Kool-Aid flavor is unusual and can be a turn off to many customers.

Sable is slightly earlier than Earliglow and is equal or better in flavor. Unfortunately it lacks fruit size and firmness. This variety is only suitable for direct retail and u-pick operations. Frost damage can be a problem because the flowers open very early.

Mid Season

Brunswick is a new variety out of Nova Scotia with fruit weight and yield similar to Honeoye. However, it has a squat, round shape and tend to be dark and bruise easily. The flavor is good but can be tart when under ripe.

Cavendish is a high yielding, high quality berry in a good year. However, high temperatures during ripening can cause uneven ripening that can be a real problem.

Darselect is a large fruited, high yielding variety. The berries are attractive and bright red with a long conical shape. The flavor is very good. However, it tends to be soft.

Kent produces medium sized berries with very good yield, especially in new plantings. Hot weather can cause skin toughness to deteriorate. It is very susceptible to leaf scorch and to angular leaf spot. It is very sensitive to terbacil (Sinbar) herbicide. It does not do well in hot weather.

L'Amour (NY1829) is a new variety from Cornell for 2004. It is an early mid-season type with excellent fruit quality. Berries are bright red and firm but not hard, with excellent eating quality and flavor. Fruit is long round-conical with a fancy calyx, which makes them very attractive. No significant disease or insect problems have been noted to date.

Mesabi is a very high yielding variety with large berries and good flavor, but does not store well. It is resistant to red stele and tolerant to leaf diseases and powdery mildew. It comes out of Minnesota and has excellent cold tolerance.

Late Season
Allstar is good yielding, high quality variety with good flavor. Unfortunately, the color is pale red to slightly orange that is unacceptable to an uninformed consumer.

Cabot produces impressive berries. Average fruit weight is larger than any variety currently available. Primary berries often top 40-50 g. The color can be pale throughout the berry and primary berries are often irregular in shape. Yields are very high. It is resistant to red stele but is susceptible to virus infection and cyclamen mites.

Clancy (NYUS304B) is a new late season release from Cornell that was developed through a joint venture with the USDA breeding program in Beltsville, MD. It has parents that are resistant to red stele root rot. The fruit is a round conical shaped with darker red color and good flavor. The flesh is very firm with good texture and eating quality. The fruiting laterals are strong and stiff, keeping the fruit off the ground until they reach full size. No significant disease or insect problems have been noted to date.

Jewel continues to be the favorite in this season. The high quality berries are large and attractive with good flavor. Yields are moderate. On a good site, it's hard to beat. It is susceptible to red stele and can have vigor problems in poor or cold sites.

Seneca is probably the firmest variety available for the northeast. The fruit is large, bright red and attractive but the flavor is only acceptable. It doe not runner heavily and can be adapted to plasticulture.

Winona has very large berries and average yields but can not compete with Jewel for fruit appearance. It has good vigor though and can be useful where Jewel does poorly. It comes from Minnesota and has very good cold tolerance.

Day Neutral
Everest is a fairly new variety out of the U.K. It has large, firm, bright red berries. It does not runner well and is only suited for plasticulture. Over wintering can be a problem with this one.

Seascape is a day neutral out of California that is seeing some success in the east. The fruit is large and very attractive. It is firm and good quality. It does not runner and is only suited for plasticulture. Over wintering can be a problem with this one.

Tribute and **Tristar** have been the standard day neutral varieties for the northeast for the last 20 years. They are disease resistant, vigorous, and runner enough for matted row production. Both are relatively small fruited and low yielding but off-season fruit may pay off. Of the two, Tribute has better size and Tristar has better flavor.

New Varieties- These are currently being tested in Geneva but no data is available as yet.

Evangeline is a new variety from Nova Scotia that ripens in the early season. The fruit is long conical in shape with a pronounced neck. The interior is pale and it is susceptible to red stele. The fruiting laterals are stiff and upright which keeps the fruit off the ground and clean.

Sapphire is a late mid-season variety from the University of Guelph in Ontario. The fruit are bright red and large. It is reported to be tolerant of the herbicide terbacil (Sinbar).

Serenity is a late season variety from the University of Guelph that is also tolerant to terbacil (Sinbar). The fruit is large and bright red. The skin tends to be soft. It is reported to be moderately resistant to scorch and mildew.

Saint-Pierre is a new variety out of Quebec. It has large conic shaped fruit that are pale red to slightly orange, much like Allstar. Fruit firmness and flavor are reported to be very good.

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Now there's A Good Idea! A Consultant's Notebook

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It sometimes seems that there are as many ideas about the best way to grow strawberries as there are strawberry growers! There are continually new techniques and products that strawberry growers and the people who advise them need to look at and evaluate. Farmers have inquiring minds and are the source of many of these great ideas. Consultants, Cooperative Extension Small Fruit Specialists, scouts, and some of the industry sales representatives get to see lots of different strawberry farms and ways of doing things over the course of time. The different planting and bedding systems, irrigation systems, fertility, and pest management are some of the topics that we will look at in this presentation. Soils are different, varieties are different, and people are different. Therefore, there is no one right way to raise strawberries-but some practices sure do work well for some people!

First, let's decide what the beginning point for a strawberry crop is. For a crop that is yet to be planted, I feel that a full year before planting is needed to prepare the site. Deep tillage, soil sampling, adding needed soil amendments, two to three cover crops with a weed destroying tillage between each, and rock picking the year before planting a strawberry crop will help to assure several years of success for the crop. For an established crop, successful growers recognize that next years strawberry crop begins with renovation and the sooner that it is begun after the last picker leaves the field, the better.

Prior to planting the crop, the grower needs to decide what type of production system to use. Will the crop be raised on a ridge, in a matted row, in a plasticulture system? The system employed determines the planting density and is the basis for determining how many plants to order. We will look at some of these choices in the presentation.

Irrigation is a serious consideration for a strawberry grower. Some of us who advise farmers caution that you may not even want to consider raising strawberries if you are not able to irrigate. Frost protection provided by irrigation during bloom is important in many growing seasons. Irrigation is also helpful for crop growth, to help to activate herbicide applications, and after renovation to ensure adequate plant growth and flower bud development for the next year's crop. Some growers utilize a couple of different irrigation techniques in the course of the season. While overhead irrigation is needed for frost protection, some growers use less labor intensive and more water efficient systems such as drip tape or center pivot irrigation systems at other times of the year.

Strawberries are not heavy users of nutrients compared to crops like corn, potatoes, and pumpkins, but they need what they need in the correct amounts at the proper times. Soil sampling and tissue sampling are management tools that many growers use to determine what the limiting nutrient factors are for their crop. There are lots of nutrient sources available. Knowing what source to use at what point in the crop cycle is useful. For instance, if magnesium is needed, ground dolomitic limestone may be the least expensive source, but if it is not applied and incorporated prior to planting it will not be readily available to the crop, whereas magnesium sulfate (Epsom salts) sprayed on the crop in a foliar application will immediately provide magnesium to the crop. Significant increases in yields have been obtained by growers who have learned how to micromanage the strawberry crop with plant growth regulators and nutrient amendments at the proper time.

Pest management is critical to good strawberry production. Weeds are often the most crop limiting pest and most costly to control of all the pests that growers deal with. No matter what technique growers use, hand weeding and cultivation, herbicides, plasticulture, or fumigation, all are expensive and all have some drawbacks. Many growers use combinations of the practices listed.

Integrated Pest Management (IPM) is a great idea. Growers need to know and understand the pests that affect their crop and how to control them. But IPM is not for everyone. Insects and diseases are confusing and complicated for many folks. This is not necessarily a bad thing-it creates job security for crop consultants!

Crop consultants can help growers with all of the topics presented here. Certified Crop Advisors and Certified Professional Agronomists have education and work experience that you can rely on. We have passed rigorous testing for certification, submitted references, signed an ethics oath, and must take part in continuing education programs to maintain our certification. A nice benefit of the continuing education process is the network that most of us develop over time with educators, state and federal regulators, and each other. These relationships ultimately are a benefit for the growers that we work with. Now, there's a Good Idea!

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Disease Management Programs for Berry Crops in the 21st Century

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Introduction

In view of the technological breakthroughs in the past 20 years alone, the advances that could conceivably occur over the next 15 to 20 years, are almost unimaginable. This is especially true in the areas of molecular genetics, bioengineering, and biotechnology. We have made great strides in better understanding and managing many of the major diseases and disease complexes for most berry crops in the 20th century. However, due to the ability of pathogens to adapt, new cultivar introductions and constantly changing production practices, diseases will continue to be a constraint to berry crop production in the 21st century, despite our past successes. Although fungicides, as well as other disease control chemicals and products, will probably remain an important part of future disease management programs, their use will most certainly be highly regulated and scrutinized by regulatory agencies as well as the general public. In order to effectively control diseases with minimal or no use of pesticides, the continued development and implementation of truly integrated disease management programs must be emphasized.

The objective of integrated disease management is to provide a commercially acceptable level of disease control on a consistent (year to year) basis with minimal fungicide use. Developing a program the *integrates* all available control methods can meet this objective. An effective disease management program must emphasize the integrated use of: knowledge of the pathogen and disease biology; disease resistant cultivars; specific cultural practices; effective biological controls; and the timely application of fungicides and other crop protection materials when needed. In order to reduce the use of fungicides to an absolute minimum, the use of disease resistance cultivars, appropriate cultural practices, and biological control will need to be strongly emphasized.

This discussion will focus on the various components of an integrated disease management program. Major pathogens attacking berry crops world-wide are numerous and varied including primarily viruses, mycoplasmas, fungi, bacteria, and nematodes. All of these pathogens can be extremely important; however, this discussion will focus primarily on fungal pathogens of strawberry and raspberry. Due to the futuristic nature of this discussion, the author assumes a certain degree of license and will attempt to briefly discuss some of the more recent or significant advances in the 20th century, as well as speculate on potential advances in the 21st century.

Knowledge of Pathogen Biology and Disease Epidemiology

This knowledge is critical to the development of effective disease management strategies, especially if minimal fungicide use is desired. In fact, it is difficult to imagine how we can effectively "manage" any plant disease without a basic knowledge of pathogen ecology, etiology and disease epidemiology. Whereas we know a great deal about most of the fungal pathogens and the diseases they cause on strawberry, when one critically reviews this body of knowledge from a disease management perspective, the gaps in our knowledge quickly become apparent. In order to improve our disease management programs in the 21st century, a great deal of research will be required in order to fill these gaps. Huge advances were made in the 20th century in developing basic knowledge of the major pathogens on most berry crops. We need to continue to develop this type of information in order to better understand how pathogens are disseminated and survive. Information on the effects of environmental conditions (primarily temperature, wetness duration and wind) on infection and dissemination of plant pathogens will be essential for continued development of disease predictive models and disease forecasting systems. Information on sources of primary inoculum and exactly when and how the pathogens infect the crop is also essential, especially in relation to clean plant production and application timing for biological control agents or other plant protection materials. The following are just a few examples of where relatively recent plant pathology research has lead to new knowledge that has greatly improved our current disease management programs. Research conducted by Braun and Sutton in the late 1980's on the ecology and epidemiology of Botrytis fruit rot clearly demonstrates the impact new knowledge can have of on disease management programs. Botrytis fruit rot or gray mold, caused by the fungus *Botrytis cinerea,* is a major pathogen of strawberry worldwide. The majority of fungicides applied world-wide to strawberry are probably directed at control of this disease. Prior to Braun and Suttons work, it was assumed that Botrytis was ubiquitous in the environment and blew into berry plantings from several sources. Growers in perennial matted-row systems generally applied fungicides from early spring through harvest for Botrytis control. Symptoms of Botrytis fruit rot do not generally appear until near harvest as fruit is maturing; thus, it was customary to apply fungicide for Botrytis control through harvest. Obviously, this resulted in an intensive use of fungicide and increased fungicide residues on fruit. Braun and Sutton demonstrated that most of the primary inoculum for fruit infection in perennial matted-row systems comes from leaf residue within the row, and not from outside the planting. They further demonstrated that most fruit infection actually occurs during bloom. Bristow in 1986 also demonstrated the importance of flower infection in strawberry. The fungus enters (infects) the fruit during bloom often through old floral parts and remains as a latent infection in green fruit. As the fruit matures, the fungus becomes active and fruit rot develops. As mentioned previously, fungicides were routinely applied shortly prior to or during harvest when the fruit rot symptoms appeared. Due largely to the research of Braun and Sutton, our current fungicide programs emphasize spraying fungicides only during bloom and generally do not recommend sprays for Botrytis during prebloom or during harvest. Thus, through better understanding the epidemiology of this disease, spray timing has been greatly improved. In addition, overall fungicide use and fungicide residues on the fruit have been greatly reduced or eliminated. Additional reductions in fungicide use could potentially result from the implementation and use of disease forecasting systems for Botrytis fruit rot.

Root rot of raspberry is a serious disease, primarily of red raspberry, world wide. It is generally a problem on poorly drained soils and usually results in death of infected plants. Prior to research reported by Wilcox in 1989, the exact cause of raspberry root rot was not known, and most people, this author included, considered the cause to be excessive soil moisture (wet feet). Importance of raspberry root rot rapidly increased in the late 1980's and early 1990's as it reached epidemic levels world-wide. Wilcox's research demonstrated that raspberry root rot was a disease caused by several species of Phytophthora. He further demonstrated differences in varietal susceptibility to the disease, and developed an integrated disease management program for root rot control based on the use of disease resistant cultivars, cultural practices and fungicide use.

Anthracnose fruit rot of strawberry, caused by the fungus *Colletotrichum acutatum*, it is an extremely destructive disease of strawberry world-wide. The disease was first identified in Ohio in 1991, and was not observed on strawberry prior to that date. Since its first occurrence in Ohio, it has become a major threat to strawberry production. The disease appears to develop sporadically and randomly in plantings at locations where it had not been seen before. The big question was, "how is the pathogen being introduced into new plantings". Research conducted by Leandro at Iowa State University in 2001, demonstrated that *C. acutatum* can sporulate and germinate on symptomless strawberry leaves. The pathogen survives and reproduces (sporulates) on apparently healthy plants; thus, its movement on apparently healthy nursery stock is very probable and at least partially explains how the disease has become so widely distributed. Knowledge about how the fungus survives and multiplies within the planting should allow us to better control the disease through development of more effective detection methods and production and distribution of disease free planting material.

For bacterial plant pathogens, primarily angular leaf blight of strawberry, caused by *Xanthomonas fragariae*, little progress in effectively controlling the disease has been made. Fortunately, there are relatively few bacterial plant pathogens that affect berry crops. In order to effectively manage bacterial plant pathogens in the 21st century, a great deal of research in the areas of pathogen detection, epidemiology and development of disease resistant cultivars will be essential.

These are just a few examples of how research has added to our knowledge base and directly benefitted or improved our disease management programs in the 20th century. Our success in controlling the major diseases and disease complexes on berry crops in the 21st century will depend largely upon the level and quality of our research programs that support all phases of production.

Use of Disease Resistance

The use of disease resistant culitvars should be and generally is the backbone of any modern plant disease management program. The importance of developing high quality cultivars with durable resistance to major diseases can not be over emphasized. Unfortunately, disease resistance to many of the most economically important diseases is not currently available in many of the currently used varieties of several berry crops. A few common examples include mummy berry of blueberry, orange rust of blackberry and black raspberry, anthracnose and Botrytis fruit rot of strawberry, angular leaf spot or bacterial blight of strawberry, and many important virus diseases on several berry crops. The lack of resistance to many economically important diseases has forced producers in the 20th century to rely heavily upon fungicides for effective disease control. It should also be noted that for many of our most limiting diseases, primarily viruses, chemical controls are not currently available.

Although resistance to many diseases is lacking in various berry crops, good resistance to several diseases is available within specific crops. Where reliable resistance is available, it should be used whenever possible. In the last century, strawberry breeding programs world-wide have done an excellent job in developing cultivars with high levels of resistance to several foliar and root rotting pathogens. Within the Midwest and Eastern United States, use of varieties with resistance to foliar diseases (leaf spot, leaf scorch, powdery mildew) and root rots (red stele and Verticillium wilt) is a major component of the disease management program. However, even with the strict use of available disease resistance, dependence upon fungicide use is still quite strong in most strawberry production areas. This is largely due to the high number of diseases that make up the disease complex, especially in humid growing areas. In addition, resistance to some of the more damaging fruit rots (Botrytis fruit rot and anthracnose fruit rot) is generally lacking at present.

Current advances in molecular genetics, genomics, bioengineering and biotechnology in general should result in rapid and highly significant advances in the discovery of resistance genes or gene products and their incorporation into high quality, high yielding varieties. In fact, it is difficult to imagine the advances that could conceivably occur within the next 20 years or less. Conventional breeding programs that have been highly successful during the 20th century need to be maintained and well supported as we enter the 21st century. However, the use of new technologies for the identification and rapid incorporation of resistance genes or gene products should be exploited as much as possible.

Through the use of biotechnology, the identification and incorporation of resistance genes or gene products into currently available varieties has great potential. In 1993, Williamson purified a polygalacturanase-inhibiting protein (PGIP) from immature raspberry fruits. The wall-bound protein acts specifically as an inhibitor of endopolygalacturanases (PGs) produced by *Botrytis cinerea*. These fungal PGs are thought to be important in pathogenesis and the onset of aggressive fruit rot as fruit matures. The presence of PGIP is probably responsible for the fact that green or immature raspberry and strawberry fruit are generally resistant to rot by Botrytis. The PGIP gene from raspberry has been cloned with the ultimate objective of using recombinant DNA technology to enhance the expression of the gene in fully ripe fruits. Through this approach, it may be possible to rapidly incorporate durable Botrytis fruit rot resistance into existing and future raspberry cultivars.

This type of research and technology, and possibly the same genes, could be applied to other fruit crops where Botrytis is an important pathogen. On strawberry, research on genetic modification to achieve Botrytis resistance has been an ongoing program at HRI, East Malling, West Malling, Kent ME196BJ since 1985. They have used gene technology methods to induce Botrytis resistance in strawberries by over expression of a polygalacturanase inhibitor (PGIP) originally isolated from pear. They are evaluating transformed clones for gene expression in petals, stamens, carpels and leaves. Thus far, two lines have shown high resistant scores on bioassays on detached flowers. Results thus far have been very promising and are an excellent example of how the use of modern genetic modification techniques may shorten the long term nature of conventional breeding programs by adding only a few desired characters at a time.

Although this new technology is exciting and has great potential, it also faces some potentially serious problems. Despite the fact that genetic modification could be used to rapidly develop Botrytis resistant raspberries and strawberries; thus, greatly reducing the current use of fungicides for fruit rot control, public reaction to the development and use of genetically modified organisms (GMOs) could prevent the use of this technology. Especially in Europe, there is strong resistance to the introduction and use of GMOs. In fact, the previously mentioned work using PGIP to develop Botrytis resistant strawberries at East Malling has been terminated. Although the development and testing of the genetically modified clones will be continued in the United States, the public and/or political acceptance of genetically modified strawberries and other fruit crops remains an unknown.

Biological Control

The use of biological control against fungal pathogens of berry crops has great potential in the 21^{st} century. At present, several biocontrol products are registered in the U.S. for control of specific diseases on various berry crops. However, current use of biological control in disease management is limited and has had relatively little impact on disease management in the 20^{th} century. Although excellent research has clearly demonstrated the potential for biological control for specific diseases in controlled experiments, the wide-scale use of biocontrol has not been adopted in commercial production systems. A great deal of research has been published on the use of various microorganisms for control of Botrytis gray mold on strawberry. Most studies have focused on the use of these microorganisms to protect flowers and fruits from infections.A wettable powder formulation of *Trichoderma harzianum* has been marketed in Israel under the trade name Tricodex, and *Trichoderma* isolates have been distributed to strawberry growers in Bulgaria. It is difficult to find published information as to the success or failure of these materials in relation to control of *Botrytis cinerea* (gray mold) on strawberry under commercial field conditions. Additional research by Sutton, on the use of *Gliocladium roseum* for gray mold control is quite promising, and may lead to the development of highly effective materials in the future. However, at least in the short term, the commercialization and use of effective biological control agents or products for control of several serious pathogens on berry crops faces many challenges, especially when their performance is compared with the use of effective fungicides.

The use of biological control for control of soilborne pathogens also has great potential in the future. The demand for effective replacements for the soil fumigant, methyl-bromide, will provide increasing pressure to fund research to explore the potential for biological alternatives. The incorporation of organic amendments such as various composts has shown great potential for suppression of soilborne pathogens in other cropping systems and should be beneficial for disease control in berry crops as well. As with all other areas of plant pathological research, biotechnology will undoubtedly have great impacts on the future of biocontrol of plant diseases. The ability to genetically manipulate or bioengineer biocontrol agents could result in more efficient and consistently reliable products. This combined with increased understanding of the microbial ecology in fruit production systems and how cultural practices impact pathogen and biocontrol agent populations should provide breakthroughs for the successful implementation of biocontrol. Molecular tools are currently being developed to identify and quantify pathogen populations as well as organisms with biocontrol capabilities. Through a great deal of innovative and multidisciplinary research, biological control will undoubtedly be an integral component of integrated disease management programs in the 21^{st} century.

Use of Cultural Practices

The use of cultural practices as effective tools for the management of berry crop diseases is becoming widely recognized. The importance of cultural practices will most certainly increase in the future, especially if reducing our dependence of fungicides remains a top priority. Any practice that affects the macro- or micro-environment within the planting can have a direct effects on disease development. In order to fully utilize these practices, a great deal of multidisciplinary research is required to better understand their affects on pathogen biology and disease epidemiology. There are numerous cultural practices that have great potential for use in disease management. The following are only a few examples of how cultural practices can impact upon our disease management programs.

The importance of pathogen free nursery stock cannot be over emphasized. During the 20th century, the nursery industry for most berry crops has made good progress towards producing high quality plants for producers. Virus indexing programs have been very effective for cleaning up the more damaging viral pathogens; however, indexing programs to insure that plants are free of fungal and bacterial pathogens generally do not exist. Genetic molecular technology that is currently available and will continue to develop and improve should be used to develop extremely sensitive indexing programs for detecting fungal, bacterial and other plant pathogens on nursery stock. Future efforts should focus on developing nursery indexing programs for detection of all important pathogens in order to provide producers with truly “disease free” planting material.

The identification and utilization of good horticultural production practices will always be critical to successful berry production. Soil drainage has long been recognized as a critical component of the disease management program. Any practice that promotes better drainage to avoid saturated soils is critical for control of root rots, caused by *Phytophthora* spp. on most berry crops. Conventional practices, such as tiling and the use of raised beds, have aided greatly to disease control in the 20th century. Innovative research in the area of soil and water management and irrigation practices will contribute greatly to the disease management program for soilborne diseases in the 21st century.

Effects of plant nutrition, primarily on development of foliar and fruit attacking pathogens have long been recognized. Excessive use of nitrogen in the spring has been associated with increased levels of *Botrytis* fruit rot and powdery mildew on several berry crops. Although the affects of plant nutrition on plant disease is widely acknowledged, little practical data or information actually exist that can be directly used as an integral portion of the disease management program. This is an area that demands a great deal of multidisciplinary research in order to determine the effects of plant nutrition on disease susceptibility. The effect of nutrition on plant canopy development and plant architecture also could have profound effects on development and dissemination of many important diseases by creating micro environments in the canopy that are more conducive to disease development.

Ground covers can have a direct effect on the development of fungal fruit rots in strawberry. A good layer of straw mulch between the rows has been shown to be highly effective for control of leather rot, caused by *Phytophthora cactorum*. The straw acts as barrier that protects the fruit from contact with the soil. In addition, straw mulch aids greatly in reducing splash dispersal of fungal pathogens that cause leather rot and anthracnose. Conversely, plastic mulch, which is commonly used in annual production systems, has been shown to enhance splash dispersal of *Collectotrichum* spp. and increase the incidence of anthracnose fruit rot. Whereas the benefits of plastic ground cover in relation to overall production may greatly outweigh the disadvantages in relations to disease development, it is important to realize the effects that ground covers and other practices may have on disease development. Future research in the development of berry crop production systems may well need to address the importance of ground covers and other factors that affect splash dispersal of pathogens, especially if these systems emphasize decreased fungicide use.

Any practice that reduces air circulation and light penetration into the plant canopy can effect the development of several plant diseases. Most fungal pathogens require water on the fruit surface in order to infect. Practices that promote faster drying of the fruit after wetting events should aid greatly in disease management. Legard demonstrated the effects of within-row plant spacing on the incidence of Botrytis fruit rot of strawberry. Wider within-row plant spacing (a more open canopy) reduced the incidence of Botrytis fruit rot.

The practice of sanitation has long been considered an important cultural practice for many diseases of berry crops. Removing infected material from the planting should aid in reducing the amount of primary and secondary inoculum and; therefore, should be beneficial in reducing disease. Although this is a good "common sense" practice, there is little information in the literature that documents the effects of sanitation on disease management. In fact, Mertely demonstrated that leaf sanitation (removal of senescent and necrotic leaves) and fruit sanitation (removal of unmarketable fruit from alleys between beds) did reduce the incidence of Botrytis fruit rot on strawberry, but did not increase marketable yield. In addition, they demonstrated that supplementing fungicides with leaf and fruit sanitation did not improve disease control and frequently reduced yield in annual strawberries.

Fungicide Use

Due to the number and potential severity of fungal pathogens on berry crops, combined with public demand for blemish free, high quality fruit, it is the authors opinion that fungicides will remain an important component of disease management programs for berry crops in the 21st century. However, there minimal use within integrated disease management programs will be strongly emphasized. Public concern and political mandate will most certainly affect the use of fungicides and other crop protection chemicals in the future. It is not inconceivable that fungicide use could be banned at some time, at least in specific areas or even countries. If such drastic action were to occur, we would have to rely solely on the remaining components of the disease management program. The best way to insure future use of fungicides is to use them safely and wisely. It is our responsibility to educate the public as to the importance of fungicides in food production, and to assure the public that they are used safely and only when needed. We need to emphasize that they are simply one component or "tool" used within the integrated disease management program.

In relation to the use of fungicides in the 21st century, it is important to remember that we have little concept of what future research in fungicide chemistry and development may achieve. It is highly probable that the fungicides and other crop protection products of the future will be highly efficacious at very low rates, environmentally benign, and nontoxic to mammals. In addition, they may have strong curative or after-infection activity for use in disease forecasting systems.

As we enter the 21st century, new diseases or other problems related to plant health will undoubtedly arise. Hopefully, plant pathologists and other plant health professionals in cooperation with the berry crop industry will be able to deal with them in a timely manner. There are, however, certain factors over which we as scientists and producers appear to have little control. Public opinion, especially in relation to topics such as GMOs and pesticide use, as well as political mandates could have strong influences on disease management programs in the 21st century.

Spider Mite Management in Strawberries

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Spider Mite Biology

The two-spotted spider mite, *Tetranychus urticae*, is a very common pest of strawberries. This species overwinters in the soil as mated adult females, which are an orange color with two darker brown spots. All subsequent generations of spider mites during the growing season are a pale green with two dark spots, one on each side of the body. Upon emergence from the soil in the spring, overwintered females start to feed and lay eggs. The eggs hatch into 6-legged nymphs, which then go through two additional molts to 8-legged stages before attaining adulthood. These mobile stages of mites feed by puncturing ~20 individual plant cells at each place where they insert their mouthparts and suck out the cells' contents. Chlorophyll is removed from each feeding site, leaving tiny chlorotic spots. With sufficient mite feeding, the leaf takes on an overall chlorotic appearance and the plant can be stunted.

The development rate of spider mites is dependent on the ambient temperature. They are high-temperature adapted mites, and are able to complete a life cycle in as little as 7 days when temperatures are in the 80's (ºF). A special challenge for strawberry growers is spider mite reproduction under floating row covers. The temperatures are elevated under row covers, permitting both the plants and the spider mites to develop faster. Spraying is obviously impossible, though, with row covers in place. The nitrogen content of leaves also influences the mite reproduction rate. Excessive nitrogen conditions favors spider mite outbreaks.

Spider mites take their common name from their ability to produce silk. Colonies of mites feed on the underside of leaves, sometimes protecting themselves from predators under a layer of silk webbing. In severe circumstances, the entire plant can become encased in silk. The silk plays an important role in dispersal, too. When populations of mites on a leaf are too high, or the leaf becomes depleted as food for mites, some of the mites will crawl to the upper part of the plant and "balloon" by releasing themselves into the wind with a trailing strand of silk. Mites can become airborne and can travel long distances in this manner.

The genetic system in spider mites is arrhenotoky, which is found in many parasitic wasps and in honeybees. Unfertilized eggs are haploid and develop into males, while fertilized eggs develop into females. Therefore, males only have one set of chromosomes and every gene is expressed as a dominant trait (similar to the genes of the human "Y" chromosome). This type of system would be very efficient for exposing chance mutations that can confer resistance to miticides. This genetic system and the ability to complete several generations each growing season makes management and resistance management of twospotted spider mites formidable.

Monitoring Methods

To assess whether you have spider mite problems that require spraying, check the undersides of leaflets with a 10_ hand lens. Spraying is justified when counts of spider mites exceed 5-25 mites per mid-tier leaflet, based on the stage of development of the plant. Within the first four months after transplanting, the threshold is lowest (5 mites per leaflet), whereas the threshold at the beginning of harvest should be 10 mites per leaflet. After harvest, the plants can tolerate up to 25 mites per leaflet. Besides doing semi-quantitative counts of mites on leaves, be sure to walk your fields and be on the lookout for any chlorotic areas or signs of webbing.

While monitoring spider mite populations, keep track of the number of predatory mites you are observing. One predatory mite for every 10 spider mites is a high population for predators, and the spider mite population can be predicted to quickly diminish. The presence of predatory mites can dramatically change the outcome of spider mite infestations in strawberries. However, these predators do need food (spider mites) to maintain their populations. This is why having a few spider mites in fields can be beneficial – their presence allows you to "grow your own" biological control in the field. There's more on this subject under "Biological control."

Control Strategies

Biological control. We are fortunate in New England in having an abundance of a very effective spider mite predator, *Neoseiulus fallacis*. This predatory mite will disperse into strawberry fields and, as long as disruptive pesticides are avoided, can keep spider mite populations low. On the west coast, growers often release beneficial predatory mites to help keep the balance between predators and prey. In fact, Oregon State University has published a guide that permits growers to calculate how many predators should be released to achieve biological control of spider mites within a user-defined length of time. To view this calculator, visit the web site (http://oregonstate.edu/Dept/entomology/ipm/mcalc.html#SAMP).

Because predatory mites are usually already found in New England strawberry fields, the more cost-effective way to use them is by implementing conservation strategies. As mentioned under "Monitoring methods," it can be beneficial to have some spider mites present in a field to provide food for predators. These act as food for predators, and as long as they remain below economical damage thresholds, you obtain benefit by "growing your own" predators. The most important component in conserving predators is avoiding pesticides that are highly toxic to predatory mites. The pesticides most toxic to predatory mites are pyrethroids (bifenthrin [Brigade], fenpropathin [Danitol], and permethrin [Pounce or Ambush]), carbaryl [Sevin], chlorpyrifos [Lorsban], and Benlate. For additional information on other pesticides and their toxicity to *N. fallacis*, see (http://www.ent.orst.edu/prattp/pesticides.html).

Foliar sprays of miticides. Several types of miticides are currently available for strawberry fields, and other new compounds may soon be labeled. The miticides can be categorized based on the stages of the mites that are killed. Horticultural oil kills by suffocation and is effective against all stages of mites, including eggs. Some miticides are only active against the mobile stages of mites. These would include dicofol (Kelthane), abamectin (Agri-Mek), bifenazate (Acramite) and Vendex (fenbutatin-oxide). Hexythiazox (Savey) and similar miticides not yet registered for use in strawberries kill the mite eggs, some the hexapod nymphs, and sterilize adult females. Notes on the characteristics for each miticide are listed below the table.

In the table on the next page, I have assumed that the normal labeled rate is being applied. Where a range in cost per acre is indicated, this reflects the range of rates on the label (in most cases), or where a lower rate is appropriate for integrated mite management (Agri-Mek). The costs are based on the per-acre quantity of material being applied. For soap and oil, which are mixed based on a dilute spray and quantity per 100 gallons of spray mix, I assume that a grower would apply 50 gallons of spray per acre.

Trade name	Active ingredient	Cost per acre	Signal word	PHI[a]	Groups killed[b]
Acramite	bifenazate	$38 - 51	Caution	1 d	SM mobile
Agri-Mek	abamectin	32 - 172	Warning	7 d	SM mobile
Kelthane	dicofol	14 - 28	Danger	3 d	CM, SM, **PM**
oils	paraffinic oils	3 - 6	Caution	0 d	all TSSM
M-Pede	soap	18	Caution	0 d	SM mobile
Savey	hexythiazox	96	Caution	3 d	SM eggs
Vendex	fenbutatin-oxide	28 - 37	Danger	1 d	SM mobile

[a]The minimum reentry interval without PPE may be 12 hours for soap and oil.
[b]CM, cyclamen mite; PM, predatory mite; SM, spider mite

Acramite, or bifenazate, has just obtained its registration for use on strawberries in Connecticut (October 23, 2003). Bifenazate is an extraordinarily active contact miticide, quickly killing mobile stages of spider mites. It reportedly also will kill some spider mite eggs. Probably more important is the fact that residues remain active long enough to kill mites when they finally hatch from eggs, so spraying when many eggs are present is not a problem. It is also essentially non-toxic to predatory mites, so it is compatible with integrated management of mites. The use rate is 0.75 – 1 lb. of product per acre.

Agri-Mek, or abamectin, is a trans-laminar systemic miticide and insecticide, meaning that it is absorbed into the leaf tissue but is not transported upward or downward in the plant. Absorption into the plant tissue is beneficial in several ways: it minimizes the contact of this product with beneficial predatory mites and insects, and it protects the active ingredient from being broken down too quickly by sunlight. It continues to be effective for ~2 weeks after application because feeding mites continue to ingest the active ingredient sequestered in the leaf. **The label rates of this product are greatly excessive.** Used at the rate suggested on the label (16 fl. oz. per acre for each spray, with two sprays), abamectin is highly toxic to predatory mites and is prohibitively expensive. A more practical application rate is 6 fluid ounces per acre, in one application (giving the $32/acre cost given above), followed by a second application only if predatory mite populations are not sufficient to finish "mopping up" the spider mite infestation. If possible, Agri-Mek should be combined with horticultural oil or DyneAmic (a miticidal adjuvant containing vegetable oil + organosilicone surfactant) for resistance management purposes and to maximize the movement of active ingredient into the leaves. The abamectin + oil combination has been my standard against which all other miticides have been compared for the last 10 years.

Brigade, or bifenthrin, is a pyrethroid insecticide that also has miticidal activity. It is extremely toxic to predatory mites and resistance to pyrethroids among twospotted spider mites is common. Therefore, outbreaks of spider mites are very common following application of this product and it should not be considered a miticide. Brigade is the mainstay for control of adult root weevils and sap beetles, so growers may have to resort to using this product. If bifenthrin application is necessary, a grower should plan to either combine it with oil or to use horticultural oil early in the growing season to avoid mite outbreaks.

Danitol, or fenpropathrin, is a pyrethroid insecticide that also has miticidal activity. It has shorter residual activity than Brigade and is not effective against root weevil adults, but it is very toxic to predatory insects and mites. Therefore, I do not see any reason to use this product in a strawberry insect or mite management program.

Kelthane, or dicofol, is an old organochlorine miticide. Its mode of action is to disrupt nerve transmission in the spider mite. It has the unfortunate characteristic of being very toxic to predatory mites, but can have a place in strawberry pest management if cyclamen mites are a problem (Thiodan, or endosulfan, also controls cyclamen mites). Cyclamen mites feed within the crown of the plant and cause leaves to be dwarfed and cupped. Be aware that spider mites probably have a long history of ancestral exposure to dicofol, meaning that resistance genes may be very common in the population. This implies that resistance could crop up nearly immediately following a single spray of this miticide. It is applied at a rate of 1 – 2 pounds of Kelthane 50W product per acre (3 – 4 pounds per acre for control of cyclamen mites).

Horticultural oils available under a variety of trade names are registered for use on strawberries. Oils are the least expensive IPM-compatible product, and are probably organically acceptable. The remarkable feature of oil is that it is generally toxic to many pests, but surprisingly does not kill many predatory mites. The challenges in using oil are that (1) it requires good agitation in the spray tank, (2) very thorough spray coverage is necessary, because the mite has to be directly contacted with the spray emulsion, and (3) it is not compatible with some other pesticides (notably Captan, Morestan, and sulfur). Oil works by suffocation, which means that all stages of spider mites are susceptible. As the respiration of the pest increases with temperature, the amount of oil required to suffocate them decreases. Therefore, even a 0.5% suspension of oil can provide great benefit for control of mites under 75-85ºF temperatures. Genes conferring tolerance to suffocation are not known in spider mites, so oil is also resistance-proof. Including oil with another miticide (such as Agri-Mek or Savey) can be a good resistance management strategy.

A very successful strategy has been the use of oil soon after overwintering spider mites are found on the foliage. 50 gallons per acre of a 1% spray emulsion applied with a tractor-driven mist blower can provide season-long control of spider mites at this time. The very early spray timing is necessary to avoid the incompatibility of oil with Captan, and takes advantage of there being minimal foliage to cover. A similar strategy may work for spraying strawberries 1-2 days following renovation mowing. The chemical cost of this treatment is negligible (~$3-6 per acre), as only 2 quarts of oil per acre need to be used.

M-Pede, or insecticidal soap, will kill mobile stages of mites directly contacted by the spray solution. However, this material is more costly and less effective than horticultural oil. Insecticidal soap is probably organically acceptable. The use rate for M-Pede is a 2% solution, or 2 gallons mixed with 98 gallons of water.

Savey, or hexythiazox, is a growth regulator miticide that kills eggs, young nymphs, and sterilizes adult female mites. One of the challenges in using hexythiazox is its inability to kill older mobile stages of spider mites. Therefore, the full effect of a Savey application may not be seen for 2-3 weeks. If spider mite populations are high at the time of spraying, considerable damage can continue to take place. On the other hand, Savey can be combined with oil for a quick knock down and residual control, and it is not toxic to predatory mites. Savey can only be applied once per year, at a rate of 6 oz. of product per acre.

Vendex, or fenbutatin-oxide, blocks oxidative phosphorylation of ADP to form ATP, which is the common currency of energy in the cell. This molecule is surprisingly selectively toxic to spider mites, so it is compatible with integrated management of spider mites. Vendex is used at a rate of 1.5 – 2 lb. of product per acre.

A management program entirely dependent on foliar sprays to control spider mites is risky. The foliage can be too dense to allow thorough enough spray coverage of the undersides of the leaves, permitting some of the mite population to remain on untreated surfaces. The reproductive rate of these mites permits survivors to repopulate the leaves quickly to damaging levels. If insecticides, fungicides, and non-selective miticides have eliminated predatory mites from strawberry fields, then multiple miticide sprays may be necessary to obtain adequate control. Some miticide labels now only allow one spray per year (to avoid excessive selection for resistance), and growers may be forced to use very expensive miticides.

Repeated resurgence of spider mites is prevented when predatory mites are conserved and a selective miticide is used. Selective miticide use leads to a situation in which there is an overabundance of predatory mites relative to their prey. The predators left on leaves from which spider mites have been eliminated then actively search for food, and will find the regions on the plants where spray coverage was inadequate. This is ideal from a mite management and resistance management perspective: the mites that would be expected to have survived due to resistance then can be subjected to intensive predation and their chance to reproduce is cut off. Furthermore, the active searching of predators into mite refuges can essentially "mop up" the mite populations following the spray.

Summary

Twospotted spider mites can be a challenge to control in strawberry plants if (1) the foliage is very dense, (2) predatory mites are not present, and (3) the plants are over-fertilized with nitrogen. Expenses can mount quickly if repeated applications of miticides (especially newer products) become necessary. Conserving predatory mites and appropriate use of selective miticides can transform mite management into an inexpensive procedure. Using horticultural oil early in the growing season is the least expensive option, and has been very successful for integrated management of spider mites.

Note: Always follow label directions. Use of a product name does not imply endorsement of the product to the exclusion of others that may also be suitable.

The Strawberry Plant: What You Should Know

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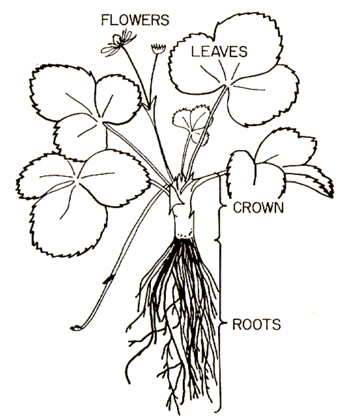
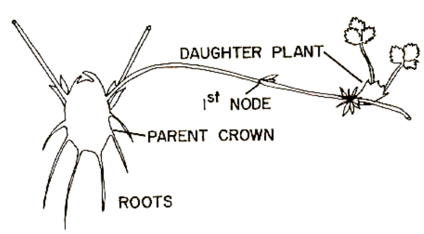
The cultivated strawberry, *Fragaria ananassa* Duch., is a relative newcomer to agriculture. Commercially grown varieties are the result of hybridization by humans, the fruit being quite different from that of the natural ancestors. The unique developmental nature of the fruit has made it the subject of much study. The plant itself also presents features of interest in its vegetative reproductive ability and its response to environmental conditions. In a more practical sense, the strawberry has become the basis of a large commercial industry, and is considered to be the most popular of small fruits in the United States.



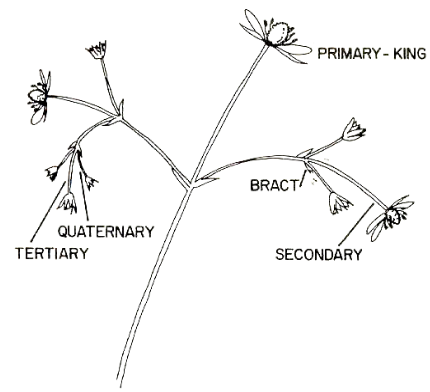
The strawberry plant is an herbaceous perennial, living for several to many years, depending upon the environment. The main stem of the plant is a greatly shortened stem called a crown. Buds formed in the crown produce leaves, flowers, stolons (runners), branch crowns and adventitious roots The leaves are arranged spirally, such that every sixth leaf is above the first. Each leaf has three leaflets at the end of a long petiole rising above the crown. Leaflets are round to oblong, with serrated edges and a thick cuticle layer. Older leaves die off in the fall, and are replaced by new leaves in the spring.

Runners and branch crowns are essentially shoots, which develop from axillary buds that form at the base of each leaf. Environmental conditions strongly influence which type of shoot will develop. Runner development is stimulated by long day lengths and warm temperatures. Therefore, runners emerge mostly during the summer months. Initial growth of runners results from development of a first internode, which extends several inches from the mother plant. Subsequent growth is from a second node at which the runner plant will develop. An axillary bud on the runner plant will typically form a secondary or continuation runner; often before the primary runner plant develops roots. Runner plants are the primary means of propagating strawberries commercially. Runners which have rooted over the summer are dug up late in the fall and stored in coolers at about 0° C (32° F) until spring for planting.



Branch crown development is stimulated by shortened day lengths and cooler temperatures and thus occurs later in the season than runner formation. Branch crowns have much the same anatomy as the main crown, being a very reduced stem with spirally arranged leaves. At one time, strawberry varieties that characteristically produced few runners were propagated by branch crowns. Whole plants would be dug in the fall, and the numerous branch crowns would be divided and stored for spring planting.

Adventitious roots arise from the crown primarily in the late summer and fall. They extend several inches into the soil and form numerous lateral roots, which are the primary means of taking in water and nutrients. Lateral roots usually live one or two years, the primary roots may live two to three years. The largest concentration of roots occurs in the upper three inches of the soil. Length and number of roots formed depends upon soil conditions and plant density. Usually each plant maintains twenty to thirty primary roots, the average length being four to six inches. Only after the development of numerous lateral roots, encouraged by proper soil moisture conditions, can runner plants become independent of the mother plant, i.e., survive without support from the connecting stolon.

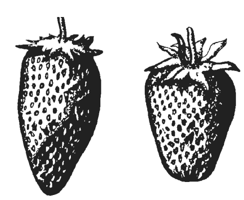


The strawberry inflorescence is a modified stem terminated by a primary blossom. Branches arise at nodes from buds in the axils of modified leaves or bracts. Each branch is terminated by a blossom. Following the primary blossom, there are typically two secondary, four tertiary and eight quaternary blossoms. The exact scheme can vary between cultivars and locations. An individual blossom typically has ten green sepals, five white petals and 20 to 35 stamens arranged in a spiral pattern in three whorls. The pistils are arranged spirally on the receptacle, with numbers ranging from 60 to 600. The greatest number of pistils occurs on the primary blossom and decreases successively down the inflorescence.

Strawberries are self-fertile. Pollen is mature prior to the opening of the anthers, but is not released for several days, encouraging cross-pollination. Stigmas remain receptive to pollen for eight to ten days. Despite self-fertility, strawberry size and yield have been shown to increase when cross-pollinated by insects. Fertilization occurs 24 to 48 hours after pollination.

Within each pistil is a carpel containing a single ovary. This structure is an achene. Achenes are the true fruits of the strawberry. Together with the receptacle they form an aggregate, which is referred to as a berry, but is not a true berry in the botanical sense.

Following fertilization, the receptacle swells to form the edible part of the "berry." The receptacle is made up of an epidermal layer, a cortex and a pith. The latter two layers are separated by vascular bundles that supply nutrients to the developing achenes. Cells in the cortex and pith are responsible for most of the receptacle growth. Cell division accounts for only a small part of the total growth of the receptacle and occurs primarily prior to bloom. Nearly ninety percent of the growth is a result of cell enlargement. Sugars, aromatic compounds and pigments all increase as the receptacle tissue grows and matures. Ripening, from bloom to harvest stage, lasts approximately 30 days, depending on environmental conditions.



Development of the receptacle is controlled by growth regulators, primarily auxin, which are synthesized in the achenes. Auxin is translocated into the receptacle tissues, stimulating growth through cell enlargement. Removal of achenes after fertilization will result in a proportionate reduction in growth. For example, leaving only three achenes on a receptacle results in three areas of growth, directly below and surrounding those achenes. A ring of achenes left on a receptacle results in a ring of growth, and so forth. The ultimate size and shape of a strawberry is thus a function of the number of achenes on the receptacle, the area of receptacle tissue surrounding each achene, and the distribution of the achenes on the receptacle. Receptacles with few achenes will be small, as is the case for fruit from the small tertiary and quaternary blossoms. Location of the achenes on the receptacle will affect the distribution of growth, and therefore berry shape.

Lack of fertilization, or damage to the achenes by frost, insects, or disease, will prevent the synthesis of auxin and result in uneven development, or malformation of the receptacle. The degree and character of the deformity will depend upon the number and location of damaged achenes. Injury to the developing receptacle tissue can also cause berry malformation.

While all strawberry plants share common characteristics, they are also extremely variable according to variety and the environment in which they are grown. Different varieties have been developed to grow all over the world, and may be narrowly adapted to a specific region. Thus varieties developed in one part of the world may not be suitable for production in another region. However, understanding the basic anatomy and functions of the strawberry plant can help farmers develop cultural practices that will encourage optimum plant growth and lead to better harvests and higher quality fruit.

[1] Much of this article was adapted from a chapter appearing in the Strawberry Production Guide for the Northeast, Midwest and Eastern Canada (NRAES-88), M. Pritts and D. Handley, eds. 1998. Some of the illustrations were taken from papers written by M. N. Dana.

Weed Biology

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Weeds are plants growing in a place where they are not wanted! Weeds affect the profitability of a farm by:
- Reduced Yields
- Reduced Crop Quality
- Increased Production Costs
- Increased Labor and Equipment Costs
- Insect and Disease Carrier or Hosts
- Poisonous or Irritating to People

Weed management in vegetables is difficult regardless of the strategies used by growers. To obtain good control of weeds, growers must be aware of a variety of information and management tools which are available. This presentation will highlight a basic understanding of weed biology dealing with weed management.

Weed Classification by Botanical Description

Weeds are classified in several ways and one of the most basic is a separation into botanical description of monocots and dicots.

Monocots include all grasses as well as sedges. Although sedges, most notably nutsedge, are sometimes called grasses, they are not the same and will not be controlled by herbicides specific for grasses. Both of these types are identified by a single shoot or spike which emerges first from a germinating seed or a tuber.

All other weeds are called broadleaf weeds or dicots. These are identified by a set of cotyledons or "seed leaves" which first emerge from a germinating seed. Broadleaf weeds can divided into two groups: herbaceous dicots and woody dicots.

Herbaceous Dicots
- Generally broad, net-veined leaves
- Root system coarse or taproot
- Seedlings contain two seed leaves
- Plants do not develop persistent woody tissue

Woody Dicots
- Root system coarse or taproot
- Seedlings contain two seed leaves
- Plants have woody tissue

Weed Classification by Life Cycle

Weeds can be discussed according to the weed's life cycles. The life cycle follows the weed's development through the following stages: seed germination, plant growth, flowers, seed matures, and plant dies. All weeds fall into one of 4 life cycle categories. These include summer annuals, winter annuals, biennials, and perennials.

Summer annuals are weeds that complete their life cycle in 1 year or less. The summer annual's life cycle starts in the spring and ends in the fall. These weeds are triggered to germinate as the soil warms in the spring with most broadleaf weeds germinating before grass weeds. In the fall, these weeds will produce viable seeds which will overwinter and germinate the following spring. Most weeds common to vegetable planting fall into this category. Examples of important summer annual broadleaf weeds include carpetweed, galinsoga, jimsonweed, common lambsquarters, black nightshade, common purslane, common ragweed, redroot pigweed, Pennsylvania smartweed, and velvetleaf. Examples of important summer annual grasses include barnyardgrass, crabgrass, fall panicum, and foxtails (yellow, green, and giant).

Winter annuals are weeds that also complete their life cycle in one year or less. In this case, however, the cycle is from fall to spring. These seeds usually germinate as the soil cools. The weeds grow vegetatively during the fall, overwinter, and then produce viable seeds before the weather becomes hot the following spring and summer. Many weeds common to small fruit plantings fall into this category. Most are winter annual broadleaf weeds. Important examples include common chickweed, wild mustards, henbit, and field pansy.

Biennials are broadleaf weeds which complete their life cycle in two years and are sometimes confused with winter annuals. They germinate and form a low rosette of leaves the first year and form an upright seed stalk during the second year. They are not usually a problem in annual cropping systems since they need such a long time to produce viable seeds although they can be a problem in small fruit plantings. Examples include common burdock and wild carrot.

Perennials are weeds that live for 3 or more years. There are two types, simple and spreading. Simple perennials grow as individual broadleaf plants with a taproot and reproduce by producing viable seeds. The most common example of a simple perennial is dandelion. Spreading perennials usually do not produce viable seeds but spread vegetatively. There are grasses, sedges, and broadleaf perennial weeds. Important examples of spreading perennials include quackgrass (sometimes called witchgrass), yellow nutsedge, and field bindweed. Usually, no part of these weeds are exposed during the winter and they must grow each year to remain alive over several years.

In summary, developing any "Weed Control Strategy" is dependent on both the botany of the plant (Moncot or Dicot) and the life cycle of the plant (Annuals, Biennials or Perennials).

Physical & Cultural Weed Management Principles

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Introduction

The 2004-2005 version of the New England Vegetable Management Guide is available and all vegetable growers should have a copy of this publication. This publication contains specific herbicide recommendations, information on stale seedbeds, weed management in plasticulture, information on cultivation, etc. This publication also contains information on insects, diseases, plant nutrition, varieties, and many other topics. I expect that some copies will be available for sale at the Conference and copies are available from all 6 New England Extension services.

Physical Weed Management

Physical weed management strategies include hand weeding and cultivation. Hand weeding is, of course, time consuming and expensive; however, it is often necessary for many reasons. These reasons include in row weed control and rouging out new species which may appear in a field.

Cultivation is an important component of weed control in vegetable crops, especially when use of chemical control is not possible. The timing of cultivation, equipment used, and accuracy of use are all important factors to consider. Weeds are best controlled when they are small. While all cultivation equipment will provide control of weeds between crop rows, equipment should, inmost cases, be chosen based on its ability to provide control of as many in-row weeds as possible with minimal crop damage. Minimizing soil movement, especially deep soil movement, is necessary to minimize movement of weeds seeds closer to the soil surface.

Several types of cultivation equipment are available. These include; rotovators, multivators, rolling cultivators, rotary hoes, sweep cultivators with discs, s-tine or Danish s-tine cultivators, basket weeders, finger weeders, spring-hoes or spyder weeders, spring-tine weeders, and wiggle hoes.

An excellent video describing each of these cultivators is available from the Vermont Extension System. Call Dr. Vern Grubinger at 802/257-7967.

Cultural Weed Management

Cultural weed management includes organic and inorganic mulches, soil preparation, stale beds with flaming, crop spacing, use of transplants, fallowing, and crop rotation.

Mulches shade the soil and act as a physical barrier and light barrier to weeds. Organic mulches such as bark mulch, grass clippings, straw, etc can delay soil warming which also slows weed germination. Inorganic mulches, such as plastic, warm soils and increase early germination of weeds. Plastic mulches act as a physical barrier to virtually all weeds except nutsedge, which can grow right through the plastic. With mulches in the row, it is still important to control weeds between the strips. For plastic mulches, control of weeds in the planting holes is also necessary, especially for slow growing crops such as pepper.

Soil that has been finely worked and firmed will yield more weed seedlings than soil which are more cloddy and left loose.

Stale beds are often used to allow the crop reduced weed pressure. The stale seedbed technique is described fully in the New England Vegetable Management Guide. In brief, the stale bed technique has several parts. Land preparation that reduces clodding, good soil moisture, warm soils, time after preparation to allow weed seeds to germinate, desiccation of the weeds through flaming, very shallow cultivation, or herbicides, and minimal soil disturbance during the planting operation.

Closer crop spacing and use of transplants increases competition with the weeds. A crop that provides a complete canopy over the soil as fast as possible, shades the soil, depresses soil temperatures, and reduces both numbers and size of weeds. Use of transplants also allow the crop a competitive advantage over weeds, due simply to being there first.

Fallowing a field allows time for weed seed numbers to be lowered, thus reducing competition from weeds. If a field is left fallow, the best option to reduce weed numbers is to reduce the weed seed bank. The best way to accomplish this is to work the soil, allow weed seeds to germinate and emerge, work the soil to kill those weeds, allow weed seeds to germinate and emerge, work the soil to kill those weeds, etc. Over the course of a season, weed seed numbers can be drastically reduced. There is a myth that use of cover crops over a fallow season will reduce weed seed numbers. This is not the case. Both annual and perennial weed pressure will likely be worse the year after use of a cover crop for an entire growing season.

Crop rotation can be used to give the crop a competitive advantage over weeds. Weeds that tend to become problems over time tend to have similar growth habits as the crops they are competing with. For example, summer annual grasses are common problems in corn; cool season weeds, especially winter annuals, are common problems in cool season crops such as cabbage and potato; and summer annuals are more of a problem in later-planted fruiting vegetables. The weed seed bank, over time, is generally lower for other weeds so rotation to a crop with a different season can reduce weed pressure. This is especially true when the same crop or type of crop has been planted in the same field year after year.

OTHER OPTIONS

Other existing or future possibilities including allelopathy, biological control, biopesticides, and transgenic plants will also be discussed.

Herbicides and Rye Mulch for Vegetable Production

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Heavy weed pressure can decrease crop yields substantially or even result in complete crop failure. In addition to competing with crops for water, nutrients and light, weeds can have other undesirable impacts in a vegetable field. Weeds can contribute to pest problems by harboring insects or pathogens. A weedy field reduces air movement and drying, thus crop leaves and fruits remain wet for a greater part of the day and are more susceptible to diseases. Also, crop harvest is a lot more difficult when many weeds are present.

Weed management in vegetable fields can be achieved through a variety of means, but 100% weed control is not necessary or even desirable. An integrated approach in which more than one strategy is employed is most likely to achieve satisfactory results. Weed management strategies include the following:

Cultural - Rotation crops and cover crops to suppress weeds; optimizing planting date and row spacing; use of plastic or organic mulches

Mechanical - Tillage; cultivation (lots of specialized cultivators available); stale seedbed approach; flame weeding

Chemical - Pre-emergence, soil-applied herbicides to prevent weeds; Post-emergence herbicides to control weeds between rows (non-selective) or within rows (selective)

Nearly all of my research experience with vegetable crops has been in pumpkins. So most of my emphasis will be on using herbicides and/or winter rye mulch for weed management in pumpkins. But much of this information is also useful for other cucurbit crops (squashes, melons, cucumbers, etc.) and some other vegetable systems.

Please refer to the latest edition of the New England Vegetable Management Guide for recommended cultural practices for all vegetable crops, and for proper selection and use of herbicides for specific crops. Of course, carefully read and follow the label directions for each herbicide product before use.

<u>Herbicide Use Precautions</u>:

- Most vegetable crops have few registered herbicide options.
- Most pre-emergence herbicides for vegetables are not broad spectrum (i.e. prevent grasses but not broadleaf weeds).
- Often there is only a small margin of crop tolerance. Don't exceed recommended application rate or injury may occur.
- Maintain and calibrate sprayer properly.
- Don't use a herbicide sprayer for other pesticides.
- Avoid spray drift into adjacent fields or neighbor's properties.

Herbicide Carryover Concerns:

• Check rotational crop guidelines on herbicide label to know what crops can be planted the following year.

• If atrazine was applied to corn, will it injure next year's vegetable crop? A simple soil bioassay can be done before planting to determine the if significant atrazine residues remain. Collect representative soil samples from the top 3 to 6 inches of soil in early spring. Mix the samples and put into a pot in greenhouse or window sill indoors. Plant seeds of the vegetable you intend to grow (or oat seeds as a substitute) into the soil and allow seedlings to grow for at least 1 week after emergence. Check seedlings for any evidence of atrazine injury (interveinal chlorosis; yellowing or browning of leaves starting at the margins).

Control of Existing Weeds Before Crop Emergence

A stale seedbed approach is useful to eliminate many weeds by stimulating their emergence prior to planting. These weed seedlings can then be killed easily before the crop is present. Three to four weeks before you plan to plant your crop, prepare the soil as if ready to plant. Allow weed seedlings to emerge. If direct seeding, spray one of the herbicides below or flame the weeds just before or after seeding. If transplanting, apply one of these herbicides or flame weeds just before setting plants. None of these chemicals has any residual herbicidal activity in soils, and thus can not cause injury via root uptake. In either case, minimize soil disturbance to reduce subsequent weed germination. A stale seedbed works best if conditions are warm enough to stimulate weed germination, and if soils will not become too crusty in the weeks between soil preparation and planting (most commonly a problem in heavier clay-based soils).

Pre- or Post-Plant (before emergence)

Roundup UltraMax (glyphosate) and Touchdown (sulfosate) - Control most weeds, including perennial weeds. Must be applied before seeding of some crops, including pumpkins (3 or more days in advance).

Gramoxone Max (paraquat) - Rapid kill of annual weeds [Restricted Use Pesticide (Danger-Poison)]

Scythe (pelargonic acid) - Burns topgrowth of weeds; like a "herbicidal soap"

A preemergence (soil-applied) herbicide that is registered for the crop could be included in the spray tank to provide residual weed control during the growing season.

Soil-applied Herbicides for Weed Prevention in Pumpkins

For weed control within pumpkin rows, preemergence herbicides are applied to the soil surface prior to crop or weed emergence. If direct seeding, apply after planting but before pumpkin seedlings emerge. If transplanting, apply to weed-free soil before transplanting. These herbicides should not be applied over the top of pumpkin plants. Herbicidal efficacy is usually dependent on more than $^{1}/_{4}$ inch of rainfall or irrigation within a few days after application.

Pre-Plant Incorporated

Prefar 4-E (bensulide) - prevents grasses, some broadleaf weeds

Command 4EC or 3ME (clomazone) - prevents grasses, velvetleaf, lambsquarters, purslane

Post-Plant (before emergence)

Curbit 3EC (ethalfluralin) - prevents grasses, pigweed, lambsquarters, carpetweed

Strategy 2.1ME (ethalfluralin + clomazone) - prevents most annual weeds

All these herbicides are effective in preventing annual grasses such as crabgrass. On the other hand, none provide satisfactory control of ragweed and some other broadleaf weeds. Prefar is not widely used because it has to be incorporated into the soil right away and is weak on many broadleaf weeds. For jack-o-lantern pumpkins, Command 4EC is the only registered formulation of clomazone. Because of its high volatility, Command 4EC must be incorporated into the soil right after application. Drift of Command spray droplets or vapors can cause serious injury to susceptible plants and trees near a treated field. Leaves of sensitive plants turn white because Command inhibits chlorophyll and other pigments in leaves. For processing pumpkins and other cucurbit crops, Command 3ME is registered. This micro-encapsulated (ME) formulation is much less volatile and has lower risk of vapor drift than the EC formulation, thus it does not need to be incorporated. Pumpkins are generally tolerant of Command at labeled use rates. Any early whitening of leaves is usually temporary and does not affect yields. Another concern is that small grain cover crops (rye, wheat, oats) are sensitive to Command residues in soil. Thus it may be difficult to establish a good cover crop in fields treated with Command. Also check the Command label for planting restrictions on various crops to avoid carryover injury problems. Velvetleaf, lambsquarters and purslane are easily controlled by Command, so it is useful in fields with large seedbanks of these weeds.

Curbit is the most commonly used of the soil-applied herbicides for cucurbit crops. Curbit usually provides good control of pigweed, lambsquarters and some other broadleaf weeds. However, its activity is very dependent on adequate rainfall or irrigation within a few days after application. The optimal amount of water to activate Curbit is $^1/_2$ to 1 inch. If rainfall or irrigation does not occur, poor weed control will result. Pumpkin tolerance of Curbit is generally good, although injury can occur under cool, wet conditions. Injury potential is reduced if seeds are planted deeper. Strategy is a pre-mix, micro-encapsulated (ME) formulation containing the active ingredients of Curbit (ethalfluralin) and Command (clomazone). Because the volatility of clomazone is greatly reduced in the ME formulation, Strategy can be sprayed on the soil surface without incorporation. Once this product contacts soil, the risk of chemical drift is minimal. The components of Strategy make a good combination in terms of weed control spectrum. For example, pigweed is tolerant of clomazone but is controlled by ethalfluralin, and velvetleaf is tolerant of ethalfluralin but is controlled by clomazone. A disadvantage of Strategy is that its active ingredient concentrations are rather low. To get satisfactory weed control, a grower may need to apply Strategy at the high end of its rate range (2 to 6 pt/A, based on soil type). Strategy is rather expensive when applied at rates of 4 to 6 pt/A.

A New Herbicide for Pumpkins and Other Vegetables - Sandea (Halosulfuron)

Halosulfuron has herbicidal activity at extremely low use rates (less than 1 oz/A). It is registered as various trade names in corn (Permit), and turf and landscape uses (Manage). Gowan Company has recently registered its herbicide Sandea 75DF (halosulfuron, 75%) in several vegetable crops including cucurbits, tomatoes, peppers, eggplant and beans. Sandea provides control of yellow nutsedge, a troublesome perennial weed, in addition to some broadleaf weeds including pigweed, ragweed and galinsoga. It does not have activity on grasses.

Sandea has pre-emergence and post-emergence herbicidal activity. Yellow nutsedge is more susceptible when sprayed after emergence, but weeds such as lambsquarters and purslane are much more susceptible to pre-emergence treatments. Pumpkins have rather marginal tolerance of Sandea even at the labeled rate of $^{2}/_{3}$ oz/A, so proper calibration of spray equipment is especially important when using this product.

I have conducted experiments in Connecticut with Sandea (along with Curbit, Command and Strategy) in pumpkins the past two years. Experiments were conducted at two sites in 2002 and 2003. The dependence of preemergence herbicides on rainfall for activation was readily apparent. At one site in 2002, about $^{1}/_{2}$ inch of rain fell within hours after treatment application. Herbicidal efficacy was excellent. The other site received only a trace of rain (and irrigation was not available) in 10 days after herbicide application, resulting in poor weed control from all treatments.

Because Sandea does not control grasses, I applied a low rate of Curbit in all Sandea plots. Sandea was applied both pre-emergence and post-emergence at rates between 0.33 and 1.0 oz/A. Most pumpkins treated with Sandea showed some injury symptoms (growth stunting and temporary yellowing of leaves). Eventual recovery was nearly or fully complete. Control of yellow nutsedge and pigweed was excellent. Sandea applied pre-emergence provided adequate control of lambsquarters and purslane, but these two weeds were mostly unaffected by post-emergence sprays. Pumpkin yields in Sandea-treated plots were reduced, but it was unclear whether the reduction was due to plant injury or to weed competition. Sandea will be a useful option for growers having problems with yellow nutsedge, ragweed and some other broadleaf weeds. However, it is definitely not a stand-alone product; it must be used in conjunction with a herbicide that controls grasses.

Use of Herbicides with Plastic

Many vegetable growers use plastic to some extent in their fields. Black plastic will prevent weeds, but if white or clear plastic strips are used, you may want to use a pre-emergence herbicide before laying the plastic. First, be sure the herbicide is registered for use with that crop and for use under plastic. Avoid crop injury due to buildup of herbicide vapors by following these steps:

1) Prepare beds of pressed soil.
2) Apply herbicide to pressed soil beds.
3) Irrigate with $^{1}/_{2}$ to 1 inch of water.
4) Wait 2 or 3 days.
5) Lay plastic over beds.
6) Plant crop through holes in plastic.

To control weeds between plastic strips, one or more of the following can be employed:

- Cultivate between strips
- Flame weeding
- Herbicides (minimize spray contact on the plastic)
  - Before planting: Banded spray of Roundup, Gramoxone, Scythe
  - After planting: Do not use Roundup; can apply a registered preemergence herbicide between strips to prevent further weeds.

Using Rye Cover Crop As Mulch for Pumpkins

I have experimented the past several years with rye mulch systems for pumpkin production. This type of approach has been studied and used by a number of researchers and growers. Dale Riggs in New York and others have conducted studies using winter rye as mulch in pumpkins and other crops. In Connecticut, Jones Family Farm in Shelton has been using a rye mulch system successfully in pumpkins. Potential benefits include soil conservation, soil moisture conservation, weed suppression, herbicide use reduction, and keeping the fruits in a cleaner condition.

I am interested in all these impacts, but particularly the effects on weed populations. A dense stand of a cover crop can suppress weeds in two ways: a physical effect via competition (crowding out weeds), or a chemical effect (allelopathy) in which biochemicals are exuded that suppress weed seed germination. A dense stand of rye can work in both these ways.

Our basic approach is to plant rye in late September (or ASAP after harvest) at 300 to 400 lb of seed per acre (about 3 times the normal cover crop rate). In April, the rye is fertilized with nitrogen (40 to 50 lb/A). The first few years I allowed rye to grow until it produced seedheads (but seeds still in "milk" stage). At that time I sprayed the rye with Roundup (1 qt/A) to assure that it would die before seed maturation, thus avoiding volunteer rye as a weed. The next day the rye was rolled flat with a heavy roller. It is important to roll rye while it is still turgid, otherwise the stems tend to rise back up again. About 1 week later, pumpkin seeds were planted by hand in rows parallel with the rolled rye. The mulch was pulled back about 6 inches where seeds were planted, and fertilizer was applied to the soil. Early pumpkin vigor tended to be poor in the rye mulch plots. In addition, weed suppression was short lived compared to that of herbicide-treated plots.

I tried a different approach the past two years. In some plots, the rye was not sprayed with Roundup before being rolled. We found if the rye was rolled when it was far enough along in its reproductive stage (but still turgid), it died naturally on its own. Thus it is not necessary to spray rye with Roundup if it is rolled at the proper time. If many weeds emerge through the rolled rye prior to planting, Roundup or other postemergence herbicide could be used to kill these weeds. The other modification was to till a 1-ft wide strip for the planting rows. In some of these plots, Curbit was applied in a narrow band to reduce weed emergence in the disturbed planting row. Pumpkin seedling emergence and vigor was better in these tilled rows than where the rye mulch was just pulled back slightly.

With proper modifications, a rye mulch system should be useful for many different vegetable crops.

Latest Techniques with High Tunnels

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There has been a tremendous increase in the popularity and adoption of the use of high tunnels for extending the production season for vegetables, small fruits, cut flowers and tree fruits by growers, not only in the Northeast but also in many other parts of the country. One reason that the use of high tunnels has become popular with growers is their simplicity and effectiveness in protecting crops from low temperatures in both spring and fall. Because high tunnels can be viewed as affordable technology, this system is particularly appealing to new-entry growers who utilize retail-marketing channels.

High tunnels do not offer the precision of conventional greenhouses for environmental control, but they do sufficiently modify the environment to enhance crop growth, yield, and quality. Although they provide some frost protection, their primary function is to elevate temperatures a few degrees each day over a period of several weeks.

In addition to temperature control, there are also the benefits of wind and rain protection, soil warming, and in some instances control of insects, diseases, and predators such as varmints and birds. Overall, these growing systems should be considered protected growing systems that enhance earliness and higher yields, improve quality, and reduce the use of pesticides in some cases.

High tunnels have sufficient versatility to make them useful on a wide diversity of crops and in various cropping systems. **Vegetables, small fruits, flowers and even tree fruits are all suited to this growing system; but the specific crops which might be grown will to a large extent depend on marketing opportunities for individual crops by individual growers.**

High Tunnel Systems

High tunnels are not conventional greenhouses. But like plastic-covered greenhouses, they are generally quonset-shaped, constructed of metal bows that are attached to metal posts which have been driven into the ground about two feet deep. They are covered with one layer of 6-mil greenhouse-grade polyethylene, and are ventilated by manually rolling up the sides each morning and rolling them down in early evening. There is no permanent heating system although it is advisable to have a standby portable propane unit to protect against unexpected below-freezing temperatures. There are no electrical connections. The only external connection is a water supply for trickle irrigation. Dr. Otho Wells, Professor Emeritus, from the University of New Hampshire was a pioneer in promoting the use of high tunnels in the northeastern United States and developed the New Hampshire design and system of production that involved covering the entire soil surface inside the tunnel with a solid sheet of 6-mil thick plastic. At Penn State we re-designed the endwalls so that they can be raised up to facilitate easy access into the tunnel of a small tractor and tiller and a system of production that uses 18- inch wide raised plastic mulch covered beds with drip irrigation tape buried 2-3 inches beneath the bed. The raised mulch beds are 44 inches apart, which allows 4 rows in a 17-foot wide high tunnel or 5 rows in a 21-foot wide high tunnel.

Details of the Penn State Design

Erection of the pipe framing is the same whether the New Hampshire Design or the Penn State Design is used. The changes come in the construction of the endwalls and the hipboard and attachment of the plastic covering. For an excellent overview of the construction of a high tunnel using the Penn State University go to the Center for Plasticulture website: http://plasticulture.cas.psu.edu and go to the high tunnel button. There is a PDF file of an article "Design and Construction of the Penn State High Tunnel" that has illustrations detailing the steps in construction of a high tunnel using the Penn State Design. This article first appeared in a 2002 issue of HortTechnology Volume 12(3): 447-453. A couple of suggestions on purchasing and positioning a high tunnel. One is to purchase a high tunnel with tall sides (approximately 5 feet from the ground to the hipboard). This will improve the ventilation capacity of the tunnel. In locating a site for the high tunnel make sure to orient the high tunnel so that the prevailing winds blow through the sides of the tunnel. The wind is your means of ventilation and temperature control and also pollination for some crops. For parts of the country that experience snow in the winter we recommend purchasing a high tunnel with a peak to protect against snow accumulating on the top of the tunnel. Fourth is to space the tunnels at least 12 feet but if room allows then 20-25 feet apart to ensure adequate ventilation in the tunnels and permit the removal of snow that could possibly buildup against the sides of the tunnels during severe winters.

At the Penn State High Tunnel Research and Education Facility we have purchased all our high tunnels from Ledgewood Farm Greenhouse Frames (603)-476-8829.

For all practical purposes, high tunnels are protected growing structures that should result in high returns. Therefore, they should be situated on the best soil -- soil that is well drained and that has had pH and nutrient adjustments as for a field soil. The soil should be smooth, firm, and moist at planting.

The high tunnels come in widths of 14 feet wide up to 30 feet wide and in any length of 4-foot intervals. Most commercial lengths are 96 feet long. After researching and using different size high tunnels we recommend purchasing a 21 feet wide by 96 feet long tunnel which would cost between $4,500 and $5,000 completely finished not including labor cost. The tunnel could be erected and ready to plant in 2-3 days.

There are other high tunnel structures being marketed which should be evaluated keeping in mind the comments made above about snow loads.

The Haygrove Multibay Tunnel System is a different type of tunnel than what we have been discussing and it is currently being used in Pennsylvania for the production of plasticulture strawberries, raspberries, cut flowers, tomatoes and sweet cherries. This type of tunnel can cover from 1/3 to 5 acres and is operated differently than the single high tunnel units discussed in the preceding paragraphs. In the Haygrove Multibay Tunnel System, the plastic covering is completely removed, covered with black plastic and stored in the gutter area between the bays for the winter whereas the single Penn State high tunnel units remained covered the entire winter.

High Tunnel Management

High tunnels are not automated but can be but then you are getting closer to a conventional greenhouse. Consequently, for maximum efficiency, they require regular daily attention, especially in the morning and evening, and during heavy rain or strong winds. Temperature and humidity are the two critical factors that should be controlled as much as feasible. Early each morning, the sides should be rolled up to flush out the humidity and to keep temperature in check. The temperature in a closed high tunnel rises very rapidly on a clear morning! In other words, don't put off rolling up the sides. In early evening, roll-down the sides to entrap as much heat as possible. Close the sides each evening until the night temperature reaches about 65ºF. In northern states, this could mean that the sides will be rolled down each day well into the summer. Ventilation is best accomplished when the prevailing wind moves through the tunnel from side to side; therefore orient the tunnel accordingly. The width of the tunnel also impacts ventilation. It is hard to be specific on the maximum width, but from experience, about 21 feet wide seems to be the maximum which allows for good ventilation, especially as plants grow taller such as, tomatoes and block the air flow.

Benefits of Tunnels. The primary benefit of tunnels is earliness. Tomatoes in a high tunnel mature on average about one month before field tomatoes. Earliness is the combination of being able to plant in high tunnels about two weeks earlier than in the field and faster ripening (about two weeks) inside the tunnel. Overall, the cost of a tunnel is recovered the first year when selling at retail prices. Another highly beneficial advantage of tunnels is disease control. The plastic cover is a rain shelter, the raised plastic mulch bed is a barrier against evaporation of soil moisture, and early morning ventilation reduces relative humidity. Therefore, the leaves of crops are dry for most of the day and night. Because of low humidity, plant leaves remain dry, impeding the incidence and spread of disease. For example, early blight of tomatoes, a serious foliage and fruit disease on field tomatoes, is not a problem in high tunnels when the tunnels are vented daily, though powdery mildew, especially in cucurbit crops can be a problem because the conditions in a high tunnel are more favorable for the development of this disease.

Although tunnels do require more manual attention than do greenhouses, the benefits of high tunnels in a diversified farm operation have proven to be a valuable asset in overcoming a short growing season. Both cool- and warm-season crops do well in the spring. With cool season crops, the season may easily be extended into early winter and even throughout the winter depending on the location, for some hardy crops. Fall-planted strawberries ripen the following spring about six weeks earlier than field-grown berries.

One of the greatest benefits of a high tunnel is that it allows a grower to plant and harvest regardless if it is raining, etc. This allows a degree of scheduling that is sometimes difficult to obtain with field production.

Crops

At the Penn State High Tunnel Research and Education Center we have been evaluating a wide variety of crops and cropping schedules. We use a lot of row covers and thermal blankets to protect the crops inside the high tunnel and further manipulate the microclimate around the crop. The following is a brief review of what we have found so far. For a more detailed description of the production system used at the facility go to the Center for Plasticulture website listed above and go to the high tunnel button and the PDF file with the article "Production System for Horticultural Crops Grown in the Penn State High Tunnel" which first appeared in HortTechnology Vol. 13(2): 358-362.

Tomatoes - This is probably the number one crop in high tunnels. Production can be at least month ahead of field production. There are very few if any diseases, not even early blight. Insects, especially white flies, can be controlled with biologicals (Encarsia formosa). The key management strategy is daily (every morning and every evening) opening and closing the high tunnels to manage temperature and humidity. This is critical to successful production of crop in a high tunnel. Another tip: do not plant so early as to have to use continual heating.

Summer Squash - Yellow, zucchini, patty pan, and other summer squashes grow very fast in tunnels. Earliness is the general rule, but not as consistently so as with tomatoes. The range of earliness is as high as a month but also as low as 7 days. Outside conditions make a big difference is squash maturity. Also, pollination is necessary; a series of bad bee days could reduce both earliness and total yield. A half hive of greenhouse bumblebees is the best insurance against casual pollination by honeybees. Incidentally, if there are several high tunnels in close proximity, the bumblebees will fly from tunnel to tunnel but go back to the hive at night. Later in the summer, powdery mildew can be a problem on squash and other cucurbits.

Cucumbers and Muskmelons - These crops also need bees for pollination. When using black plastic mulch beds in the tunnel, the cucumbers will stay clean without having to trellis them. From a retail point of view, the yield of non-trellised cucumbers is quite profitable. Trellising cucumbers certainly increases the labor bill. European greenhouse cucumbers can be grown quite successfully in a high tunnel but need a trellis system and pruning similar to traditional greenhouse production system. Muskmelon production in high tunnels is questionable from the standpoint of economics. We recommend that growers try early varieties with and without trellising to determine if this crop has a place in high tunnels. Use a specialty melon.

Pepper - Fruit set of peppers (bell types) in a high tunnel is far more dependable that with field-grown peppers. We have used Paladin and had excellent results. Some of the newer Dutch varieties should be ideal for tunnels. The economics of pepper production looks good. Pricing peppers for retail markets will be the key. Hot pepper varieties also grow very well and yield superbly in high tunnels. The use of colored peppers for specialty markets is also recommended. Excellent red peppers can be grown in high tunnels because of the protected environment.

Leafy Green Crops - If you are looking to grow the ingredients for a salad the high tunnel is the place to grow them. The extra heat provided by the tunnels will greatly accelerate the maturity and thereby make way for succession cropping. A wide variety of lettuce, spinach and leafy greens (mustard and turnip) respond well to production in high tunnels and the use of a floating row cover can even be incorporated into the system to provide an even earlier and more favorable growing environment. The lettuce and spinach can be the first crops of the season and also the last crops of the season in a high tunnel. In the high tunnels at the Horticulture Farm, Rock Springs, PA we can grow leafy greens all winter. Micro-greens or spring salad mixes are excellent in high tunnels. They also do quite well on permanent raised bed.

Broccoli, Cabbage, Cauliflower, Kale and Collards - These crops also have great potential for production in high tunnels. Most of these crops can be used in a rotation scheme in tunnels as an early spring crop, which is then followed by a summer crop and then followed by a late fall/early winter crop of these vegetables. We have had excellent broccoli up to Christmas and would have had it even longer if we had put a thermal blanket over the crop.

Onions and Garlic – These crops do extremely well in high tunnels. They are transplanted on raised, plastic covered beds using drip irrigation. The return of garlic is 10 lbs of garlic for every 1 lb planted in the high tunnel. In addition, the crops are earlier and of better quality that those produced in the field. The variety Candy, a sweet Spanish onion type is planted in the early spring and harvested in late June or early July and the onions can be pulled and dried on the plastic beds in the high tunnel.

Other Vegetable Crops – Almost any crop can be grown in a high tunnel but the economics and individual growers marketing opportunities will dictate if crops like okra, sweet potatoes, asparagus, sweet corn, bush pumpkins, snap beans, lima beans, peas, radishes, beets, turnips and carrots will be produced in high tunnels

Herbs - There are dozens of herbs that are used in a variety of ways. High tunnels offer an excellent protective environment for these crops, including the capacity for drying and storing. The high tunnels maintain the high quality of the herbs. Opportunity for herbs used in ethnic foods.

Strawberries and other Small Fruit - Strawberries grown from plugs and planted in the fall on raised beds covered with plastic mulch is a way to get fruit production about six weeks earlier than in the field. The use of 'Chandler', a California/Florida variety, has been one of the best varieties because it over winters quite well in high tunnels. The goal is to get a minimum of one pound per plant. Other small fruit crops that have really performed well are raspberries (equivalent of 19,000 lbs/A), blackberries. The yields and shelf life are excellent. Also blueberries may be another crop, depending on marketing opportunities. We also have hardy kiwi planted and growing in an overhead trellis in the a large 30-foot wide by 48-foot long high tunnel.

Niche Crops - The definition of "niche or specialty" crops is wide ranging, but the potential to grow crop that may be considered niche, ethnic or even exotic is excellent for high tunnels. Because temperature can be further manipulated inside the tunnels by using various colors of plastic mulch, row covers, and thermal blankets there is a good possibility that many of these crops can be grown year around. One niche market is specialty potatoes, that have a different skin type or flesh color or a very early crop of "new" small red potatoes that can command a high price on the early spring retail market. One can even make the "Spud Flag" for the 4th of July sales using the following potato varieties: Dark Red Norland, Eva, and Michigan Purple.

Cut Flowers - On a square foot basis, the value of cut flowers is near (or at) the top of the charts. Inside a high tunnel, flower stems are longer than outdoors, the foliage is nearly disease free, and the flowers themselves are brilliant in color. The plants are almost always completely dry; therefore, disease problems are minimized. Both traditional spring planted flowers and spring-flowering bulbs (planted in the late fall) grow very nicely in high tunnels.

Tree Fruits – The tree fruit being produced in high tunnels at Penn State are sweet cherries. The reason that sweet cherries were chosen is that they are a high value crops and the two main problems associated with sweet cherry production, bird feeding and fruit cracking can be eliminated in the high tunnels. It seems that the production of sweet cherries in high tunnels has a tremendous potential. Currently the cultivars Bing and Ranier, on a Gisela 5 rootstock, which is a semi-dwarfing rootstock, are being grown in a 17-foot wide by 36-foot long high tunnel. This size high tunnel is too small for the production of cherries, as we have seen tremendous growth of the trees in the high tunnel. This is one crop that could use the 30-foot wide high tunnel because of the increased height that comes with that size tunnel.

High tunnels provide an ideal protective growing environment for any number of crops, but all crops might not be economical for any number of reasons. Therefore, a good approach to take would be to try different crops in light of market demands and marketing strategies

There are temperature limitations to a high tunnel, which is not designed to be as warm as a greenhouse. Some type of supplemental heat should be available just in case there is a sudden unexpected drop in the temperature that would permanently injure the crop. The critical low temperature will depend on the crop. If the intent is to have a permanent heat source in a high tunnel, then if would be well to consider constructing a bona-fide greenhouse, which easily could be used year around.

Innovative Approach to Heating High Tunnels in the Future

We are currently in the process of constructing a 30-foot wide by 96-foot long high tunnel at the Penn State University Horticulture Farm that will be heated using Plastofuel (nuggets of used agricultural plastic waste) burned directly in a boiler unit generating hot water, that was developed in South Korea. This project is a partnership between Jim Garthe in the Department of Biological and Agricultural Engineering and the High Tunnel Research and Education Facility and a private entrepreneur from South Korea. This utilization of this currently perceived waste material to generate heat might allow even more year around cropping options in high tunnels in the future.

For addition information on the plasticulture and high tunnels contact the following websites:

American Society for Plasticulture: **http://www.plasticulture.org/**
Center for Plasticulture, Penn State University: **http://plasticulture.cas.psu.edu**

2003 High Tunnel Production Manual- a157 page manual is available for $25.00 from Dr. Bill Lamont at the above address. Checks should be made out to The Pennsylvania State University.

Novel Structures for Extending the Cut Flower Season

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Cut flower growers in New York use several season-extending strategies to produce marketable flowers continuously from spring through fall. Growers use early blooming cultivars, early sites on the farm, cultural practices that warm the soil and plant environment, and a variety of structures to extend favorable growing conditions. Spring bulbs and early-blooming perennials are good options for extending the season. The annual cultivars often selected for early production are stock, campanula, snapdragon, Bells of Ireland, larkspur, godetia, and sweet peas – all species that produce well in the cold, wet conditions typical of our spring weather, and that can be made to bloom even earlier with modest investments in growing structures.

Site selection is important for early field production. The earliest plants should be transplanted into soils that are well drained, because these are the first to warm. Fields should be selected that are protected from cold, desiccating winds, and that have a southerly aspect. Some flower growers use raised beds to create a drier and warmer root zone, and floating row covers, to create a warmer microclimate for the above-ground portion of the plant. And some growers use plastic mulches in various colors to enhance earliness. Use of these simple strategies can extend the season by two weeks or more, and usually produce flowers of superior quality.

Cut flower growers use a number of structures to extend the cut flower season, including low tunnels, walk-in tunnels, and high tunnels. Low tunnels are used widely in commercial vegetable production. They are made by placing #10 wire hoops over the row every 6 to 10' in order to suspend wide or narrow floating row covers over the young plants. This provides wind protection and a few degrees of frost protection. The cost of low tunnels can be as little as $.05/ft^2. The problem that some farmers face is that the flowers outgrow the low tunnels before problems with wind and cold temperatures have abated.

Walk-in tunnels are portable tunnels that may be covered with greenhouse plastic or Typar. They are variable in size, but often measure 10 to16' wide by 100 to 300' long. They have two to three 48" beds. The hoops are slipped over re-bar ground stakes. A rope tied from hoop to hoop is used to form the ridge purlin. The covering is held fast by ropes that are drawn over the top of the structure and are secured to stakes in the ground. The tunnels are tall enough to walk in (hence, the name). The flexible tunnel length enables growers to place a tunnel virtually anywhere on the farm because it is sized to fit into a farms' existing bed spacing. This dimension also allows for the use of commonly available greenhouse film (4-year, 6 mil) or Typar (1.25 oz.yd^3 floating row cover). The tunnels are accessed and vented by rolling up the sides. Walk-in tunnels are intermediate between high and low tunnels with respect to wind protection, temperature modification, impact on the timing of crop maturity, ease of construction, and cost (less than $.25/ft^2). These field tunnels produce their blooms three to four weeks ahead of those in the field. In addition to the early flowers listed above, the season's first sunflowers might be produced in these structures. In the summer, the tunnels may be used to keep China asters free of the insects that transmit aster yellows. Walk-in tunnels may be used in the fall to produce a second succession of annuals. These tunnels may be erected after beds are formed in the spring. For earlier production, it may be worthwhile to form beds and erect hoops in the fall.

High tunnels are essentially greenhouses without heaters or automated ventilation. These structures are covered with standard greenhouse plastic. Ventilation is accomplished using roll-up sides. Some growers use portable heating systems to prevent freezing injury to crops. A wide range of sizes is available. Inside the high tunnels, raised beds and wide row covers are frequently used. High tunnels produce the earliest and latest flowers of all the tunnels discussed, and some growers use them to produce their most valuable varieties, including early spring bulbs, lisianthus and lilies. The high tunnels are about a week earlier than the walk-in tunnels because they are larger and are less affected by perimeter cooling. Growers begin planting annuals at the end of March, and start harvesting in mid- to late May. Bulbs are even earlier. Although not nearly as expensive as heated greenhouses, the over $\$2.00/ft^2$ cost of these units can be prohibitive. To reduce unit costs, growers often produce two successions of flowers each year from each bed in a tunnel.

Mark Parlee of Parlee Farms, Tyngsboro, MA
Greenhouse / Season Extension Session – Tuesday, Dec. 16, 2003 4:00pm
'*Grower Panel: Winds, Wildlife, and Weeds: Managing Row Covers*'

Mark Parlee of Parlee Farms, Tyngsboro, MA will be discussing his use of floating row covers on strawberries, raspberries, corn and flowers. Slides of the row cover in use and resulting crop will be shown. During the panel discussion, the following topics will be addressed:

ADVANTAGES OF ROW COVER -

- Promotes early season production
- Acts as a barrier for insect control
- Frost protection
- Protection from deer browsing

DISADVANTAGES OF ROW COVER –

- Increased disease pressure (fungus and bacteria)
- Increase insect damage
- Increased frost damage and frost control
- Increased weed pressure
- Increased root disease resulting from overhead irrigation for frost control
- Deer damage to certain row cover
- Wind damage to row cover

The Pick of the Crop – Highmoor Farm Pepper Variety Trial

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Materials and Methods

We evaluated 15 pepper varieties in a replicated trial with three replicates. Plants were started on in the greenhouse April 23 and transplanted to the field on June 9, 2003. Three plots of each variety were planted in a randomized design. Each plot consisted of 20 plants planted in double rows on black plastic covered 42" beds spaced 6' apart. Plant spacing within rows was 18". Prior to forming the beds the field was fertilized with 10-10-10 at a rate equal to 500 lb/acre. The plants also received started solution at transplanting. No other supplemental irrigation was provided. No sprays were made to manage insects or disease.

Harvest dates were August 18, September 4, 16, and 26. The center 16 plants of each bed were harvested for data collection, the first and last pair of plants in each plot served as guard plants. The individual plots were divided in half: the first group of 8 plants n each plot were harvested at the mature green fruit stage and the second group of 8 plants in each plot were harvested at the colored fruit stage. On the final harvest date, all marketable green fruit were also harvested from the colored fruit portion of each plot. Number of fruit and fruit weight were recorded for each plot and the data combined for analysis. Fruit length, width, and wall thickness were determined from 10 randomly selected fruit of each variety.

Results

The summer of 2003 was a particularly challenging summer to grow peppers. The cool wet spring followed by widely fluctuating temperatures and moisture resulting in many aborted blossoms and corresponding yield reductions (Table 1). Ace and New Ace were clearly the top producers for both green and colored fruit. However, fruit of these varieties tend to be small, thin walled and often misshapen (Table 2). Vivaldi and Aristotle X3R were the second greatest yielders followed by a clustering of varieties. Heritage, Gourmet and Queen produced unacceptable low yields. Fruit sizes ranged from 5 oz (Ace) to 9.25 oz (Socrates)

Table 1. Performance of pepper varieties evaluated at Highmoor Farm, Monmouth Maine 2003.

Variety	Total Fruit	Total Yield (lb./plot)[1]	Number Green Fruit per plot	Green Fruit Yield (lb/plot)[2]	Number Colored Fruit per Plot	Colored Fruit Yield (lb/plot)[3]
Ace	110	35.85	86	26.61	25	9.23
New Ace	84	28.64	60	19.39	24	9.25
Vivaldi	40	16.83	40	16.57	1	0.36
Aristotle X3R	38	13.45	37	12.94	1	0.51
Socrates	21	12.05	13	6.46	8	5.59
King Arthur	23	9.61	20	6.89	3	2.72
Brigadier	19	9.52	18	8.73	1	0.78
Early Sunsation	23	9.32	19	6.99	4	2.32
Ironsides	21	9.17	17	6.50	4	2.67
Double-Up	27	8.84	25	7.61	2	1.22
Patriot	16	7.30	16	7.30	0	0.00
Olympus	11	5.59	9	4.51	2	1.08
Heritage	8	4.37	7	4.02	0	0.35
Gourmet	9	3.76	4	1.31	6	2.45
Queen	9	3.71	6	2.16	3	1.54
LSD 0.05[4]	18	7.80	16	6.49	7	3.05

1 Plots were 15' double row bed with rows 18" apart and 18" between plants within rows. 6' between beds, and 20 plants per plot.
2 Green fruit were harvested from 8 plants, the first half of each plot.
3 Red fruit were harvested from 8 plants, the second half of each plot.
4 Data within each column must differ by this much to be considered statistically different.

Table 2. **Average fruit sizes[1] of peppers grown at Highmoor Farm, Monmouth Maine 2003.**

Variety	Ave fruit wt (oz)	Length (in)	Width (in)	Thickness (mm)
Socrates	9.25	4.4	3.78	7.4
Heritage	9.11	4.7	3.89	8.0
Olympus	8.26	3.8	3.28	7.4
Patriot	7.42	4.0	3.88	8.4
Brigadier	7.4	3.9	3.45	7.4
Ironsides	7.28	4.0	3.32	6.3
King Arthur	6.99	3.9	3.41	7.2
Vivaldi	6.74	4.9	3.57	7.3
Early Sunsation	6.46	3.9	3.75	6.9
Queen	6.42	3.7	3.35	7.1
Gourmet	6.17	3.6	3.41	6.9
Aristotle X3R	5.66	3.5	3.61	7.8
New Ace	5.47	3.8	3.39	5.9
Double-Up	5.36	3.9	3.28	7.3
Ace	5.19	3.8	3.30	5.3
LSD 0.05[2]	1.86	0.5	0.41	1.5

[1] Averages were obtained by measuring 10 randomly selected green fruit.
[2] Data within each column must differ by this much to be considered statistically different.

Pepper Disease Control –
It Starts with the Seed

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Plant diseases can be a limiting factor in pepper production wherever the crop is grown. Moisture in the form of wind blown rain, saturated soils and high humidity plays a major role in the occurrence of both bacterial and fungal diseases. Insects that attack pepper serve to create wounds favorable for bacterial soft rot and spread several virus diseases. Clean seed, greenhouse sanitation, crop rotation, and cultural measures in the field are all key components for disease control, but it all starts with the seed! This is especially true for the first disease discussed, bacterial leaf spot. All major seed companies are incorporating disease resistance into most released varieties with emphasis placed on bacterial leaf spot, Phytophthora blight, and assorted virus diseases.

Bacteria

Bacterial Leaf Spot (BLS)

Bacterial leaf spot is caused by two major groups of bacteria, *Xanthomonas campestris* pv. *vesicatoria* and *Xanthomonas vesicatoria* (some literature will also mention *Xanthomonas axonopodis* pv. *vesicatoria*). A number of races occur for each of these pathogens, with some occurring more commonly on pepper and others on tomato. Both bacteria are gram-negative rods, have a single polar flagellum used for mobility, and are found only in association with plants or plant materials. The BLS pathogens are seedborne, both within the seed and on the seed surface. BLS may also survive on plant debris in the soil for 1-2 years, therefore a 2-year rotation out of pepper and tomato is essential.

Seed can be treated with hot water (122°F for 25 minutes) or with Clorox® (EPA Reg. No. 5813-1; label available from Clorox at 800-446-4686). Hot water is more effective for controlling bacteria on and within seed, but hot water can adversely affect germination if not properly performed (see ref. 3). Treating the seed yourself nullifies the seed company's liability and voids their guarantees. Mix 1 quart of Clorox® bleach (calcium hypochlorite) with 4 quarts of water to treat up to 1 pound of seed in a cheesecloth bag, add _ tsp. of surfactant (dishwashing detergent), and submerge in the solution with agitation for 40 minutes, rinse under running tap water for 5 min, and dry seed thoroughly. Treated seed should be dusted with Thiram 75W [dithiocarbamate] (1 tsp. per pound of seed), and planted soon after treatment.

Some varieties currently have resistance to all three races of BLS (BLSR1, 2, 3) that commonly occur in our area. These include Boynton Bell, Aristotle, Commandant, Enterprise, Revolution, X3R Camelot, and X3R Wizard. King Arthur is resistant to race 2 and Admiral is resistant to races 1 and 2. Resistance to races 1 and 3 are most important for the Northeast.

Use of disease-free seed and a 2-year rotation in the field should solve most of the BLS problems, but some persistent cases may require chemical treatments. Streptomycin (Agri-Mycin 17, Agri-Strep) sprays (1 lb per 100 gallons or 1 _ tsp per gallon) may be applied to transplants prior to transplanting. In the field, applying fixed copper (1 lb active ingredient per acre) plus maneb (1 _ lb 80WP per acre) has been shown to reduce the spread of BLS.

Bacterial Soft Rot (BSR)

Bacterial soft rot is caused primarily by *Erwinia carotovora* subsp. *carotovora*. The bacterium is commonly associated with plants, soils and surface water, and thus is a common contaminant. BSR is primarily a post-harvest problem except when fruit are injured in the field by insect feeding. The European corn borer larvae tunnel under the calyx (cap), and their entry holes are marked by sawdust-like frass. Insecticide treatments should coincide with peaks in adult activity as determined by pheromone or light traps. Registered insecticides include cyfluthrin (Baythroid 2), esfenvalerate (Asana XL), permethrin (Ambush), and spinosad (SpinTor 2SC). Hot pepper varieties are most resistant to larval feeding, while green bell peppers are most susceptible.

Post-harvest wash water can spread the bacterium from contaminated to healthy fruit, therefore most peppers are packed dry to minimize BSR. If wash water is used, maintaining 25 ppm chlorine in the wash water (1 TBS of Clorox®, 5.25% sodium hypochlorite, per 8 gallons of water). Make sure that the wash water is not cooler than the fruit temperature, or bacteria will move into the fruit or stem end.

Oomycetes

Pythium Damping Off (also caused by *Phytophthora* spp., and *Rhizoctonia solani*)

Growing media can be a source of various soil-borne fungi, so care must be exercised in selection of the appropriate media and attention paid to characteristics that will allow the growing media to remain moist but not continually wet. Addition of soil amendments that contribute to suppression of soil-borne pathogens can be considered. SoilGard 12G, containing the naturally occurring fungus *Gliocladium virens* is known to be antagonistic to fungi such as *Pythium* and *Rhizoctonia*, two of the more common fungi responsible for damping off.

Pythium Root Rot

Pythium root rot generally occurs after peppers are transplanted in polyethylene mulch/drip irrigation culture. Cultural practices that contribute to Pythium root rot are planting in low areas of the field, overwatering in an attempt to reduce wilting, and planting into beds with fresh plant material (cover crop, weeds, etc.) before microbial breakdown of the plant material has occurred. The infected roots of infected plants will appear brown rather than white, and the cortical tissue of the main affected roots can easily be removed from the central steele with a finger nail. After removing transplants from the greenhouse and prior to transplanting, plants can be drenched with the systemic fungicide mefenoxam (**Group 4** fungicide) (Ridomil Gold 4E or Ultra Flourish 2E). Apply Ridomil 4E at 0.75 fl.oz. /2,000 ft^2/100 gallons of water or Ultra Flourish 2E at 1.5 fl.oz. /200ft^2/100 gallons of water.

Phytophthora Crown Rot and Aerial Blight

Phytophthora blight can be one of the most serious diseases affecting pepper as well as eggplants, tomatoes, and the entire cucurbit family. Because it affects such a wide range of vegetables, growers are challenged to develop adequate rotational strategies. Consequently, control must depend upon cultural, chemical and selection of resistant varieties when available. Phytophthora blight is caused by the soil borne oomycete *Phytophthora capsici*. The disease can be divided into two distinct phases, a crown rot phase and an aerial blight phase.

In the crown rot phase of the disease, a black girdling lesion occurs at the soil line. In some plants the lower tissue of the wilted plants must be removed to expose the girdling lesion in the cortical tissue beneath the epidermis. Most cases of the crown rot phase occur in July and August in the lower areas of the field and from there the disease can spread to adjoining areas of the field. Phytophthora is considered a weather event disease, meaning that heavy rainfall (in excess of 2 inches) leading to saturated soils is critical for infections to occur. Generally soil temperatures are > 65°F and air temperatures are in the range of 75-85°F.

The aerial phase of Phytophthora blight occurs later in the season as the spores produced on the lesions of plants infected in the crown rot phase are spread by heavy, wind driven rains. These typically occur following a tropical storm or hurricane, another major weather event. Infection occurs at the axil of a branch and stem with a 2-3 inch black, girdling lesion developing on the stem. All of the leaves on the branch above the lesion will wilt and eventually the entire plant dies.

Cultural control measures aim to mitigate the affects of the weather events mentioned above. Avoid planting in low-lying areas of the field that are prone to standing water following rain events. Raised and dome shaped beds without depressions in the top will allow for speedy movement of moisture away from the crown region of the plants. Provide drainage at the end of the field to allow excess water to flow out of the fields. When crown rot infected plants occur in the field, remove infected plants to avoid production of spores leading to the aerial phase of the disease.

Chemical control measures may be necessary to augment the cultural practices mentioned above. This is especially true in fields with a history of Phytophthora blight and that are likely to experience saturated soils following heavy rains. The fungicide mefenoxam (**Group 4** fungicide) (Ridomil Gold 4E, Ultra Flourish 2E) can be applied as a banded spray over the row shortly after transplanting or it can be injected through the drip irrigation system to protect against the crown rot phase of the disease. Mefenoxam needs to be reapplied twice at 30-day intervals after the transplant application. Two weeks after the last application of mefenoxam, begin foliar applications of a fixed copper fungicide with a spreader sticker to provide protection against the foliar phase of the disease. Tanos (a mixture of famoxadone [**Group 11**] and cymoxanil [**Group 27**]) is also labeled for peppers. For best results tank mix Tanos with a copper fungicide, and for resistance management do not make more than one application of this mixture before alternating with a fungicide with a different mode of action.

Resistant varieties are being developed to reduce the incidence of Phytophthora blight in pepper. Resistance genes are required for both the crown rot and aerial phases of the disease, and these must be bred into commercially acceptable varieties. The varieties 'Emerald Isle' and 'Reinger' possess resistance to the crown rot phase of Phytophthora, but do not possess sufficient horticultural characteristics to be commercially acceptable. The variety 'Paladin has excellent resistance to the crown rot phase of Phytophthora but does not provide sufficient resistance toward the aerial phase. The variety 'Aristotle' provides only tolerance to the crown rot phase and like 'Paladin' has insufficient resistance for the aerial phase. Both 'Paladin' and 'Aristotle' do have excellent horticultural characteristics similar to the variety 'Camelot'. One occasional flaw in both 'Paladin' and 'Aristotle', and possibly related to Phytophthora resistance, is the development of a "silvering' pattern on the fruit. 'Paladin' also develops fine shoulder cracks when allowed to mature to the red stage, and is therefore not recommended for the red fruit market. Additional Phytophthora tolerant hybrids include 'Conquest' and 'Revolution'.

Fungi

White Mold

White mold is caused by the soil borne fungus *Sclerotinia sclerotiorum*. Many vegetable crops are susceptible to this fungus, although corn and grasses are not. Leading susceptible crops include tomato, cabbage, lettuce, carrot, celery, snap bean, several cucurbits, and of course pepper. The pathogen produces hard, black sclerotia, like small, flattened and elongated raisins which serve as the overwintering means for the fungus. These sclerotia, which can survive in the soil for years, may be produced inside of the stems or on the surface of affected areas. Sclerotia germinate at an optimal temperature of 52°F; *Sclerotinia* is a low-temperature fungus, able to cause infection from 32-82°F. The fungus also requires abundant moisture for a week or longer for infection to occur. Sclerotia germinate to produce slender stalks that end in an apothecia (cup-shaped structure in which asci and ascospores are produced) or they may germinate by mycelium in some *Sclerotia* species. Although ascospores are short lived, they are blown within a field, landing on senescent or injured susceptible tissue and penetrate directly. In pepper, infections occur on stems or in the axil of branches.

Pepper growers in western NY lost 5% of their pepper crop due to white mold infections during the cool and wet growing conditions for summer 2003. Rotation out of pepper and not using other susceptible crops in rotational scheduling will be critical for next season and into the foreseeable future. Mycoparasites are known to destroy existing sclerotia and inhibit the development of new sclerotia. The commercial product Contans WG (*Coniothyrium minitans*, EPA Reg. No. 7244-1, and OMRI listed) has shown great promise in significantly reducing sclerotial populations. The product needs to be applied to the soil prior to planting (1-4 lb/A), and once applied, incorporated into the top 2 inches. If incorporation will be greater than 2 inches, then the application rate should be increased to 2-6 lb/A.

Anthracnose

Anthracnose, also known as ripe fruit disease, is potentially caused by three species of the fungus *Colletotrichum*: *C. coccodes*, *C. capsici*, and *C. gloeosporioides*. Although most commonly seen on maturing hot and sweet peppers, under appropriate conditions infections can occur on immature fruit, stems, and even leaves. Infections appear as sunken lesions on the fruit. The lesions may turn black with the formation of setae and sclerotia, or the center of the lesion may develop pustules (acervuli) that contain a salmon-colored spore mass. *Colletotrichum* typically produces microsclerotia that allows the fungus to overwinter in the soil. Microsclerotia can survive for many years, but even a 2 or 3-year rotation out of susceptible crops (mainly solanaceous) can significantly reduce inoculum.

For late maturing red peppers the following fungicides are registered: maneb (**Group M3**), 7DTH; Quadris and Cabrio (both **Group 11** fungicides), 0DTH.

Viruses

Cucumber Mosaic Virus (cucumovirus, aphid transmitted, not seed transmitted in pepper, many weed hosts)

Cucumber mosaic virus (CMV) is the most common virus infecting peppers in the Northeast. The virus can infect more than 800 plant species worldwide. CMV is readily transmitted from perennial weeds by aphids in a nonpersistent method. It is often the earliest virus transmitted in the spring. Important weed hosts include common milkweed (Perennial), common chickweed (Winter Annual, but can become perennialized in cool moist areas, also

CMV is seedborne in this species), marsh yellow cress (A, Biennial, short-lived P), and yellow rocket (Win A, Bie) and more (3, a more complete list is provided). As aphid populations develop on peppers during the spring and summer, extensive spread may occur. Pepper plants on the edge of fields and rows are frequently the first plants to be infected.

Destroy important weeds before the crop is established in the field. Intercropping with corn or other nonsusceptible tall barrier crops have been used keep virus from invading the crop. Rouging infected plants especially from the ends of rows before secondary spread occurs may be helpful. Because of the nonpersistent manner of transmission, control of aphids to prevent spread within the crop is not an option. Inheritance of resistance to CMV is very complex, so it is doubtful there are of any truly CMV-resistant peppers.

Tobacco Mosaic Virus (tobamovirus, mechanical transmission, seed transmitted, solanaceous weed hosts)

TMV is worldwide in distribution and can readily be transmitted by physical contact. No insect vectors are known. TMV is one of the most stable plant viruses, capable of surviving on dried plant debris and roots of tomato and probably pepper for many years. It is known to be seedborne in pepper and tomato. Although the natural host range of TMV is wide, it is primarily a problem for solanaceous crops (pepper and tomato).

Sanitation is important for the control of TMV. This is particularly true in greenhouse settings where the virus has been diagnosed previously. Dispose of all plant material including roots. Sanitize all flats and bench surfaces with a strong disinfectant prior to establishing a new crop and make sure the greenhouse and surrounding areas are free of weeds that may harbor the virus. Some key perennial weed species include marsh yellowcress (*Rorippa islandica*), broadleaf plantain (*Plantago major*), horsenettle (*Solanum carolinense*), and smooth (*Physalis subglabrata*) and clammy groundcherry (*P. heterophylla*), to name a few (3). Because TMV is seedborne in pepper and other solanaceous crops, make sure to purchase disease-free seed from a reputable seed company. If seed is of questionable quality, the seed should be soaked for 30 minutes in a 10% solution of household bleach or for 15 minutes in a 10% solution of trisodium phosphate (Na_3P04), often used to soften dried paint brushes. Either of these treatments will remove most virus from the surface, unless the virus is in the seed endosperm. Recently released varieties have moderate to high tolerance to some strains of TMV.

Tomato Spotted Wilt Virus (tospovirus, thrips transmission, not seed transmitted, many weed hosts)

Tomato spotted wilt virus (TSWV) causes brown spotting or dark ringspots on foliage and fruit, and stunting and distortion of the young growth of pepper plants. TSWV is transmitted by at least 8 species of thrips, with the tobacco thrips (*Frankliniella fusca*) and western flower thrips (*F. occidentalis*) considered to be the most important vectors. Thrips acquire TSWV by feeding on infected plants only as larvae. After a latent period of 3-7 days, they are then able to transmit the virus to uninfected plants for the remainder of their lives. TSWV has a host range in excess of 600 plant species, but many of these plants do not support thrips reproduction and are considered "dead ends" for virus spread.

A recent survey of the role of weed hosts for TSWV and the tobacco thrips in North Caroline concluded that key weeds included mouseear (P) and common chickweed (Win A, but can become perennialized in cool, moist areas), spiny sowthistle (A), dandelion (P), blackseed plantain (P), and a buttercup species (A) (3). Sanitation around greenhouses is essential as well as growing vegetable transplants in a greenhouse separate from ornamentals that commonly serve as reservoirs. There is no cure for infected plants, which should be removed from the greenhouse or the field as soon as they are detected. SpinTor (spinosad) has been one of the most effective controls for thrips on labeled crops (such as tomatoes and peppers) and applications on peppers for European corn borer will also provide incidental control of thrips present.

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Insect Management Update for Peppers & Eggplant

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PEPPERS: The European corn borer (ECB) is the most important and destructive insect pest of peppers throughout New England. The female moth lays many egg masses that consist of 15-30 eggs each. The egg masses resemble fish scales and are deposited mainly on the undersurface of leaves and on fruit. Eggs hatch in 3 to 14 days depending upon the temperature. The young caterpillars migrate to the fruit and enter just under the cap near the stem. Upon breaking the epidermis, they often innoculate the inner flesh with the pathogen for bacterial soft rot. The soft rot starts slowly near the entry wound, but soon engulfs the entire fruit causing it to drip from the plant as a mass of ooze. As the fruit begin to rot, the developing larvae will leave and migrate into adjacent fruit, bringing the soft rot bacterium with them. Sometimes 90% or 100% of the fruit in a field can be infested and destroyed by the borer and resulting epidemic. Large sweet peppers varieties, such as bells, tend to incur more damage than smaller, hotter varieties.

There is a single generation of ECB moths in northern New England and two generations in the southern part of the region. There may be no fruit present on the plants during the first generation in the south, so the second generation is usually the only one that requires management. The important moth flight(s) and peak oviposition or egg laying periods usually occur in July in the north and in August in the south. The ECB populations can be monitored over time using two Scentry Heliothis traps, baited with either the NY (E or II) or the IO (Z or 1) pheromone lures. Traps should be placed in the fields at least a couple weeks before the local moth flight is expected and checked weekly. The two traps should be spaced at least 50 yards apart in tall grass or weeds along the edge of the pepper field. The opening of the traps should be right at grass height to catch the maximum number of moths. If fruit are present on the plants, insecticide applications should begin one week after trap counts (sum of both traps) reach or exceed 7 moths per week. The fruit should be protected throughout most of the moth flight or until a week after trap captures decline below 21 moths per week. Some insecticides have longer residual periods of effectiveness than others. The spray interval for effective control depends upon the insecticide you choose to use (see table).

Insecticide type/class	**Common name**	**Trade name**	**Spray Interval**
Microbial	B.t. (Bacillus thuringiensis)	Javelin, etc.	3-4 days
Carbamate	methomyl	Lannate	3-4 days
Microbial/Naturalyte	spinosad	SpinTor/Entrust	7 days
Pyrethroids	permethrin, etc.	Ambush, Warrior	5-10 days
Organophosphate	acephate	Orthene	7-14 days
Insect Growth Regulators	methoxyfenozide, tenufenozide	Intrepid, Confirm	10-14 days

Choosing selective materials for ECB control that spare predators and parasites is an important part of a pepper IPM program. Products like B.t.'s, IGR's and spinosad, that spare beneficials help prevent aphid problems and other secondary pest outbreaks. There were two new selective products available for ECB control in 2003: Entrust and Intrepid. Intrepid is an insect growth regulator specific to caterpillars (moths and butterflies) which causes a premature lethal molt when ingested. Larval mortality may take a couple of days but feeding stops within hours of ingestion. Intrepid is labeled for control of many caterpillars on cole crops, leafy and fruiting vegetables and on sweet corn. Entrust is a new dry formulation of spinosad which meets USDA National Organic Standards. Entrust gives organic growers something they have been looking for a long time...something that will control many of the toughest pests on a variety of different crops, including ECB on peppers.

Having said that, I should diverge for a minute to update you on recent findings about spinosad. I guess there is never any good news without some bad news tagging along. Although harmless to most common insect predators in our fields, recent studies have shown that spinosad can produce near 100% mortality of some important parasitic wasps like *Trichogramma* species, *Encarsia formosa* the whitefly parasite, and *Diadigma insulare*, our most important natural enemy of the diamondback moth. Spinosad is much more lethal for these wasps when directly exposed during application or when they come in contact with residues less than 1-3 days old.

Here is an interesting story to go along with that. In 2002, two Connecticut pepper growers who used 5-6 applications of SpinTor for ECB control, experience major outbreaks of green peach aphid. These two growers had been using spinosad since it came on the market, specifically to help prevent aphid problems, and the strategy had worked up until that time. Normally, they only required 2-4 spinosad sprays to make it through the second generation moth flight, but unusual climatic events last year caused the ECB flight to last much longer than usual. I couldn't find any evidence of parasitized aphids in either field, but the wasp was present in pepper fields on a dozen other farms that I checked. In 2003, when these two growers broke up their SpinTor sprays with an application of Intrepid, or used fewer applications for ECB, they experienced few aphids, and most were parasitized. I guess the moral of the story is that too much of a good thing can get you in trouble.

For combined aphid and ECB management, the UConn Pepper IPM Program is now recommending alternating with an insect growth regulator and spinosad or B.t. All of these products will also provide effective control of sporadic caterpillar pests like fall armyworm, corn earworm and hornworms. The good news is that all these products can be applied within a day of harvest so that insecticide applications won't interfere with picking and marketing schedules. Two of the three materials also have long periods of residual activity so that in most years you should only need 2-3 sprays to get through the moth flight. Most important parasites and predators should survive this spray schedule and continue to work on your behalf. Also, by not relying on acephate (i.e. Orthene) for routine borer control, you will not have to worry about insecticide resistance if you ever have an aphid outbreak. Some other (newer) products that are effective for aphid control include the IGR Knack and the "reduced-risk" material Fulfill.

Another potential option for pepper ECB control in the near future would include periodic releases of the egg parasite *Trichogramma ostriniae.* Researchers at UMass, in cooperation with folks at Cornell, are using releases of 50,000 wasps per acre to reduce the number of insecticide applications necessary to manage ECB. This wasp has been very helpful with ECB management in sweet corn fields. Two years ago, this parasite was available from Canada at a cost of about $25 per acre, but this wasp was not allowed to be imported in 2003, and was supplied to UMass researchers by Cornell University. This is a project that is being (at least partially) funded by your NEVB Association. If you would like more information about the project contact Pam Westgate or Ruth Hazzard at UMass.

The pepper maggot is also a major pepper pest on many farms in southern New England. In CT, there are four growers who have been using Perimeter Trap Cropping (PTC) to stop this pest on peppers for the last few years and one who tried it on eggplant in 2003. PTC involves planting one or more rows of hot cherry peppers around your bell peppers and treating (just) the trap crop with an effective insecticide when the cherry peppers begin to be stung. All these growers have had great results using this technique.

When they compared results using PTC with their conventional program of multiple full-field sprays, they were surprised to find they got much better control (<1% damage on most farms) and dramatically reduced insecticide use (90%). By not spraying the main crop with broad-spectrum insecticides for maggot control, they also preserved the natural enemies that help control aphids. Most of the PTC growers say that the system saves them time and money and is simpler to use than multiple full-field sprays. They found that using the new system simplifies, monitoring procedures, spray applications, and picking/marketing schedules because there are no reentry intervals or pre-harvest (dh) restrictions on unsprayed bell peppers. Some of these growers are now using PTC on multiple crops to help simplify their lives and improve farm profitability (see article on PTC for Summer Squash and Cucumbers).

EGGPLANT: Its unusual for pepper maggots to attack eggplant, and there are currently no effective insecticides registered to control the pest on this crop. One CT grower had 100% of his eggplant riddled by this pest over the past few years despite multiple full-field sprays. He switched to PTC in 2003 and marketed 100% of his crop this past season. On a post-season survey he said "I highly recommend PTC, especially for big commercial growers...you're crazy not to do it!"

Unfortunately, PTC does not work for pepper maggot on organic farms. One MA grower tried it the last couple of years, and at first got better control. However, this season the pest broke right through the trap crop barrier. That's because, without the perimeter spray to kill off the adult flies, the pest completes its life-cycle, and by providing thousands of host plants (cherry, bell or eggplant) the population grows to artificially high levels that are tough to control. Organic growers must rely on crop rotation, row covers or early harvests to prevent pepper maggot damage.

Colorado potato beetle is the most important and destructive pest on eggplant. The adult beetle overwinters and emerges in the spring to mate and lay eggs. A second generation of adults emerges in late July or August. Eggplants are one of the beetles favorite hosts. Numerous larvae are produced from each egg mass and can completely defoliate individual plants and even whole fields, if the population gets out-of-control.

In recent years CPB populations throughout the region have been relatively low due to the widespread use of effective insecticides like imidacloprid (Admire), thiamethoxam (Platinum), acetamiprid (Assail), spinosad (SpinTor), cryolite (Kryocide) and *B.t. tenebrionis* (Novodor). There are many other insecticides registered for CPB control, but most are rather broad-spectrum in activity and can lead to secondary pest problems on this crop.

Resistance management is a crucial component of any IPM program for CPB, since this pest will become resistant to any insecticide within as little as 3 years. The first three insecticides mentioned (above) are all in the nicotinoid class and should only be used on one generation every other year. Its best to use a nicotinoid on the first generation in alternate years, because the products are so effective there is usually no need to treat the second generation, unless resistance has already become a problem on the farm. Spinosad is a good choice for the first generation the second year because it controls both adult beetles and larvae.

Both of these products are expensive when used at the rates recommended for CPB. However, there are ways to dramatically lower the cost of using these materials. Fields rotated _ mile may not even need to be treated for this pest and many growers get by with spot sprays of just a few plants with a backpack sprayer. It takes a while for newly emerged beetles to develop flight muscles, so beetles tend to colonize nearby host plants primarily by walking. If long distance crop rotation is not practical, you can simply rotate to the other side of the field and plant and treat a trap crop (like early-planted potatoes) so that it intercepts the migrating beetles.

One of the best ways to reduce costs with a soil-applied systemic like Admire, is to apply below-label-rates to transplants before they go into the field. Use _ ounce of Admire to treat 1,000 plants and apply it with a standard watering can. It is recommended to harden the plants properly prior to treatment to avoid phytotoxicity and to dilute the chemical in one pint of water per flat. After you finish, rinse the foliage with a second can of water alone, to wash the chemical from the foliage into the growing media where it can be taken up by the roots. This treatment usually completely controls the first generation of susceptible beetles. If you want to spend even less money, just treat enough plants to ring the field with 5-10 rows of treated eggplant. Now your only spending a couple of dollars per acre and using a form of PTC. Thanks to a grant from you (NEVBA), we are currently working on PTC systems for CPB that utilize even more effective trap crops. We will discuss the results of our studies on eggplant and tomatoes next winter.

Potato leaf hoppers (PLH) have presented the biggest insect challenge on eggplant in the last half-dozen years, at least in southern New England. This is a migratory pest from the Gulf States that began to arrive in huge numbers back in 1997. The saliva of this insect is toxic to crops like alfalfa, potatoes, beans and to a lesser extent, eggplant. When populations exceed 1 to 1.5 PLH per leaf on eggplant, the edges of the leaves begin to yellow and curl upwards, and yields are reduced. Some varieties of specialty eggplants are even more susceptible to damage by this insect.

The biggest problem is that most of the materials that are effective at controlling the PLH (like many synthetic pyrethroids) will almost certainly bring on problems with two-spotted mites, aphids or possibly other secondary pests. Two-spotted mites can be a huge problem on eggplant, especially in a dry season. The IPM consultant that works in CT has found the best way to deal with the combo PLH/mite problem is to use azadirachtin (i.e. Azatin) or neem oil (i.e. Trilogy) to control PLH nymphs and immature mites and to help repel adult leaf hoppers. Low-dose endosulfan sprays are used if adult PLH become too abundant, in an attempt to spare as many of the numerous mite natural enemies as possible.

There are many different sporadic insect pests of eggplant including: cutworms, flea beetles hornworms and, in rare cases, ECB. Even the "old fashioned potato bug" or margined blister beetle, and the three-lined potato bug, can occasionally consume a lot of foliage on a few plants in low- or no-spray situations. Finally, the newest arrival of them all, is the oriental beetle. It is the same shape and size as the Japanese beetle, but is brown with a lighter mottling on its back, and it lacks the green iridescent color. They were introduced into the country much later than Japanese beetles and spread through New England in the 1990's. Their numbers seem to be on the increase in the past few years and they tend to consume more foliage than their more-familiar cousin. They may become a problem on eggplant in the near future.

We wish to thank the Northeast IPM Program for funding the pepper maggot PTC research and both the Northeast Sustainable Agriculture Research and Education Program and the New England Vegetable and Berry Growers Association for funding current PTC research.

Organic Apple Production from a Grower's Perspective

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I have managed a small certified organic apple orchard since 1988. It is about an acre with about 140 trees, mostly Jonagold, Liberty, Golden Delicious, Idared, and Melrose on MM111 or MM106. Since 1997 West Haven Farm of Ithaca has also been a partner in this orchard. We market the apples at the Ithaca Farmers' Market and some small wholesale accounts. Our site at 1300 feet elevation has very good air drainage but marginal soils.

In the past few years there have been important developments in Northeast organic apple production methods that have reduced pest damage. The first major change was the introduction of Surround which has allowed us good plum curculio control. Because of that, we are also able to thin the trees on time and are starting to reduce a severe alternate bearing problem. The second was the introduction last year of an approved spinosad product, Entrust. This gave us excellent control of caterpillar pests.

In 2002, the National Organic Program came into full force. To us, this meant that requirements for the products we use became even stricter than before. For instance, I trialed compost tea against apple scab on a few trees. Since I had mistakenly used a non-approved compost product for the tea, those trees were decertified. Another problem we had was that we could not find an organically-approved lime sulfur product that was also registered in NYS.

The 2003 season was wet, and we had a scab control failure. We use sulfur sprays against scab, and control was good in the early season. However, a 2 inch rain on June 1 must have washed off the sulfur residues, and about 17 days later scab lesions were common on the susceptible trees. It is possible that spraying the sulfur and Surround together interferes with the sulfur's effectiveness. Things went downhill from there, as we had a very wet season. I think that a lime sulfur spray after the heavy rain would have improved the situation. Later I found that the lime sulfur product under the Miller label sold in NYS is the same as the approved product (repackaged by Ag Formulators, Inc.), but I didn't know that at the time.

Nonetheless, our Liberty, Melrose, Paulared, Redfree, and other scab-resistant or tolerant varieties graded out better than ever, with 75% or more going into our "select" grade.

Our spray program this year included sulfur sprays from first green to June 21. Surround was applied from pink through June 16. Three of those sprays, including the last two, included Dipel. This presumably gave us reasonable early season caterpillar control. Then we put up pheromone traps and monitored Codling Moth, Lesser Apple Worm, Oriental Fruit Moth, and Obliquebanded Leafroller. We sprayed Entrust on July 7 for the midseason flights, then Dipel on August 16, based on the trap results. Unlike the data from the Geneva Experiment Station last year, at our orchard three of the four pests tracked close enough together that we felt we could catch most of them on these dates. We put the sprays on one week after the peak flights, trying to target peak egg-laying. OBLR numbers were low and didn't really factor in. There was greatly reduced lep damage at harvest compared to previous years.

We are still dealing with alternate bearing. The orchard yielded over 400 bu. in 2001, was down to around 100 last year, and will come in around 250-300 bu. this year. There are still a number of young replants, especially in an area of interstem trees that did not do well on our soil.

We have been able to get very good prices for our apples—$7.50 per half peck (about 5.5 lb) of "select" grade at the farmers' market. Our bushel wholesale price is $32-$40. Cider goes for $5.50 per gallon. There is no doubt in my mind that our apples are highly flavored compared to most—I think because of the lack of an herbicide strip.

Important frontiers for organic apple production include reliable, biologically-based scab control, thinning, and sooty blotch/flyspeck control. Of course, we always need to better understand orchard nutrition and ground cover management, as well as refine our overall pest management programs. I would also like to point out that other Northeast organic orchardists, including Biodynamic farmers, have been able to achieve better results than we have, so we are always learning from them.

Mineral Nutrient Management for Organic Fruit Production

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Many apple growers are currently seeking to increase profitability through market diversification. One way that growers can distinguish their product to consumers is by describing and promoting the process by which it is produced (O'Rourke, 2002). Examples of "process-driven" market alternatives include Integrated Fruit Production, Integrated Pest Management, Sustainable, Organic, and Biodynamic. The largest and best established of these is organic production, a label that provides an alternative for affluent socially conscious consumers who prefer fewer chemicals in their food (Fresh Trends, 2002).

Although mineral nutrition is an important component of organic orchard management, there are other factors that are more critical to the success of an organic orchard. Factors which must be in place include good market demographics, grower commitment, and a workable pest management strategy. Demand for organic produce is higher in metropolitan areas, especially those with nearby college campuses, than in rural areas (Fresh Trends, 2002). While some consumers are willing to pay a modest premium for organic produce, the extreme complexity of apple pest management, with the limited organic management options and higher production costs requires great dedication on the part of the grower. Only growers who are committed to making the system work will remain organic in the long run.

Organic Regulations

Organic production has a regulatory component: typically third party certification that only approved practices and products were used in the production and handling of the crop. The USDA National Organic Program (NOP) established national standards for organic labeling in 2002, and these regulations are interpreted by accredited state or private certification agencies. The certification agency has the final word on whether the crop can be certified as organically produced, although the NOP should result in uniform, consistent standards. Certification agencies can vary considerably by fees, documentation required, and sometimes by the products that are restricted or the practices that are required. Make sure you have read and understood the rules for certification, and make sure your intended customer accepts the same practices and products as the certifying agency.
Farms with less than $5000 in annual sales of organic products can be exempt from certification, but still must abide by NOP standards. A person who knowingly sells or labels a product that fails to meet NOP standards as organic can face a civil penalty of up to $10,000.

The Organic Material Review Institute (OMRI) is an organization that evaluates proprietary products to see if they meet the standards for organic production under the NOP. OMRI lists brand name products, such as blended fertilizers with more than one ingredient. They also provide a "generic materials list" for single ingredient products such as ground limestone or peat moss, which can be used regardless of brand name, provided the product is pure. Not all manufacturers are willing to pay the fees to have their products listed by OMRI. It is possible that an unlisted product may be organically acceptable, however the grower must determine whether all the product's ingredients and its manufacturing process are organically acceptable.

Mineral Nutrition & Groundcover Management

Groundcover management and mineral nutrition are integrally linked. While it is beyond the scope of this paper to present an in-depth description of organic groundcover management, some inclusion is necessary to help the reader envision the type of groundcover system into which the mineral nutrient practices are being integrated.

Orchards are typically planted on slopes where erosion is a concern. A permanent fescue sod between the tree rows will prevent erosion and reduce soil compaction from the operation of farm equipment in the alleys. Hard or red fescues are slow growing, reducing the need for mowing, and are poor alternate hosts for apple pest organisms. Because fescues are slow to establish, it is best to apply the seed at the high end of the recommended seeding rate to establish a full ground cover as rapidly as possible and prevent weeds from becoming reestablished. A seeding mixture of annual rye and fescue is sometimes used to speed the rate of groundcover establishment.

Apple is a weak competitor for water and nutrients. A three- to four- foot-wide weed-free strip under the trees is maintained to lessen this competition. This is particularly important during the first several seasons of the orchard. Newly transplanted trees have impaired root systems and this further weakens the ability of the trees to compete with weeds. An effective weed management program fosters rapid early tree growth and early fruit production, resulting in a faster return on investment. Weed management is among the biggest challenges in organic apple production (Jim Bittner, Singer Farms, personal communication).

The primary weed control options for organic blocks are cultivation or mulches, and each option has pros and cons. Cultivation provides immediate and effective weed control, but must be reapplied several times each season, resulting in increased labor and fuel costs (Schupp and McCue, 1996). Long-term use of cultivation reduces soil organic matter. To minimize the negatives, cultivation should be limited to monthly applications in May, June and July, followed by a cover crop of canola or vetch in late August.

Mulches can provide adequate weed control if renewed every one or two years, but are expensive, and create a favorable habitat for voles. The decomposition of mulches contributes organic matter to the soil in the long term, but ties up mineral nutrients in the short term, especially N, the lack of which can be limiting to tree growth and productivity. Coarse shredded bark or woodchip mulch will decompose more slowly than finer materials and is less favorable to voles (Merwin, 1995). Bark or woodchip mulch should be supplemented with hand or flame weeding when the trees are young.

Site Selection & Preparation

The primary component of organic mineral nutrient management is building and maintaining a soil that is biologically active and high in organic matter. Orchard sites are typically selected for climatic conditions, slope, elevation, location relative to other producers and markets, and of course, availability of the real estate. Soil characteristics of a prospective orchard site are often a secondary consideration. Selecting an orchard site with good soil properties is essential when planning an organic block.

Changing soil characteristics is a long-term process and correcting soil problems in an established orchard is difficult. Furthermore, there are few rapid rescue options available to the organic grower. Starting out with soil that has adequate depth, drainage, texture, water and nutrient holding capacity, pH and mineral nutrient content is always advisable, but with organic production, it is vital.

Once an appropriate site has been selected, pre-plant soil preparations to correct any deficiencies, and to increase organic matter and biodiversity of the soil begin. Ideally one should plan on spending two years on site improvement before planting the orchard.

Soil testing is used to establish the baseline values of soil acidity, organic matter content, nutrient holding capacity, and mineral nutrient content. Liming to increase soil pH and measures to increase organic matter and mineral nutrients are best addressed prior to planting. In this way lime and organic matter can be incorporated deeply into the soil with cultivation so that soil properties are optimized throughout the root zone. This is also the time to tile poorly drained parts of the site and eliminate existing weeds.

Lime should be added to raise the soil pH to 6.5. If the soil test indicates a need for magnesium (Mg), dolomitic, or “high mag” lime should be used. One or two annual applications of 20-25 tons per acre cow or chicken manure can also be beneficial for increasing organic matter and adding mineral nutrients to the soil. Horse manure should be avoided, as it is low in nutrient value relative to other animal manures. Furthermore, weed seeds often survive the inefficient digestion of a horse’s gut and can contribute to the introduction of new weed species.

Animal manure must not be stockpiled prior to use, as it can cause severe problems with neighboring residences due to both odor and flies. Manure should be tilled in promptly after spreading to incorporate it and prevent loss of N due to volatilization. Typically, seeding a green manure or cover crop such as buckwheat or Sudax follows manure applications. These crops are mowed down before going to seed and then tilled down. The manure application and cover crop are repeated, followed by seeding the permanent ground cover in late summer the season before planting.

Pre-plant Compost

Organic matter is often low in many existing orchard soils, and increasing it improves soil water and nutrient holding capacity. This enhances root regeneration and promotes overall tree vigor. Adding compost as a source of organic matter to planting holes has been demonstrated to have beneficial effects on young apple tree growth in experiments in Massachusetts and Maine (Autio, et al., 1991). The effects of planting hole treatments are most visible during the year of planting. As root growth extends beyond the volume of the planting hole, the effects of planting hole treatments diminish. If organic matter amendments were broadcast throughout the orchard soil, perhaps the beneficial growth response could be sustained for a longer period.

For pre-plant compost to be a feasible management practice, an economical, local source of compost must be available. University of Maine Cooperative Extension developed an apple pomace composting project in cooperation with Chick Orchards, Monmouth, Maine. Apple pomace from Chick's cider operation was mixed with leaf waste from the local waste transfer station, and chicken manure from a local egg farm at a 2:6:1 ratio by volume. Wood ash was used to adjust the pH to 5.8 prior to composting. Composting reduced the volume of apple pomace waste by 50%, and converted it into an organic soil amendment with highly desirable characteristics. A study was initiated in Maine in 1998 to determine if pre-plant incorporated apple compost or synthetic phosphate (P) fertilizer, either alone or in combination, would improve early apple tree growth and precocity.

The results of this study indicated that pre-plant compost incorporation was more effective than P fertilization for increasing tree growth during the establishment years (Schupp and Moran, 2002). Soil-incorporated compost resulted in increased tree growth and flowering into the third year after planting. Greater tree growth with compost was most likely due to improved N and K status of the trees, and through improved soil aeration and water holding capacity. Cumulative yield has been greater for trees grown in compost plots over the first six years of the study. These results show that trees planted in soil amended with apple pomace compost fill their space more quickly and are more productive than untreated trees in the first years of cropping.

Mineral Nutrient Maintenance

Harvesting an apple crop doesn't remove large amounts minerals from the soil, compared to many crops (Stiles and Reid, 1991). Apple trees are deciduous perennials with mechanisms for remobilizing essential minerals and storing these in the perennial organs prior to leaf abscission in the autumn. Potassium is the one mineral that is removed in significant amounts with the harvested crop. The result is a production system that requires relatively modest mineral nutrient inputs to maintain optimal production.

Selecting soils with good nutrient holding capacity, maintaining optimal soil pH, and maintaining high (3-4%) soil organic matter can lead to most of the orchard's nutritional needs being met by natural cycling, provided weed control is adequate to prevent competition. Still, some supplementary fertilizer application is usually necessary to maintain optimal yield and fruit quality.

The primary method of providing both organic matter and mineral nutrients is the application of compost. The availability of mineral nutrients from compost is usually slower than from inorganic salts. For this reason, compost is often applied after harvest in autumn or at bud break in early spring. The compost application rate is often based upon the amount of available N relative to that required by the block. For example, if one were applying compost with 5 percent N to an orchard requiring 40 lb actual N per acre, the rate of compost would be 800 lb. By comparison the rate of compost with two percent N for the same block would be 2000 lb per acre.

Composts can vary greatly by ingredients, nutrient value and cost. Use care in selecting composts that originated from approvable ingredients and processes, that provide adequate amounts of the nutrients needed, and that provide good value relative to the cost. One way to reduce the both the purchase price and transportation cost of compost is to use farm waste to produce one's own. Apple pomace is one potential source of high carbon waste available to many apple growers, and can be combined with other ingredients to produce high quality compost, as previously described. See Edwards (1998) for detailed information on on-farm composting.

Under NOP regulations products, including fertilizers, are listed as "allowed" or "not allowed", "not prohibited" or "prohibited". Only those materials that are listed "allowed" and "not prohibited" may be used on organic crops. In some cases the origin of a substance affects its status. Gypsum from a mined source is non-synthetic and is not prohibited, while gypsum by-products, such as scrapped dry wall is synthetic and not allowed. Always check with the certifying agency to make sure that the products you intend to use comply with organic standards.

Adequate mineral nutrients must be available in order for the trees to assimilate large amounts of carbohydrates, partition those assimilates into fruits, and for those fruits to maintain premium eating quality until consumed. Organic nutrient sources are lower in nutrient concentration and generally more complex than non-organic salts. Organically derived nutrients may not be readily available until decomposition. This lower-slower process requires management with a long-term perspective.

Tracking the trends in mineral nutrient levels in annual leaf samples over several years is the single best way to monitor orchard fertilizer needs. The annual leaf sample should be supplemented with a soil sample every third year. Steps can then be taken to begin corrective measures when a macronutrient shows a trend toward becoming sub-optimal, rather than waiting for an actual shortage to develop. Conversely, foliar sprays of micronutrient fertilizers are permitted under NOP guidelines only when there is a documented shortage. In either case, leaf analysis is necessary to assess the situation.

The principal nutrient required to maintain adequate tree vigor and productivity is N. Organic N sources include manure, fish emulsion/meal, bone meal and blood meal.

Animal manures should be applied pre-bloom in most cases, as NOP regulations prohibit use of animal manures within 90 days of harvest to prevent possible E. coli contamination of the crop. Manures can provide higher concentrations of mineral nutrients, especially N, compared to compost, however much of the N value of manure can be lost to volatilization unless it is soil incorporated. For this reason, manures are better suited to groundcover management systems utilizing cultivation.

Matching nutrient needs with those provided by alternative sources allows the grower to provide the best fit of nutrient supplements. Manures provide multiple nutrients besides N. For example chicken manure is high in phosphorous.

Fertilizers containing soluble forms are more expensive, but are more quickly available, thus useful for correcting a deficiency. Sodium nitrate (Chilean nitrate) is listed as not prohibited as long as use is restricted to no more than 20% of the crop's total nitrogen requirement. Organic standards in the UK prohibit the use of blood and bone meals, so these N sources should not be used on fruit grown for export.

Harvest removes 60-100 lb per acre of potassium (K) annually, while most orchard soils in the northeastern U.S are naturally low in magnesium (Mg) (Stiles and Reid, 1991). Compost can provide meaningful amounts of these minerals (Schupp and Moran, 2002). In addition to organically derived sources, Sulpomag, a mined material, is frequently used as a source of both K and Mg. Magnesium sulfate (Epsom salts) is allowed as a soil amendment if there is a documented soil Mg deficiency.

Calcium (Ca) deficiency is often associated with low soil pH, thus lime is the primary material for maintaining soil Ca. Mined gypsum may be applied when it is desired to increase soil Ca without raising pH.

Bitter pit is an apple disorder associated with low fruit Ca (see the preceding article by Watkins, et al.). Nutritional imbalances such as excessive N, K, or Mg, and deficient B, as well as non-nutritional factors, such as variety, excessive fruit size/low crop load, or drought can contribute to low fruit Ca, even when soil Ca is adequate. In such instances, foliar sprays of calcium chloride ($CaCl_2$) are permitted to reduce the incidence of bitter pit. Under NOP regulations, the $CaCl_2$ used in organic orchards must be extracted from brine.

Deficiency of boron and other micronutrients may be corrected using synthetic foliar fertilizers, if a deficiency is documented by soil or leaf analysis. In general, micronutrient chelates and sulfates are allowed. Those made from nitrates or chlorides are not allowed.

Summary

Organic production requires a holistic approach to agricultural ecosystem management. Because of the perennial nature of apple orchards, this is not a great departure from conventional orchard management, except that corrective techniques are limited primarily to naturally derived materials. It is very challenging to produce apples organically, because of the need to maintain the planting over many years without rotation, the vast pest complex, and the exacting demand for high quality, unblemished fruit in the fresh apple market, where much of the growth potential for organic fruit lies.

Organic mineral nutrition management hinges on two principals: 1) practices that lead to the buildup and maintenance of soil that is biologically active and high in organic matter; and 2) supplementing the mineral nutrients provided by the soil with fertilizers from approved sources. Organic orchards should be sited on land with superior soils and pre-plant soil preparation to increase organic matter and correct any sub-optimal soil characteristics. Weed management is critical to reduce competition for nutrients and water.

Soil and leaf analysis provide the basis for correcting mineral nutrient deficiencies or imbalances, and with organic production, changes should be tracked over several years. It may be necessary to use a number of strategies to supply mineral nutrients over the life of the orchard. The slower, natural methods applied require a management approach that is simultaneously patient and dynamic. The organic approach may increase crop value, however as with most premium market niches, the value is balanced with higher production costs and more management inputs. Personal satisfaction has to be considered part of the reward in order to sustain the energy required to manage an organic orchard.

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Information Resources for Organic Apple Production

Organic Certification

National Organic Program (NOP): http://www.ams.usda.gov/nop/

Organic Material Review Institute: http://www.omri.org/crops_generic.pdf

Organic Apple Production Manuals

Edwards, Linda. 1998. Organic Tree Fruit Management. Certified Organic Associations of British Columbia, Keremeos, BC, Canada. ISBN 0-7726-3615-X

Swezy, S.L., P. Vossen, J. Caprile, and W. Bentley. 2000. Organic Apple Production Manual. Univ. Calif. Agric. and Nat. Resources Publ. 3403. Univ. Calif. Agric. and Nat. Resources Commun. Serv., Oakland, CA. ISBN 1-879906-48-1

Organic Apple Web Sites

http://www.attra.org/attra-pub/apple.html

http://www.attra.org/attra-pub/fruitover.html

http://www.attra.org/attra-pub/ipm.html

http://www.caf.wvu.edu/kearneysville/organic-apple.html

http://www.canr.msu.edu/vanburen/appleweb.htm

http://www.canr.msu.edu/vanburen/organasp.htm

http://orchard.uvm.edu/uvmapple/pest/#Organic Pest Management

Ground Floor Management and Rootstock Selection for Organic Apple Production

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The production of organically grown products continues to gain favor and interest by consumers. Consumers see organic products as arising from an agricultural management system that enhances biodiversity, which appreciates the nature of biological cycles, and stresses the importance of soil biological activity. A research and outreach project to grow organic apples was initiated in spring 2000 at the Clarksville Horticulture Experiment Station, Clarksville, MI. This is a study which includes scientists from many disciplines and an advisory panel of organic growers. Part of the research in the plot being carried out by horticulturists is to study the interaction of ground floor management systems and rootstock performance. We are using a hypothesis that rootstocks with higher vigor might compensate for greater stress imposed by weed competition and other pest infestations. A second hypothesis establishes the fact that soil cover and weed management affects the timing of N availability and uptake in the system, and impact apple tree's growth under organic production practices.

We began this work by establishing some 468 trees of Pacific Gala on three rootstocks, M.9 NAKB 337, M.9 RN 29 and Supporter 4. Trees have been trained to a Vertical Axe, planted at variable spacing of 1.35 (NAKB 337), 1.65 (RN 29) and 1.95 (Spptr 4) X 4.5 m apart with drip irrigation. The orchard floor is being managed within the protocols of three systems; mulching, weed suppression flaming and the Swiss Sandwich system. The mulch treatment is comprised of alfalfa hay laid in a 1 meter wide strip on each side of the row. The flaming treatment consists of the use of a Propane burner: 4 torches of 220,000 BTU/h on a strip 1 meter wide when vegetation grows over 10 cm high. The Swiss Sandwich System was developed at the Research Station for Organic Production, FiBL in Frick, Switzerland. The center of the tree row (60 cm wide) allows the development of spontaneous vegetation with two side strips (60 cm wide) tilled at each side. A rotovator and spring tooth harrow has been used when weeds get around 10 cm in height.

Preliminary Results

This was our first cropping year for the planting with limited volume.

- Treatments affect nitrate-N content in soil (Mulch showed the highest values)
- Total N in leaf tissue is being affected by the treatments but is at adequate levels.
- Rootstock vigor differences appear as expected with Spptr 4>RN 29>NAKB 337.
- The Ground Floor treatment effect is not having a significant impact on tree branch growth, but does effect trunk vigor.
- The first harvest showed differences among treatments and rootstocks, with a significant interaction between both factors. (Flaming lowest and M9-NAKB 337 highest).
- The volunteer vegetation (species) is changing in the sandwich strip.

Remarks

Applicability of the flaming needs more engineering and evaluation of the effect of heat . Mulching requires less maintenance but has some draw backs: rodents, fire, nitrogen and weed establishment in the mulch. Secondly, mulching effectiveness is heavily affected by redressing to compensate for decomposition. The sandwich system is simple to manage and results are promising in Michigan. It appears at this time that an adjustment is needed related to area of soil inhabited by vegetation versus tilled area.

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Development of Alternative Thinning Strategies

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The Most Important Single Spray?

- Crop load mgt. important for good:
  - fruit size
  - fruit quality
  - return bloom
- Concerns:
  - Consistency of response
  - Cost
  - Regulatory/ Market issues

New Thinners Needed

- New MOA, timings for use in multiple thinner programs.
- Carbaryl concerns:
  - Possible FQPA actions,
  - IFP restrictions on UK exports.
- Organically acceptable options.

Fish Oil + Lime Sulfur (FOLS)

- Liquid Lime Sulfur reduced fruit set when used as a pesticide in early era.
- Burns flowers / Reduced assimilation.
- Certain cultivars susceptible (Macs).
- Role of Fish Oil?
  - Surfactant/penetrant.
  - Also reduces assimilation.

Materials:

- FOLS
  - Crocker's Fish Oil (G.S. Long),
    - Dilute Rate: 2 gal. / 100.
  - Liquid lime sulfur (Miller Chemical),
    - Dilute Rate: 2.5 gal. / 100.
- NC 99 calcium/magnesium brine
  - G. S. Long Co., Yakima, WA,
    - Dilute Rate: 4 gal. / 100.
- Ammonium Thiosulfate (ATS) 1 gal/100.

Hudson Valley Study, 2000

- Mature Delicious / M. 7 trees.
- Transitional block.
- Applied air-blast @ 120 gal./ acre.
- Materials concentrated to dilute equiv.
- Timings: 80% bloom or
  20% + 80% bloom.
- Dates: 2 May, and 5 May, 2000.

Western N.Y. Study, 2000

- Mature McIntosh, Cortland and Delicious trees on seedling rootstock.
- Certified Organic block.
- Single application at 80-100% bloom.
- Applied air-blast, 100 gal / acre.
- Materials not concentrated.
- Date: May 8, 2000.

Delicious, Hudson Valley, 2000

Treatment	Set (%)	Yield / tree (kg)
Control	138 a	150 a
FOLS	67 bc	102 b
FOLS (2)	40 bc	121 ab
NC99	98 ab	125 ab
NC99 (2)	106 ab	141 ab

Delicious, Hudson Valley, 2000

Treatment	Wt. (g)	Dia. (in.)
Control	157 b	2.77 b
FOLS	200 a	3.02 a
FOLS (2)	180 ab	2.89 ab
NC99	185 a	2.94 a
NC99 (2)	183 a	2.94 a

Delicious, W. N.Y., 2000

Treatment	Set (%)	Size (g)	Yield (kg)
Control	42 a	168 b	65 a
FOLS	26 b	186 a	59 a
NC 99	21 b	170 ab	68 a
ATS	46 a	176 ab	66 a

2000 Summary

- Both NC 99 and FOLS show promise as blossom thinners for apple.
- Double applications were slightly better than a single spray at 80% bloom.
- No russetting in 2000.

Gala Set & Yield , 2001

Treatment	Fruit Set (%)	Yield/ tree (lb)
Control	79 a	111 a
NC 99 x 1	62 ab	109 a
NC 99 x 2	47 bc	75 ab
FOLS x 1	52 b	75 ab
FOLS x 2	57 ab	69 ab
FOLS PF + FC	25 c	47 b
Wilthin	76 a	101 a

Gala Fruit Size , 2001

Treatment	Fruit dia. (in)	Fruit wt. (g)
Control	2.4 b	116 b
NC 99 x 1	2.5 b	126 b
NC 99 x 2	2.8 a	150 a
FOLS x 1	2.5 b	124 b
FOLS x 2	2.8 a	151 a
FOLS PF + FC	2.8 a	167 a
Wilthin	2.4 b	117 b

Gala Phytotoxicity, 2001

Treatment	Leaf Burn	Russet
Control	0 d	1 b
NC 99 x 1	2 b	1 b
NC 99 x 2	3 a	1 b
FOLS x 1	1 c	1 b
FOLS x 2	3 a	2 a
FOLS PF + FC	1 c	1 b
Wilthin	0 d	1 b

Post-bloom FOLS Timing,2002

- 12-year-old Empire and McIntosh/M.26 trees.
- RCBD with 4 reps in Empire and 5 reps in McIntosh.
- Tank mixed and applied with a high pressure hand gun sprayer.

Treatments

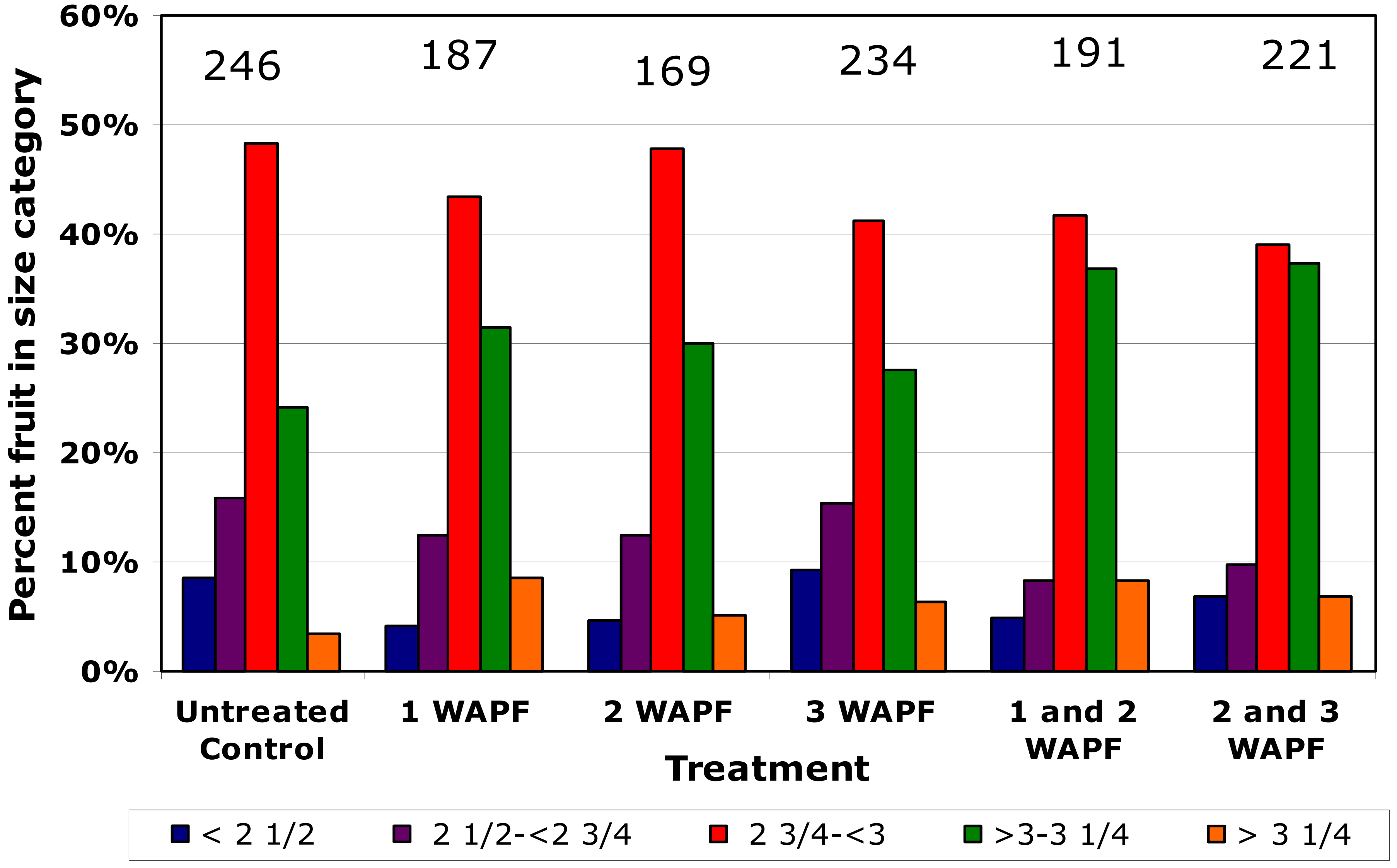
- Control
- 1 week after petal fall (WAPF)
- 2 WAPF
- 3 WAPF
- 1 and 2 WAPF
- 2 and 3 WAPF

Sprays were applied on May 6, 16, and 22.

FOLS Timing: McIntosh, 2002

Treatment	Set (%)	Fruit wt (g)	3 in. & up (%)
Control	120 a	164	27
5 DAPF	89 b	180	40
15 DAPF	74 bc	173	35
21 DAPF	83 bc	172	34
5 + 15	69 bc	180	45
15 + 21	55 c	181	44

McIntosh Fruit Size Distribution



Fruit Russet

Treatment	Fruit Russet (1-5 scale) Empire	McIntosh
Control	1.3 c	1.9 b
1 WAPF	2.2 a	2.2 ab
2 WAPF	1.4 bc	2.3 a
3 WAPF	1.4 c	2.2 ab
1 and 2 WAPF	1.9 ab	2.4 a
2 and 3 WAPF	1.5 bc	2.3 a

No differences in L:D ratio or seed number

Return Bloom 2003

Treatment	Blossoms/LCSA Empire	Blossoms/LCSA McIntosh
Untreated control	10.9	8.4
1 WAPF	16.9	8.5
2 WAPF	10.8	6.9
3 WAPF	15.0	8.0
1 + 2 WAPF	10.7	9.2
2 + 3 WAPF	16.6	7.9

McIntosh Summary

- FOLS reduced fruit set in all treatments.
- Double applications and early thinning of FOLS resulted in the largest fruit.
- FOLS slightly increased fruit russet.

Post Bloom Timing Conclusions

- Post-bloom FOLS applications were effective, especially on McIntosh.
- Later timing more effective, but may not result in larger fruit.
- Growers will have to accept noticeable amounts of leaf burn.
- More studies are needed before FOLS is recommended.

Liberty Thinning, 2002

Treatment	Rate	Dates applied
Control	--	--
FOLS	2% + 2.5 %	22, 28 May
Kerry seaweed extract	22 fl. oz./ 100	16, 22, 28 May & 2 June
6BA (Valent)	150 ppm	16, 22 May

Liberty Thinning, Fruit Size, 2002

Treatment	Juice	Bags	120 ct	100 ct	80 ct
Control	28 a	34 a	35 c	3 c	0.4 b
FOLS	5 b	16 b	61 a	17 b	0.6 b
Kerry	32 a	39 a	25 d	3 c	0.3 b
6BA	6 b	12 b	47 b	31 a	4 a

FOLS Negatives

- Smelly, corrosive, hard to wash off.
- Limited availability of FO.
- Potentially phytotoxic.
- Not Cheap: $US 45-$90 / Acre.
- Not fully researched.

LS Concentration & LS:FO Ratio

Lime Sulfur (%)	Fish Oil (%)
0.0	0
1.5	0
2.5	0
0.0	1
0.0	2
1.5	1
1.5	2
2.5	1
2.5	2

LS Concentration & LS:FO Ratio

Treatment	Crop Load	Fruit wt.	Leaf burn
Control	9.4 ab	98 b	0.2 c
LS 1.5	9.8 ab	122 a	0.7 b
LS 2.5	10.1 a	109 ab	0.4 bc
FO 1.0	8.3 abc	113 ab	0.7 b
FO 2.0	6.1 cd	126 a	0.4 bc
1.5: 1.0	6.4 cd	128 a	0.6 bc
1.5 : 2.0	7.6 bc	113 ab	0.5 bc
2.5 : 1.0	6.5 cd	118 ab	0.8 b
2.5 : 2.0	8.1 abc	114 ab	0.4 bc
NC99 4%	5.4 d	130 a	2.4 a

FOLS Summary

- Effective, consistent thinner.
- Broad application window.
  - Effective blossom thinner,
  - Excellent post-bloom activity.
- FOLS shows promise as a replacement for carbaryl & as an organic thinner.
- More research underway.

FOLS Research Needs

- Alternatives to Crocker's fish oil.
- Effect of timing on efficacy and on fruit size.
- Effect of spray volume and concentration on efficacy, $/acre, and crop safety.
- Confirm MOA.
- Pest Mgt. implications need study (scab, beneficials).

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Early Season Fertilization Basics and Irrigation Management

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In New England, sweet corn is grown on more farms than any other vegetable. Farm stands often build their reputation on the quality of their sweet corn and use that as a way to ensure customer loyalty. Unfortunately, it's not easy to grow corn in our climate known for its cool, wet springs and what seems like increasingly droughty summers (this summer being the exception). A proper fertilizer program and timely irrigation can go a long way to ensure the best crop you can have.

I. Irrigation

Sweet corn seed, especially supersweet types, can pose a big challenge when it comes to uniform emergence. At temperatures below 55F, seed emergence will be spotty and stands poor. We like to see a minimum soil temperature of 60F, so that seed will emerge uniformly. If the early market requires you to plant earlier, mulches and row covers to enhance soil temperatures and germination are essential. Remember, however, that the cost of these materials will be between $300 - $400 dollars per acre. Your market will determine if the return on early corn will pay for the increase in expenses.

Typically, in the spring, the biggest problem with soil moisture is soils that are too wet. Wet soils also tend to be cool as it takes much more energy to warm a wet soil than a cool soil. There is little a grower can do to overcome a wet soil. Planting more shallow will be helpful as the soil nearer the surface will be warmer and moist, perfect conditions for germination. Planting on ridges will help too.

Over the last ten years, we've experienced two or three where conditions were very dry in the spring. We have found that sprinkling a small amount of water PRIOR to planting is more effective than irrigating after planting. About 0.1 to 0.2 inches of irrigation, a day prior to planting, makes the soil moisture ideal for planting. Irrigation after planting can result in soil crusting and a cool down of the soil for a day or two – conditions you are trying to avoid. If you must irrigate after planting but prior to seed emergence, do so first thing in the morning so that soils will warm through the day.

Once the sweet corn has emerged, it's important to maintain uniform soil moisture. Allow the soil to dry out in the first couple of inches to encourage deeper rooting and more drought tolerant plants. The most critical time to avoid drought in sweet corn is during silking and tasselling and ear development. Generally, dry conditions early in the plant's development (4-10 leaf stage) leads to smaller ears while later in the season (silking) results in poor kernel development and tip fill.

Monitoring soil water status directly is often the best way to determine when to irrigate. This does not have to be complicated or expensive, but it does involve checking soil moisture at the roots because looking at the top inch or two of surface soil is not informative. In addition, parts of the field with different soil type, slope, and drainage characteristics must be monitored separately.

Several sensors are available that can be placed in the field at various depths and locations to monitor soil water status. Tensiometers, which usually cost between $30 and $50, measure soil dryness using a vacuum-based system. Units of measurement are centibars (cb) - the dryer the soil, the greater number of centibars. The texture of the soil influences the soil tension range measured by tensiometers. The placement of tensiometers in the field is extremely important. They should be placed where plant roots are actively growing, usually at a depth of 6 to 12 inches and within 6 to 12 inches from the plant's base. It may be useful to place them at various depths to determine if irrigation or rainfall has reached that depth. One caution when using tensiometers. They go off scale easily if the soil dries (above 80 cb), and they must be refilled with water and vacuum pumped by hand to become functional again.

Gypsum blocks and ceramic moisture sensors operate on an electrical principle. They are not expensive, but a voltmeter-type device (usually $150 to $250) is required to use them. They are placed in the root zone as are tensiometers. Ceramic sensors have a narrower operating range than gypsum blocks and therefore tend to be more accurate. A disadvantage of both electrical types is that their calibration may lose accuracy with time, particularly if used for more than one season.

Another approach to scheduling irrigation, usually referred to as the "water budget" method, is much like balancing a checkbook and involves keeping track of "deposits" (rain and irrigation) and "withdrawals" (crop water use). Weather records or evaporation pan data can be used to derive useful approximations of potential crop water use. This is known as "potential evapotranspiration" or "ET." During the months of July and August, expect ET rates of 1 to 1.5 inches of water per week with lower values during other months. Maximum water use can be much lower (e.g., 50 to 60 percent of potential ET) if temperatures are cool and humidity high.

Light irrigation is needed more frequently at early seedling stages because the plant has only a small soil water reservoir. Later in the season, less frequent but deeper irrigations are used to replenish a larger rooted volume. Information on water-holding capacity is important so as to avoid adding more water at any one time than the soil can hold. Light-textured soils hold less water than do heavy clay (and most muck) soils; thus a grower with a sandy soil will irrigate more frequently and apply less at each irrigation.

II. Fertilizer

High quality sweet corn begins with a soil test, something that should be done on all fields every three years. Growing any crop without reliable soil test results is risky and just not worth it.

For under $20 a soil test can give you the pH, organic matter content, cation exchange capacity, and the levels of most of the nutrients needed for plants.

Let's start with the pH. Sweet corn, like most vegetable crops, does best in a slightly acid soil, from 6.0 to 6.7. If the pH is below 5.5, it's best to apply limestone in the fall so that it has time to react with the entire plow layer (at least two plowings). If a fall application is not possible or more than four tons per acre need to be added, a split application is recommended. Plow down half and apply the rest to the surface and disk in. This will provide a pH favorable for seedling development.

Once you have the pH adjusted, it's time to plan your fertilizer program. In New York, we recommend the following;

Table 2. Recommended rate of nutrients to apply to sweet corn based on soil tests.

N pounds/Acre	**P_2O_5 pounds/acre**			**K_2O pounds/acre**			**Comments**
	Soil Test Level			**Soil Test Level**			
	low	**med.**	**high**	**low**	**med.**	**high**	
120-140	**120**	**80**	**40**	**120**	**80**	**40**	**Total Recommended**
40	80	40	0	80	40	0	Broadcast and disk in[1]
40	40	40	40	40	40	40	Band place with planter
40-60	0	0	0	0	0	0	Sidedress when corn is 6" to 12" high

[1]A second sidedressing could replace the preplant, broadcast application of nitrogen if applied when corn is 12" to 18" tall. This is preferable on leachable soils.

Starter fertilizer

Cool soils will tie-up some of the nutrients needed for plant growth. Nitrogen, normally slowly released from soil organic matter, becomes available only as the soil warms up. Phosphorus too is bound in the soil at temperatures 60F and below. Only about 1/3 is available at 60F compared to 70F. We can see early season P deficiencies even in soils that are very high in P.

To get corn off to a good start, a starter fertilizer is recommended. Typically, a banded fertilizer is placed no closer than two inches to the side and two inches below the seed furrow as it is planted. The fertilizer should stay far enough from the seed to avoid burning but close enough to provide nutrients. Never apply more than 80 – 100 pounds of the combined N and potassium (K) in the band or you risk burning the seedlings. The level of P in the band is not as critical as P is normally less likely to burn.

Another option for starter is using a pop-up fertilizer. Pop-up are fertilizers used in very low amounts that are placed in the seed furrow. Of concern with pop-ups is the potential for burning and significant stand reduction since the fertilizer is so close to the seed. To reduce this risk, no more than 5 to 8 pounds of N and K per acre should ever be applied (5 lbs/A on lighter soils and 8 lbs/A on heavier soils.

I have not seen any reliable information that indicates that pop-ups provide advantages to the traditional 2x2 placement. I have seen several studies that show that in some years, usually when soils are dry and fertilizer salt damage is more likely, pop-ups in the furrow can cause stand reductions. The idea that plants will benefit from closer proximity to the fertilizer seems to make sense until you look at the seed itself. For the first two to three weeks, after planting, the pant relies on the nutrients in the seed, not the fertilizer. By the time these reserves are depleted, root development should be adequate to reach the 2x2 band. The greatest benefit for pop-ups may be in using low amounts of P in the seed furrow in soils that already have plenty (at least they will have plenty once the soil warms). Growers should stay away from any pop-ups that include ammonia (urea, mono or diammonium phosphate) as the ammonia can cause problems.

Once the corn is up and growing, a sidedressing of 40 to 60 ponds per acre is recommended. This should be done when the corn is between 6 and 12 inches in height. Soils high in organic matter (from manure or cover crops) may not require the sidedressing. There are several soil tests that can be performed prior to sidedressing (pre-sidedress nitrate tests or PSNT) to measure the available nitrate. Normally, soils with nitrate levels above 25 to 30 PPM, will not respond to additional nitrogen.

Trickle Irrigation for Sweet Corn

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I'm not sure just how I was fortunate enough to receive this rare invitation to address such a distinguished group. As I look over the list of attendants, it gives a new meaning to the old phrase "preaching to the choir", but I'll give it a shot.

Living here in the Northeast and trying to grow sweet corn, one thing we can depend on is that every year is different. Last year we started in late March and early April with about one nice week. We got our plowing done and some corn planted and the next six weeks were cold and wet, and it alternated with being wet and dry all season.

First, let me tell you about our operation in Niagara County, NY. Our farms are along the Ridge Road where the soils are gravelly, very nicely suited for early season vegetable crops. We can get on them early in the spring since they hold the heat but not the water. Most of these soils are located close to the Ridge Road in a pretty heavily populated area. We lease about 12 fields which vary in size from 1 to 10 acres, and they are often cut up and a pain to work but most have a county water supply available. This is a very important part of our trickle decision.

We raise about 65 acres of fresh market sweet corn. About 30 acres of this is planted under plastic with the intention to harvest from approximately July 1st through July 20th. To complicate our operation, we also raise about 15 acres of strawberries – which puts a strain on our available manpower for irrigation work at a critical time for our early corn. We supply our own roadside market, a few other local roadside markets, and some local Wegmans and Tops supermarkets.

It used to be that we could stick in some Seneca Horizon, Harmony or Sundance and you had a corner on the early market. $15.00 per box wasn't even questioned. Now the Southern Super Sweets continue to pour into our markets well into July – cheap – and <u>not bad quality</u>. So the challenge gets tougher.

Every year, we see new varieties coming along with fairly good cold tolerances and disease resistance, and many with great eating qualities. So we have good varieties to work with. Most growers with a little timely spraying still have products enough to keep us insect free. So we've narrowed the field down to other management practices.
I consider the two most important to be fertilizer and water.

We have used overhead sprinklers, we have a couple of reels and have recently added trickle. Now – if used properly – <u>they all work</u>. Which one or more work best is a management decision.

Now – to talk about trickle irrigation. I'll tell you some of the things we use to make our decisions, and the economics involved as I see them.

1. I'm older and lazier.
2. Trouble getting good reliable help.
3. Getting things done on time.
4. Most important – We must have acceptable marketable yields of quality corn.

The most expensive corn we grow is the corn that <u>doesn't fill to the tip</u>. If you don't believe this – load up fifty boxes of corn that hasn't filled or that had immature tips and drop it off to Wegmans. Chances are that you'll haul that corn back home. That's expensive.

Let me tell you about my failed sales promotion program. I call it the "Butter Handle" program. Faced with a considerable amount of corn with those unfilled tips that I called "butter handles", I tried to convince customers that it was premium stuff and when you eat it off the cob, the butter won't run off, down your arms and drip off your elbows. It sounded reasonable enough and I was actually able to convince two little old ladies and one new bride that it was a good idea. But I failed to convince produce buyers and about 99% of regular customers that this was the way to go. So much for my "Butter Handle" program. But we have learned to grow "butter handles". Simply fluctuate your moisture supply to your corn. Rain is seldom dependable enough, especially on drier soils, to maintain consistent growth.

We first tried trickle 5 years ago. We liked what we saw. Some of our methods and equipment are "Mickey Mouse" but they work for us.

Our 2-row, 3-point hitch planter plants two rows 17" apart. We use an old cultivator shoe to make an open furrow for the planter and also build a ridge between the two rows. Trickle tape is laid under the center ridge about 2 – 3" deep. It takes a littler longer to plant obviously, but not much. A couple of tips: 1) I leave a little extra tape at the end of each row so when it is hooked up, flow can be easily checked from the truck window. 2) When laying tape, we found that a cement block at each end tied to a pair of vise grips, when attached to the end of the tape, will avoid tape slippage or dragging of the tape.

Let's briefly talk of economics. Don't hold me to any of these figures since they are all "ballpark" figures. Talk to your supplier for exact figures.

1. Planting corn as we do under plastic, 2 rows – 17" apart under a 4' roll of plastic, it takes 8,700 feet to give you one acre of corn. We plant at 5' row spacing which breaks down to 30" rows.
2. Since our trickle tape is laid between the two 17" rows we can adequately water 17,400 linear feet of corn row with 8,700 feet of "T" tape, or approximately one acre.
3. Using 8 mil tape at a cost of approximately 1.6 cents/foot your tape will cost about $140 per acre. Now depending on the shape of your field and how close you are to your water supply, add another $40- $45 per acre for your header bringing the cost to about $185 / acre. Now this sounds like a lot of money, and it is! But we

have found that with a little careful management we can get 2 – 3 years out of that tape, bringing the cost down to about $60 per acre.

Reusing the tape requires a little more "Mickey Mouse" work. We use our plastic puller to rewind the tape on old wire spools for reuse. Since we do grow much corn after corn – we rewind it so it can be used right back in the same fields the next season. Sometimes you get a few nicks and bangs that have to be repaired – but not bad – and you'll learn fast.

General Operations – Advantage of the System

Once installed, the system is easy to use and is almost labor free - just turn it on. Timeliness of application is achieved with the regular flow tape – 5 gal/1,000 ft/min, or 43 gal/min/acre. (Low flow tape gives approximately _ as much.) Our blocks are approximately 2 acres in size. We like to put on 1"/acre equivalent. (It takes approximately 27,000 gallons of water to do 1 acre overall. Since we only cover _ of that acre with trickle we need about 14,000 gallons.)

On our gravel soils we run approximately 6 – 7 hours at a run which gives us about a 2 foot strip nicely saturated right where it's needed. Depending on rainfall, we think about 2" per week is necessary to do the job. We install an in-line pressure regulator set at about 11 psi which gives adequate flow and stops errors and blowouts. This season we experienced a countywide restriction on hydrant water use except from 10PM to 10AM. Trickle use was exempt from this restriction.

The other option we like is running Nitrogen or fertilizer into the system. We're still experimenting on how to best utilize this probably with several applications over the season. On plastic, maybe an application before we pull would be worthwhile. But fertigation makes sense. It's a fast, easy and on-target method for your fertilizer.

Introducing fertilizer into the system is really pretty simple – injector kits are available. We use our sprayer set at an idling speed to inject 100mgallons of fertilizer solution into the system in only 15 minutes. Note: You must of course have proper back flow valves in place.

In Conclusion

We feel trickle on corn does have a place – it works great. It takes a little extra management. The economics can actually look pretty good, especially if you can get 2 - 3 years use out of the tape. We are planting all of our corn with the same planter we use for plastic – 17" rows on 5' centers – since this will give us the option of using trickle wherever practical (bareground or plastic) and not having to change plants or cultivators. Trickle is a good option – unless you can sell "butter handles". I hope that maybe I have offered some useful information.

Thank You.

Sweet Corn Genotypes – How Do They Differ?

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History

Corn's history can be traced to about 5000 BC and it's been cultivated for 4,000 years. The development of sweet corn has been much more recent. Before the **sugary gene (su), people** ate field (dent) corn pulled at an immature stage. Sweet corn was documented in the 1770's in Pennsylvania, but had probably been cultivated by American Indians prior to that time. Sweet corn was first listed in a seed catalog in the 1820's. White sweet corn dominated the scene until 1902 when a yellow variety, Golden Bantam, was developed. Bi-colors were the logical next step when crosses were made between the other two colors.

Although color is the central theme to many sweet corn debates, color does not have a significant role in the flavor or the quality of the variety. Color is driven by regional preferences and marketing strategies. Because consumers buy with their eyes, it is an important consideration, but it won't be part of this discussion on eating quality.

The University of Illinois did much of the early development of the **shrunken (sh2)** gene in the 1950's. The sh2 gene greatly boosted the sugar levels of the endosperm. The gene defect also slowed the conversion of simple sugars to starch.

In the 1960's, also at the University of Illinois, a corn was bred that was sweet and creamy and had a tender pericarp. This type of corn became known as **sugary enhanced (se).**

Variations of Eating Quality Within the Three Main Genotypes

There are some standard sugary varieties that taste better than other varieties. This is also true for sugary enhanced and supersweet varieties. In the case of the sugary enhanced varieties, it is fairly easy to understand that some varieties receive the se gene from both parents while other varieties only receive the gene from one parent. The varieties that receive the gene from both parents are called homozygous for the trait (double se), while the varieties that only receive the gene from one parent are called heterozygous (single se). A homozygous se variety has 100% se kernels, while a heterozygous se variety only has 25% enhanced kernels. Since the se trait boosts the quality, it's easy to see why a homozygous variety, typically, has better eating qualities than a similar heterozygous variety. But how does this explain why some su or sh2 varieties taste better than other varieties in a similar class? Also, some varieties within the same se class taste better than similar varieties. This is because there are other genes, described as modifier genes, which can also affect the eating quality. These modifier genes can come from one parent (heterozygous) or both parents (homozygous). Like the se gene, a variety that is homozygous for a modifier gene will have the trait in all of its kernels. Likewise, a variety that is heterozygous for the modifier gene will have a lower occurrence of the trait in its kernels. So it is possible to have a 75 day, bi-color, homozygous se variety that eats much better than a similarly classed variety. This makes it possible to breed for flavor differences within a major genetic class.

New Genotypes in the Marketplace

Sugary (su) varieties have good corn flavor, but lose their sweetness rapidly after maturity. The supersweet gene gives us higher levels of sugar and a slow conversion to starch, but it often contributes a tough pericarp. Supersweets can also lack creaminess and a complex corn flavor. Sugary enhanced varieties have a tender pericarp, a creamy texture and good corn flavor, but the sugars still convert to starch faster than in supersweet sweet varieties. What we really want are the best characteristics of each of the three main genotypes.

In the past few years, breeders have been "stacking" these genes. Now varieties may contain a number of different combinations of the three major genes and their modifier genes. Many of these new types have a much superior flavor than their old counterparts.

These new types can be broken down into two "pollination groups." They generally behave as either a supersweet or sugary variety.

SU GROUP (SU AND SE TYPES)	**I**	***SH2 GROUP (SUPERSWEET TYPES)***
Normal (su)	**S**	Shrunken (sh2)
Sugar Enhanced (se)	**O**	**Augmented**
Synergistic:	**L**	Gourmet Sweet Brand™
Sweet Breeds™	**A**	Multisweet™
TripleSweet™	**T**	Xtra-Tender Brand™
Table Sweet™	**E**	Mirai™

These different backgrounds bring unique benefits to the grower. Because of the modifier genes, the quality can vary between varieties within classes. Here's a brief look at each individual type.

Synergistic (2 types):

Description:	***Example***	***Kernel Types and benefits:***
Synergistic on a heterozygous se background	**Sweet Breed™** varieties such as Sweet Chorus, Sweet Rhythm	Roughly 25% se kernels, 25% sh2 kernels, 50% normal kernels. Typically has good seed quality. Su vigor, but should have higher sugars than a su.
Synergistic on a homozygous se background.	Bojangles, Charmed, **TripleSweet™** varieties such as Providence (BC4806)	100% se kernels, 25% kernels also have a supersweet trait. Sweeter than typical homozygous se varieties. Very good flavor. Characteristic homozygous se vigor.

Table Sweet™ :

Description:	***Example***	***Kernel Types and benefits:***

Tablesweets™ are a high quality homozygous se.	**Table Sweet™** varieties such as Parfait.	The early se hybrids were all crosses between a very sweet line and a less sweet se line. The Tablesweets™ have both parents in the very sweet category. This results in a hybrid with much better holding ability and higher sugar levels.

Augmented Shrunken:

Description:	***Example***	***Kernel Types and benefits:***
Supersweet types that also carry the se trait	**Gourmet Sweet Brand™** **Multisweet™** **Xtra-Tender Brand™** 278A, 282A, Obsession	Supersweet background with se and modifier genes also in kernels. High sugars like supersweets, slow conversion to starch. Tender like a se.

Mirai:

Description:	***Example***	***Kernel Types and benefits:***
Supersweet types that also carry the se and su traits	Mirai 002	Supersweet background with se, su and modifier genes also in kernels. High sugars like supersweets, slow conversion to starch. Tender like a se. Excellent "mouth feel." Currently only available as a yellow.

Choosing Varieties for Your Farm

Each year there are actually many thousands of new hybrid crosses made. Breeders have the daunting task of sorting through large blocks of these varieties. The breeders pare down these crosses to a few thousand of the most likely to succeed. These crosses advance to trials where they are again evaluated by the breeders and often product managers, salesmen and dealers. Typically, a few dozen will filter down to pre-commercial trials. Often, these trials are grown on local farms in strips or blocks. For several years a variety may be evaluated for disease tolerance, vigor, flavor and performance. Eventually, a few get named and sold. Perhaps some will become viable commercial varieties. A grower wouldn't be expected to be able to sort through so many varieties. Some farms will find it is more desirable to pick out "performance varieties" with adequate flavor, while other farms will choose flavor over performance. That is why it becomes so vitally important for you to find good representatives to work with from your seed company.

Almost all of these new types have better flavor than their old counterparts. Some also have better performance. These new genetics represent the future of the corn industry.

Early Sweet Corn Variety Trials

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Introduction

New England farmers have many options when it comes to selecting sweet corn varieties to grow. In addition to color options (yellow, white, bicolor, and now red) and maturity ranges, growers must also choose which sugar type best suits their production style and markets. The standard sugary type corns (abbreviated "su"), have been giving way to sugar-enhanced ("se" and "se+") and supersweet ("sh^2") types. The supersweet types have very high levels of sweetness and can hold sugar levels for many hours after harvest, in contrast to standard varieties. However, they also tend to have a tougher texture and less "corn" flavor, they must be isolated from other types of corn to prevent cross-pollination, and they germinate poorly under cold soil temperatures. The sugar-enhanced types also hold sugar levels longer after harvest than standard varieties, but not as long as the supersweet types. They do not have the tough texture of the super sweet types, nor do they require isolation, and they tend to have better cold soil germination. For this reason the sugar-enhanced varieties have, in recent years, become the most popular type of sweet corn grown in northern New England. Now there are also choices within the sugar-enhanced varieties. Some varieties are listed as "se" while others are listed as "se+" or "se se". If the variety came from a cross of a normal (su) parent and a sugar-enhanced (se) parent it is called an se type (technically, it is heterozygous for this trait). If the variety is from a cross of two se parents it is referred to as se+ or se se (i.e. it is homozygous for this trait). The latest wrinkle in the sugar-type puzzle is varieties that have traits from su, se and super sweet types. These are proprietary and go under commercial labels such as "Triple Sweet" and "Sweet Breed". The idea is to take the best characteristics of each type, and blend them into new varieties. Most of these are new to the market and grower evaluations have just begun.

Over the past few years we have tested numerous varieties of sweet corn at the Maine Agricultural Experiment Station, concentrating on early to midseason bicolor varieties. In 1999 and 2002 we looked at se-types and in 2001 we looked at supersweet types. All of the trials were replicated and randomized for statistical validity. Reports for each of the studies are included below. We would like to thank all of the companies that provided seed for this trial, including Harris, Johnny's Selected Seeds, Seedway, Stokes, and Twilley.

Early Bicolor Sugar-Enhanced (se) Sweet Corn Trial 1999

Seed germination in all plots was very good. All of the varieties preformed well under the very hot, dry conditions that characterized this growing season. Fleet was the first variety to mature in the trial, and had characteristics similar to its sister variety Quickie, being a short plant with relatively small ears set close the to ground. Ear quality was fair to good. Ecstasy II, Geronimo, July Gem, Seneca Arrowhead, and Trinity were in the second early harvest. Ecstasy often produced two marketable ears per plant. The ears were fair quality, relatively small and had the poorest tip cover in the trial, meaning that the husks may not adequately protect the ear tips from birds and insects. Geronimo produced relatively large ears, averaging 15 rows of big kernels. They were low to the ground however, and somewhat difficult to pick (the ears did not easily snap off the stalk). July Gem produced a good-sized attractive ear, but it was the most difficult variety to pick, and its maturity was variable. Seneca Arrowhead produced a good quality ear, somewhat short but averaging 16 rows of kernels. Tip cover on this variety was among the poorest in the trial. Trinity produced a small to medium-sized ear that picked easily, although it was low to the ground. Tip fill tended to be poor, reducing ear quality. The third early harvest included Double Gem, Seneca Tomahawk, Sweet Chorus and Sweet Rhythm. Double Gem produced a good-sized ear of high quality that picked easily, although its maturity was variable. It also had the poorest germination rate in the trial, but it was still acceptable. Seneca Tomahawk had good ear length, but averaged only 13 rows of kernels. It was among the poorest for tip cover, but it was very easy to husk. Sweet Chorus had among the largest ears in the trial. It was easy to pick with good tip cover, but had some poor tip fill under the dry growing conditions. Sweet Rhythm was a shorter, fuller ear with good quality, but somewhat less tip cover and similar problems with tip fill. Ear height for this variety was the most variable, which may pose a problem for mechanical harvesting. Mystique and Sweet Symphony were harvested three days following the third harvest group. Mystique was a large plant with the ears placed well off the ground, but it was among the hardest to pick. The ears were good quality and the largest in the trial, but sometimes had poor tip fill. Sweet Symphony was a large, uniform plant with ears well off the ground. The ears were very good quality with excellent tip cover. Wizard was harvested three days after Sweet Symphony and Mystique and had the highest germination rate in the trial. It was also the tallest plant in the trial, and had good picking ease and tip cover, but the maturity was variable. The ears were large and had the highest number of rows of kernels (18) in the trial. Lancelot was the last variety harvested in the trial, maturing four days after Wizard. It was a large, though somewhat variable, plant, which held the ears higher off the ground than any other variety. Picking ease was good, although maturity was somewhat variable, and the large ears had very good quality.

Sweet Corn Bicolor se Variety Trial 1999
Highmoor Farm, Monmouth, Maine
University of Maine Cooperative Extension

Variety	Days to Harvest[1]	Harvest Date	Plants/ row	Height (in.)	Ear Ht. (in.)[2]	Picking Ease[3]	Tip Cover[4]	Ear Length (in.)	Rows of Kernels	Comments
Double Gem✓	75	8/3	44	73.5 ±2.6	17.2 ±1.5	2.8	2.0	7.3 ±0.5	16	Variable maturity
Ecstasy II	68	8/2	48	68.8 ±3.2	14.5 ±1.8	2.4	1.3	7.2 ±0.3	13	Marketable 2nd ear
Fleet	65	7/29	53	61.0 ±3.2	9.1 ±1.9	2.7	2.0	7.2 ±0.2	13	Tassels on ear tips
Geronimo	69	8/2	52	63.4 ±3.2	12.6 ±1.5	1.8	2.0	7.5 ±0.1	15	Large kernels
July Gem	71	8/2	53	68.7 ±2.6	13.9 ±1.8	1.5	2.3	7.4 ±0.4	15	Variable maturity
Lancelot✓	80	8/13	51	77.5 ±5.6	23.3 ±1.1	2.7	2.2	7.3 ±0.2	17	Variable maturity
Mystique	75	8/6	47	78.1 ±1.6	20.9 ±1.2	1.7	2.0	8.1 ±0.5	15	Poor tip fill
S. Arrowhead✓	62	8/2	55	68.7 ±2.5	13.6 ±0.4	2.0	1.9	7.2 ±0.3	16	Tassels on ear tips
S. Tomahawk	68	8/3	49	73.5 ±3.8	19.1 ±1.8	2.2	1.8	7.4 ±0.1	13	Easy husking
Sweet Chorus✓	67	8/3	54	76.9 ±1.3	15.4 ±1.5	2.7	2.5	7.6 ±0.5	14	Poor tip fill
Sweet Rhythm	74	8/3	56	78.8 ±2.9	22.9 ±3.3	2.3	2.1	7.1 ±0.1	15	Poor tip fill
Sweet Symphony✓	76	8/6	50	77.1 ±.95	21.8 ±0.5	2.4	3.0	7.3 ±0.2	16	Consistent, bright color
Trinity	68	8/2	53	68.9 ±2.5	11.4 ±1.2	2.9	2.1	7.2 ±0.2	14	Poor tip fill
Wizard✓	72	8/9	59	89.2 ±2.9	20.6 ±1.2	2.6	2.5	7.4 ±0.2	18	Variable maturity
LSD 0.05			6.5	3.4	2.5			0.4	0.8	

1 Maturity date according to seed catalog. Seed planted manually 5/21-5/27
2 Ear height measured from base of ear to soil surface
3 Picking ease rated on a scale of 1 to 3 with 1 being difficult to snap and 3 being easy to snap.
4 Tip cover rated on a scale of 1 to 3 with 1 indicating an exposed tip and 3 indicating three or more inches of tip cover.

✓Best of show

Early Bicolor Supersweet (sh_2) Sweet Corn Trial 2001 Variety Notes

Everprime: Fair germination, good yield. Tall plant, but ear sits low. Picks well. Poor to fair tip cover. Good ear size and appearance. Good flavor.

Fantasy: Good germination, good yield. Short plant, ears low on the stalk. Picks well. Poor tip cover. Smallest ear in trial with fewer rows, but highest sugar content.

Fortune: Good germination, but lowest yield in trial. Good sized plant with ears well off the ground. Picks very well. Fair tip cover. Medium-sized ear, lower sugar content than others.

Jumpstart: Among the earliest to mature. Good germination, only fair yield. Fair-sized plant, but ears close to the ground. Somewhat tough to pick, but good tip cover. Fewest rows and large kernels. Good sugar content.

Majesty: Among the latest in the trial. Good germination, good yield. Tallest plant and good ear height. Picks well. Only fair tip cover. Large, attractive ear. Good sugar content.

Milk n' Honey II: Among the earliest to mature. Good germination and yield. Shorter plant, picks very well. Fair tip cover. Large ear, but lowest sugars in the trial.

Confection: Fair germination, good yield. Tallest plant in trial, ear fairly high on plant. Picks well, fair tip cover. Medium-sized, attractive ear with good sugar content.

Sweet Heart: Among the earliest to mature. Very good germination and good yield. Medium-sized plant but low ear height. Picks well, fair tip cover. Smaller ear, with only fair sugar content.

SS 6082: Among the earliest to mature. Fair germination, good yield. Short plant ears close to ground. Picks well, good tip cover. Medium sized year, good sugar content.

SS 7422: Very good germination, but only fair yield. Shorter, picks well. Fair tip cover. Large attractive ear, but low sugar content.

270A Extra Tender: Among the earliest to mature. Good germination, fair yield. Shortest plant in trial, ears low to the ground. Somewhat tough to pick, fair tip cover. Large ear, lower sugar content.

275A Extra Tender: Highest germination rate, best yielding in trial. Tall plant with ears set highest of any variety. Picks well with fair to good tip cover. Good sized ear with fair sugar content.

277A Extra Tender: Later maturing. Lower germination rate and yield. Smaller plant. Somewhat tough to pick, fair tip cover. Large attractive ear with high sugar content.

GS 276A: Later maturing. Good germination and yield. Medium-tall plant, picks well. Large, attractive ear with good sugar content.

Bicolor Supersweet (sh_2) Corn Variety Trial 2001

Highmoor Farm, Monmouth, Maine

University of Maine Cooperative Extension

Variety	Days to Harvest[1]	Harvest Date	Plants/ Row	Height (in.)[1]	Height of Ear[2]	Yield/ Plot	Picking Ease[3]	Tip Cover[4]	Length of Ear	Rows of Kernels	Sugar (brix)
Everprime	77	8/22	29.25	71.97	16.52	25.50	2.12	1.25	7.54	14.95	14.05
Fantasy	75	8/22	31.50	58.53	13.65	24.75	2.12	1.02	6.81	14.20	16.67
Fortune	75	8/22	32.75	68.55	22.08	17.25	2.75	1.41	7.29	14.66	12.20
Jumpstart	71	8/17	32.00	69.00	15.13	21.50	1.87	2.53	7.29	12.90	14.20
Majesty✓	75	8/27	32.50	73.07	27.35	24.25	2.37	1.37	7.79	16.17	13.75
Milk&Honey II✓	71	8/17	32.25	67.36	17.95	26.00	2.62	1.89	7.89	15.35	11.02
Confection✓	74	8/21	29.25	72.65	24.60	26.25	2.25	1.89	7.41	15.18	14.40
Sweet Heart	70	8/17	34.25	68.65	16.50	24.00	2.25	1.69	6.96	13.88	13.10
SS#6082 BC	73	8/17	30.25	63.45	16.55	24.00	2.75	1.88	7.38	14.55	14.07
SS#7422 BC	74	8/22	33.75	62.65	17.85	20.00	2.25	1.30	8.04	14.75	11.57
270A Xtra Tndr	71	8/17	31.25	58.22	13.93	22.25	1.62	1.42	7.55	15.10	12.80
275A Xtra Tndr✓	75	8/22	34.75	70.80	27.55	31.00	2.12	1.82	6.95	17.95	13.40
277A Xtra Tndr ✓	77	8/24	29.25	60.53	17.92	29.25	1.62	1.47	7.32	17.67	15.88
GS276A✓	76	8/24	32.50	64.90	23.15	30.25	2.37	1.80	7.72	17.25	14.70
LSD 0.05			3.52	7.90	3.77	8.54	0.56	0.40	0.35	0.77	1.38

[1] Maturity date according to seed catalog. Seed planted manually 6/5/01

[2] Height of ear measured from base of ear to soil surface (in inches).

[3] Picking ease rated on a scale of 1 to 3 with 1 being the easy to snap and 3 being difficult to snap.

[4] Tip cover rated on a scale of 1 to 3 with 1 indicating an exposed tip and 3 indicating three or more inches of tip cover.

✓Best of show

Sweet Corn Bicolor se Variety Trial 2002
Rogers Farm, Stillwater, Maine
University of Maine Cooperative Extension

Variety	Days to Harvest[1]	Harvest Date	Plants/ Row	Height (in.)[1]	Height of Ear (in.)[2]	Picking Ease[3]	Tip Cover[4]	Length of Ear (in.)	Rows of Kernels	Insects/ Ear	Comments
Absolute✓	78	9/18	23.25	72.40	18.31	1.25	1.74	7.75	16.60	1.83	Easy to husk
Bojangles	78	9/5	21.50	63.53	14.29	1.25	1.55	7.15	13.97	1.77	synergistic
Bon Appetite	71	9/9	21.25	74.15	15.18	1.25	2.33	7.00	15.05	1.80	
Delectable✓	80	9/11	22.50	66.36	18.95	2.25	2.16	7.68	17.42	1.78	Easy to husk
Double Choice	72	9/9	21.00	64.10	13.86	1.25	2.03	7.34	13.38	1.63	
Luscious	75	9/5	21.75	70.43	16.95	1.25	1.60	6.94	16.92	2.05	
Providence✓	80	9/18	22.50	62.78	17.07	2.25	3.05	8.23	15.55	1.23	
SEB 6803	76	9/11	20.25	63.27	18.29	1.50	0.86	7.94	18.08	1.75	
Serendipity✓	80	9/18	20.75	64.22	18.24	1.75	2.66	7.86	14.88	1.38	Not uniform
Sir Prize	72	9/5	23.25	68.80	17.81	1.50	1.89	7.01	17.17	1.15	
Sweet Satin	77	9/18	21.25	69.65	24.17	1.50	1.98	7.62	15.15	2.00	White, synergistic
Sweet Symphony	76	9/9	21.50	62.15	17.95	2.00	2.60	6.35	15.43	1.38	Short ears, synergistic
Terrific	77	9/11	19.25	74.53	17.76	1.75	1.99	7.14	15.27	1.78	
Twilight✓	78	9/11	21.00	62.20	18.00	1.50	2.83	7.18	17.25	1.68	
War Dance	78	9/18	20.75	56.85	14.93	1.75	2.65	7.30	17.70	1.73	

[1] Maturity date according to seed catalog. Seed planted manually 6/21/02
[2] Height of ear measured from base of ear to soil surface.
[3] Picking ease rated on a scale of 1 to 3 with 1 being the easy to snap and 3 being difficult to snap.
[4] Tip cover rated on a scale of 1 to 3 with 1 indicating an exposed tip and 3 indicating three or more inches of tip cover.

✓Best of show

Blueberry Diseases

Frank L. Caruso, Cranberry Experiment Station
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This presentation (in Blueberry I) will be the first part of a two-part discussion on blueberry diseases and their management. The focus of this article will be a series of short synopses on the diseases, their symptoms, the causal agents and some specifics on the epidemiology. In the second part (in Blueberry II), Dr. Annemiek Schilder will focus on the management of the diseases most important to the region. The emphasis will be on highbush blueberry (*Vaccinium corymbosi*), although many of these diseases can also affect lowbush blueberry (*V. angustifolium* and *V. myrtilloides*). Diseases with a fungus as the causal agent are mummy berry, Botrytis blight, Phomopsis twig blight, Fusicoccum (Godronia) canker, anthracnose, powdery mildew, Phytophthora root rot, Armillaria root rot, and witches' broom. Diseases with a virus as the causal agent are scorch and tomato ringspot. A phytoplasma is the causal agent of stunt. At this point, there are no diseases of economic importance in the region caused by a bacterium or a nematode.

<u>Mummy berry</u>: This is probably the most important disease in terms of its widespread occurrence and because it has the potential of causing the most economic crop losses. It occurs sporadically and is at its highest incidence during cool, wet springs. There are two phases of the disease, a leaf and stem blight and a flower blight which results in the formation of the mummified berries. The disease is caused by the fungus *Monilinia vaccinii-corymbosi*. The fungus overwinters in the fallen mummies on the ground as mycelium. When temperatures are favorable, an apothecium (the perfect or sexual stage) forms and ascospores are released. These spores are the primary inoculum of the fungus and these infect the emerging leaves and young shoots, resulting in blighted tissue. Eventually, the fungus sporulates on this tissue, producing conidia (the imperfect or asexual stage). These conidia infect the flowers, but the symptoms are not apparent until the berries begin to ripen. Infected berries are initially tan or pink and as they harden and shrivel, they eventually turn gray and fall to the ground. The majority of the mummy consists of fungus tissue.

<u>Botrytis blight</u>: This is normally uncommon in blueberry fields, but in 2003 there were severe outbreaks of the disease because the weather was cool and rainy when the plants were in bloom and because it was very difficult for growers to apply protectant fungicides. The fungus *Botrytis cinerea* overwinters on blueberry stems or on a variety of other plant hosts and produces conidia that infect the flowers, resulting in blossom blight. The fungus produces a second crop of conidia on the blighted flower, resulting in the 'gray mold' phase of the disease. These conidia can cause a second round of infections, resulting in further damage to the plants, or infecting other later blooming blueberry cultivars. Normally, symptoms are confined to the flowers. However, in severe epidemics infected twigs are blighted and turn brown or black and later bleach tan or gray. This symptom can be confused with winter injury. Infected leaves may also show blackened areas of dead tissue. If wet weather persists into berry development, the fungus can also infect the fruit, resulting in gray mold symptoms on the berries. These conidia can infect other nearby fruit.

Phomopsis twig blight: This disease can be found in most fields every year. Its incidence tends to be linked to stresses on the bush such as winter injury or drought injury. The fungus *Phomopsis vaccinii* overwinters in the cankered stems in the blueberry field or in neighboring cranberry beds or on lowbush blueberry in the uplands. Conidia (or possibly ascospores although the perfect stage is very rare in nature) infect the emerging new growth in the spring into the mid-summer, resulting in blighted stems. The infection may advance downward on the stem and reach the main stem. There may be multiple infected twigs on a single bush. Entire canes may eventually be killed, as the fungus enters the vascular tissue of the stems and blocks water transport. There is a fruit rot phase of the disease, but this is not observed in New England.

Fusicoccum (Godronia) canker: This canker disease is much less common than Phomopsis twig blight. It tends to be confined to the more northernly climates. The fungus *Fusicoccum putrefaciens* overwinters as mycelium on infected wood. Conidia produced from these old cankers infect newly produced tissue, resulting in blighted twigs similar to those caused by *Phomopsis*. A unique difference between the two cankers, however, is a red-maroon-brown lesion centered around a leaf scar for this disease. As the lesion enlarges, a bulls-eye pattern results. The center of this lesion dries out, turns gray, and the fungus will produce numerous black pynidia (asexual stage) on the stems. The infected twigs may suddenly wilt and die during especially hot and dry periods. This fungus can also overwinter in cranberry or lowbush blueberry stems.

Anthracnose: This disease has increased its incidence in New England during the past ten years. The fungus *Colletotrichum gloeosporioides* causes tremendous losses in New Jersey in certain growing seasons. The pathogen primarily damages fruit but may also infect twigs and leaves if environmental conditions are favorable. Symptoms may initially be observed as blossom blight, but normally symptoms are not seen until the berries mature. The fungus develops within the green ripening berry as a latent pathogen. At maturation, the blossom end of the berry becomes soft and sunken and masses of salmon-colored conidia appear on the fruit exterior. One sporulating infected berry can spread the disease very quickly to other berries in a cluster on the bush or to other berries in post-harvest containers. Losses are most serious when long periods of warm and wet weather occur during bloom and/or just prior to harvest.

Powdery mildew: This disease is more of a problem in lowbush blueberry fields in New England. The disease is uncommon in highbush blueberry, and symptoms normally occur in mid-summer, sometimes after fruit have been harvested. The fungus *Microsphaera vaccinii* grows all over the exterior of the leaves, producing the white powdery appearance on the foliage. In rare instances, the fungus may also be found on the stems and berries. The disease is worst during periods of warm, dry weather when the relative humidity is high, but when there is no free water on the plant surface. In severe infections, defoliation may occur.

Phytophthora root rot: This disease normally occurs in the poorly drained areas of a field where water puddles for an extended period of time. The fungus *Phytophthora cinnamomi* is soil-borne, and infects the fine absorbing roots of the plant. The root systems will have many dead roots that are discolored or black. Above-ground symptoms include stunting, reddening or yellowing of the foliage, poor fruit production and death of the plant in some instances. The fungus overwinters as chlamydospores in the soil or in the infected plant's root system. These spores germinate in the spring and infect the fine rootlets where water is abundant. Water movement within a field can spread the pathogen to other uninfected plants. The fungus is a major pathogen of cranberry plants, and consequently, cranberry beds are an important source of inoculum. Rhododendrons, azaleas and other Ericaceous plants in the landscape can serve as inoculum sources.

Armillaria root rot: This disease is uncommon, usually occurring in fields that were recently pine/oak woods. The fungus *Armillaria mellea* is a Basidiomycete that infects a wide diversity of different plant hosts. The fungus colonizes the roots of many oak and pine species, but usually causes little mortality in these plants. When the trees in these woods are cut and removed, root pieces of these hosts remain in the soil, and this is the inoculum source for this disease. The fungus primarily overwinters as rhizomorphs in these pieces, and hyphae growing from the rhizomorphs infects the blueberry roots. The fungus slowly colonizes the root system and eventually grows to the crown of the plant. The symptoms of the disease are not clear-cut. The vigor of the plant slowly declines over several years, fruiting less each year and the plant shows symptoms very typical of nutrient deficiency. Eventually, canes may die or the entire bush may die, particularly during periods of dry and hot weather. The fungus may produce basidiocarps (mushrooms) at the base of an infected bush. Excavating the roots of the plant will also reveal the rhizomorphs tightly attached to the root system and the base of the crown. The fungus can move to neighboring uninfected bushes via root grafts.

Witches' broom: This disease is more common in lowbush fields, but may occasionally be found on a single highbush plant. Affected plants have broom-like masses of swollen shoots, and no fruit will be produced on the affected canes. There may be several brooms on a single plant. The rust fungus *Pucciniastrum goeppertianum* carries out its life cycle on two hosts, blueberry and several species of fir. Spores produced on fir are spread to blueberry via wind/rain in the summer and infect the leaves and stems. It takes one year after infection for the first appearance of symptoms. Eventually the fungus in the broom will sporulate and these spores will infect fir trees, thus completing the life cycle. Brooms will continue to serve as inoculum sources for several years, if they are not removed.

Scorch: This disease (originally called Sheep Pen Hill Disease) is a serious problem in New Jersey, and was recently diagnosed in fields in Massachusetts and Connecticut. The disease is caused by a carlavirus and vectored by different aphid species. There is a wide array of symptoms produced in infected bushes, the most prominent being a blossom and leaf blight very similar to that produced by *Botrytis*. The necrosis in this phase may occur on one or several canes, and may lead to death of the bush. In some cultivars, the blight may be lacking but the bush may have declining yield and vigor. Later in the season, a distinctive line pattern may be observed in the leaves of certain cultivars. After introduction of the virus, it may take two years for symptoms to be displayed.

Tomato ringspot: This disease was detected in a blueberry field in Massachusetts in 2003, although it is seldom observed in New England. Occurrence and intensity of symptoms of the disease vary according to the cultivar. Infected leaves are cupped and malformed, and smaller in size. Young leaves may be chlorotic and misshapen. Necrotic spots may occur on the leaves or stems. Defoliation may occur, and fruit production may be severely affected due to reduced vigor of the plant. The disease may predispose the plants to winter injury. The causal agent is a nepovirus that is vectored by the dagger nematode *Xiphinema* spp. The disease occurs in 'hot spots' in a field, and spread of the disease is very slow from these areas.

Stunt: The disease regularly occurs in New Jersey, but is infrequently encountered in New England. The primary symptom is a general dwarfing of the bush. Leaves may be cupped downward and smaller in size and chlorosis may occur between the veins. Plants will be excessively branched and foliage will turn brilliant red prematurely in the late summer. The causal agent is a phytoplasma which is vectored by the sharp-nosed leafhopper. The leafhopper can survive on several woody plants outside a blueberry field.

Mulching and Organic Matter - Keeping Your Plants Happy

Kathy Demchak, Penn State University
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While it is important to know what practices work best on your farm for growing blueberries or any other crop, it is also valuable to understand why these practices work. Most important to the subject of this talk is an understanding of the characteristics and growth of blueberry roots, and the conditions that are important in maintaining a healthy blueberry root system.

In nature, blueberry plants, whether highbush or lowbush, are found in soils with a relatively high organic matter content. Highbush blueberries typically grow in bog areas on hillocks, while other species such as lowbush often grow as a forest understory where humus and leaf litter cover a mineral soil. Both highbush and lowbush blueberries are also found on sandy soils covered by a layer of organic matter. Usually (though not always), these sites also have a good supply of moisture.

Roots are often considered less frequently than the above-ground portions of the plant, probably because they are less obvious. However, it is important to remember that the foundation for a healthy blueberry plant lies in a healthy root system, and if the roots aren't growing well, the rest of the plant won't grow well. Blueberry roots are very fine, and grow best wherever they find organic matter. Therefore, they are usually shallow, and can dry out easily. Roots in general grow best at cool soil temperatures, and blueberry roots in particular have been found to grow best at soil temperatures of 54 - 62 degrees F, with grow rate slowed as the soil temperature becomes further from this range. It is then easy to recognize that organic matter is important to blueberry plants for a number of reasons. First, organic matter increases the ability of the soil to hold and retain water, and keep roots, especially shallow ones, from drying out. Surface organic matter, in the form of mulch, insulates the soil and mitigates changes in soil temperature, so extremes are not reached that would slow the growth of the roots. Organic matter also holds nutrients in place, especially nitrogen, and can be a reservoir of other gradually-released nutrients as well. This helps in decreasing leaching of nutrients into water sources. Organic matter also helps to buffer the soil pH, and improves the soil structure.

One basic principle which should be understood, because it determines when nitrogen in organic matter become available, is that of the carbon:nitrogen ratio. As one can guess from the name, this is the amount of carbon in the organic matter as compared to the amount of nitrogen. The two critical number when considering C:N (carbon:nitrogen) ratios are 30:1 and 20:1. Organic matter sources with a C:N ratio greater than 30:1 will tie up nitrogen. If the C:N ratio is less than 20:1, the mulch will be a source of nitrogen for the plants. Mulches with C:N ratios between these two will neither tie up nor release nitrogen. The C:N ratio for any material decreases as it decomposes. C:N ratios for legumes range from 9:1 to 19:1, so they are a nitrogen source for plants. The C:N ratio for peat moss is approximately 45:1. The C:N ratio for various types of straw can be anywhere from 20:1 to 50:1; for aged, dark brown, hardwood sawdust is around 60:1; and for fresh sawdust ranges from 300:1 to 700:1. This is one of the reasons that fresh sawdust should not be applied to plants, and is why additional nitrogen usually needs to be applied when plants are mulched with sawdust, even when it is aged.

So, considering all of this, which practices utilizing organic matter are best for optimizing the growth of blueberry plants?

First, amending the planting hole during planting is valuable. Research studies that have tracked where blueberry roots grow can be summarized quite simply. Generally, the roots tend to grow where the organic matter is found. In plantings where the planting holes have been amended, blueberry roots tend to grow more deeply, but spread out less. Peat moss is the material that has most consistently improved yields in this use. If amending the planting hole with peat, make sure to moisten the peat first! Compost can also be used, but the compost should be analyzed at an analytical lab first to find out the pH, C:N ratio, and levels of nutrients that are being applied with the compost. Some labs that do soil testing also run a compost analysis, but for a higher fee as the analysis is more complete. While sawdust can be used to amend the planting hole, it is more likely to tie up nitrogen and has less consistently shown improvements in yields than peat moss for this use. Addition of nitrogen to the planting hole if sawdust is used is not recommended as a way to circumvent this problem, however, as the fertilizer would be likely to burn the young roots.

Second, yields have almost always been improved by mulching the blueberry plants, though there have been a few exceptions, possibly related to sources of sawdust used. However, it is important to remember that since the roots grow where they find organic matter, (i.e., mulching will tend to make the roots grow more shallowly), organic matter applied as a mulch needs to be consistently replenished at least every two years. With highbush blueberries, 4-6 inches at planting, followed by 1-3 inches per year for replenishment, should be applied to maintain a consistent depth of mulch. Amounts greater than this that would allow the mulch depth to increase should not be used, at the roots will tend to be produced higher on the stem, and eventually the entire root system may be located in primarily in the mulch alone. Mulching, once started, should not be discontinued. Mulch generally is not added to lowbush blueberry plantings, though it has been found to improved establishment of young lowbush plantings if used lightly (2-3 inches at planting).

What sources of mulch are recommended (or not)? Rotted sawdust (not fresh) tends to fare better in improving yields when used as a mulch as opposed to being used for amending the soil in the planting hole. The difference is likely due to less nitrogen tie-up, as growers usually fertilize their plantings with nitrogen (lightly when the plants are young), making the tie-up of nitrogen in the mulch less critical than in the planting hole. Either hardwood or softwood sawdust (or bark mulch) can be used, though red maple and beech have been reported to have negative effects. Depending on location, growers sometimes find sawdust that has been used as a bedding material, usually for horses, is much more readily available than sawdust alone. This used bedding material often has a high nutrient content, and higher salt concentration than what is acceptable. In addition, there are health concerns and regulations to be considered concerning the use of animal manures. However, this material has been used successfully, if it is allowed to decompose for at least a year (away from the blueberry plants), exposed to rain so that salts can be leached out. The pH level should be checked, and the material also should be analyzed for nutrients so that the maximum amount that should be applied per year can be calculated. This may be less than the recommended 1-3 inches/year. Fertilizer rates can be adjusted downward to compensate for its use. Fresh sawdust should not be used, as the danger of nitrogen deficiency and leaching of toxic compounds from fresh sawdust, depending on the species of tree, is too great to be worth the risk. Mushroom compost, widely marketed in PA and surrounding states, is not recommended, as it has a high pH (often 8.0 or greater), and a high salt concentration, of which blueberries are intolerant. Other types of composts, or a mixture of compost with rotted sawdust, have been found to work well. If compost is used, the compost should be analyzed, and fertilizer application rates adjusted downward to compensate for the nutrients applied in the compost, as with bedding materials. Compost should be applied as early in the spring as possible, and not in the fall, as it may encourage succulent growth on the plants, thereby increasing the occurrence of winter injury. Peat, though acceptable, is expensive, tends to dry out on the surface, and is difficult to re-wet, so it is not often used for this purpose. Straw can be used, and is perfectly acceptable from the plants' point of view, but tends to decompose rapidly. Other locally-available sources such as ground corn cobs, pine needles, or leaves can be used, but little is known about their particular characteristics.

Trickle irrigation lines should be located underneath the mulch (especially if peat or sawdust are used), and of a sufficiently heavy type to avoid problems from rodents chewing through the lines. Use of any mulch can increase the local population of small rodents.

If possible, the pH of the organic matter used should be checked before application. If the pH of the organic matter is high (>6.0 or so), either another source should be found if possible, or, if the material is used, the soil pH should be monitored yearly. Using ammonium sulfate as a nitrogen source will usually compensate for application of a mulch with a higher-than-ideal pH. A foliar nutrient analysis should also be conducted at least every other year, a good practice in general, to monitor potential nutrient deficiencies or excesses.

The Way We Grow Bean for The Farm Stand;
Harvesting by Machine

Paul Gove, Gove Farm, Leominster, Mass.

Site Selection:
Dry land- we can always irrigate, but wet sites create problems
Less fertility- we try to stay away from land that was heavily manured the previous year

Soil Preparation:
Plow, harrow, fertilize very lightly if necessary
Preplant incorporate herbicide using chain link drag

Planting:
Spacing: ideally 2” apart in 36” rows
Timing: usually 3 to 5 days between batches, when the plants are just emerging, seed again

Growing:
Cultivate, side dress very lightly in wet years
walk the rows once for large weeds
spray, usually for leafhoppers

Mechanical Harvest:
Pixall Pullpix one row harvester
Operates best when plants are dry, early afternoon is optimal
Use slowest gear on the tractor
Depth control critical, especially on early, shorter plants
Picks about one bushel per minute

Grading and Sorting:
Vibratory sorting table- removes short and broken beans
White belt grading table- to manually remove defective beans

Comments:
We wouldn’t grow beans if we couldn’t pick by machine, due to the labor commitment at harvest.

Insect Pests of Beans & Peas in New England

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My comments here are heavily influenced by my experiences in New Hampshire, but I've included information from southern New England as well. To me, the main message is that insect problems aren't common here on beans and peas. I have listed them in order of significance:

Potato leafhopper is a sporadic pest. It doesn't overwinter in New England. It re-invades New England every summer, by being blown in from the south. We usually find our first ones (adults of course) in June, sometimes July. They are yellow-green in color, and quickly fly when disturbed. In most situations, any yellow-green leafhopper you find on beans in summer is probably this one. You can confirm identification by the fact that the leafhoppers have a series of white lines on and just behind the top of the head. You'll need slight magnification to see this. This insect has piercing-sucking mouthparts, and it injects toxic saliva when it feeds. Leaves that have been attacked quickly turn yellow at the edges. The yellow spreads and eventually the leaf edges die.

In some years this is a problem, but others it is a no-show in New Hampshire. I've never seen damage on peas, but I have on bean, cantaloupe, potato, eggplant, alfalfa, basil, raspberry, apple, and dahlia. If they number more than one per leaflet on bean (yes, you should count), it may be helpful to apply an insecticide. The New England Vegetable Pest Management Guide lists insecticides. The most important area to hit is the UNDERSIDES of the leaves.

Seed corn maggot is a sporadic pest problem. It is worst in cool, wet springs, on soils with heavy application of manure. The flies lay eggs in early spring, and the maggots tunnel into the seeds of bean, peas, corn and squash (occasionally others). If soil temperatures are warm, the plants quickly emerge and have little damage. If temperatures are cool, the maggots beat the plants and kill many germinating seeds. The best defense is to select soils that warm up early for early planted crops, and avoid heavy application of manure on fields for early planting. If you could control the weather, that would help.

Corn earworm Earworm can be a pest of beans when earworm moths are abundant, and there are young fruit. The larvae feed on the fruit, not the leaves. They can also hit soybean and tomato. This is an occasional problem in late July or August. Except in highly unusual situations where the soil doesn't freeze, earworms don't survive New England winters. They re-invade from the south, at times that are difficult to predict. There are traps that will help you tell if they are a problem on your farm. I can't find published thresholds for New England states, but south of us, typical thresholds are 20 to30 earworm moths per night in a plastic mesh corn earworm trap. **Fall armyworm** also sometimes damages beans, when populations are high. It feeds on foliage as well as the fruit.

Mexican bean beetle is a significant pest farther south, but here it is mainly a backyard problem. It is uncommon, and many growers don't recognize it when I show specimens. The insects overwinter as adults, protected by leaf litter or similar debris. They might appear in your beans as early as June. (No, not on peas.) Adults are yellow to coppery brown, with 16 black spots on their backs. They are members of the ladybug family. The soft-bodied yellow spiny larvae are distinctive, and they skeletonize the leaves, just as the adults do. Rotation helps keep them under control. If defoliation exceeds 10% during podding (or 20% pre bloom), you might consider applying a pesticide. Really look at the leaves — 20% loss of leaf area is a lot, but that really is the suggested threshold here. The plants can often withstand more injury than the farmers.

Aphids seem to be listed in lots of pesticide guides, but I don't really see them as problems here on peas and beans. If you are too "trigger happy" with pesticides, you can create aphid problems, by killing off the aphid predators and parasites.

Others Asiatic garden beetle larvae have been seen attacking peas (roots) in CT and VT. They are typical white grubs; soft bodied, C-shaped whitish larvae with obvious legs. Adults of this insect feed on the foliage (of many things) at night. Larvae of gray hairstreak butterfly sometimes damage peas. The velvety, green caterpillars chew leaves and bore into the fruit. They are more of a curiosity than a problem. Green cloverworm also feeds on foliage of bean and pea. The caterpillars are abundant in soybean fields in the south, but I've never seen them here on bean or pea. Springtails were a problem for some southern New England bean growers this year (2003). With so much rain in June, springtail numbers were really high, especially on silty soils. European corn borer sometimes bores through stems and fruit of bean. This seems more likely the farther south you travel. Twospotted spider mites occasionally cause problems on beans, but I have seen this only in a greenhouse situation. Tarnished plant bug is listed in the New England Vegetable Pest Management Guide, but I have never seen a problem from TPB on beans or peas. Apparently problems are most likely on lima bean. Buds and young, developing fruit are most likely targets. Nymphs do more injury than adults.

Pesticides:

Please rely on the current New England Vegetable Management Guide. Old versions are outdated! As I write this, the new (2004-5) version is not available, but it should be by the time you read this in the meeting proceedings. Since pesticide labels are constantly being changed, amended or withdrawn, your pest management specialists from Cooperative Extension will help keep you apprized of updates and changes. You can look at most agricultural pesticide labels online at the crop data management system website http://www.cdms.net A few pesticide companies do not belong to the sponsoring group, so their products are missing. If you look at labels online, remember that there can be more than one current label (with different pests) for a particular formulation of pesticide, so you may need to check several before finding what you wanted to know. Sometimes this happens because products with the same active ingredient were developed by rival companies, but are now owned by the same company.

Beans and peas are not mega-bucks commodities in the US, so there are fewer pesticides registered for these crops, compared to cotton, corn, citrus and apples. Some recent additions and/or expansions of info in the 2002-3 New England Vegetable Management Guide are:

Organic growers: Surround is listed to **suppress** leafhopper and Mexican bean beetle numbers. Even coverage is essential with surround. Entrust (OMRI certified) has the same active ingredient as Spintor. It is listed for European corn borer, corn earworm, and armyworms (Yes, I'd interpret that to include fall armyworm). There are several formulations of *Bacillus thuringiensis* that have very broadly worded labels that include peas and beans. Dipel and Deliver are just two examples. You'll see earworm, European corn borer, and possibly fall armyworm listed, among other caterpillars. In my experience, earworm is one of the tougher ones to kill with *Bt* products.

Non-organic products: Baythroid 2E is listed for some insects on **dry** peas. (Anyone grow those?) Mustang 1.5E is registered for beans and peas. Target pests include aphids, European corn borer, corn earworm, and Mexican bean beetle. Provado 1.6F is listed on both beans and peas, for leafhoppers and aphids. Spintor 2SC is listed on beans and peas for the same insects as Entrust (ECB, CEW, armyworms). Warrior w/Zeon technology is listed for both beans and peas. Pests listed on the label include aphids, corn earworm, fall armyworm, European corn borer, green cloverworm, Mexican bean beetle and leafhoppers.

There are many insect growth regulators on the market, and sooner or later some will be registered for insects of beans and peas. Remember that they are effective on the immature stages only, so if adults are causing your problem, IGR's won't be good alternatives.

I hope this review is helpful. Beans and peas aren't very heavily hit by insects in New England, so don't go overboard with spraying (or scouting!).

Alan Eaton October 2003

Orchard Soils and Their Influence on Apple Root Systems

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Apples have root systems that inhabit the soil profile with relative permanence. The fact that roots develop at the mercy of underground conditions means that soil characteristics have a major impact on development, survival and orchard performance. In the Great Lakes, soils are extremely variable due to the nature of how they were formed through glacial retreat. Soils in New England were formed as a result of Glacial action (Wisconsinan advance in all of NE) which deposited unsorted materials within and under glacial ice. The material ends up being a heterogeneous mixture of particle sizes from rocks to clay. Basal tills left by glacial retreat formed drumlins and moraines which characteristically have dense restrictive layers which inhibits water movement and root penetration. These hard pans can occur on a hill (drumlin or moraine) which perches water and floods root systems. Glacial outwash (melt water) left behind plains and deltas with stratified layers of sand and other materials. Following glacial retreat, Elolian sands were spread across the surface for some areas in New England (Northern Michigan also). Therefore, some sites have a surface layer of mineral sand in the top 1.5 – 3 feet. When it comes to orchard sites, those which possess elevation changes and slope are not only helpful in cold air drainage, they often can be beneficial to relieve soil drainage. The exception would be in drumlins and moraines where a hard pan perches water on slope.

What is a desirable orchard soil? Basically, historical research has indicated that in general, fruit tree root systems need about 3 feet or 1 meter of cultivatable well drained soil to support good consistent crops and be long-lived. Tree roots prefer loamy soils with good Cation Exchange Capacity to retain nutrients and good moisture holding capacity. Soils with coarse texture (sandy soils) may provide excellent internal drainage, but often are poor in water and nutrient holding capacities. We often see apples on dwarfing rootstocks which struggle in such soils and rarely fill their spacing in Michigan. The other extreme in soil conditions for apple root systems is where the soil has fine texture (heavy clay) which causes problems related to poor aeration and conditions that foster Phytophthora root rotting. Plant roots absorb oxygen and release carbon dioxide.

Most terrestrial plants can not transfer oxygen from the above ground to the below ground portions of the plant. Therefore, adequate root respiration requires the soil to be aerated. Gas composition in soil will be similar to air if well aerated. Respiration by plants and microbes can increase the amount of carbon dioxide by 10 to 100 times if aeration is poor. Under saturated conditions, oxygen content of soil can approach zero. Plant growth depends more upon the occurrence and duration of periods of oxygen deficiency than upon average conditions. Anaerobiosis (wet feet), caused by oxygen stress, occurs when the rate of supply is less than demand. The detrimental effects are lessened in winter, very early spring and late fall when trees are less active or have less leaf area. Once a tree is actively growing during the season, it is very vulnerable to stresses caused by wet feet or drought.

Soils which are shallow, caused by a hard pan in the B horizon, can force roots to develop near the surface where soils dry readily during the summer. Many or most of the dwarfing rootstocks that have limited root systems such as M.9 to M.26, which do not handle soil stresses as well as more vigorous rootstocks. More vigorous stocks should be selected where soils are inherently more sandy or where soils are shallow.

Methods to Alleviate and Improve Soil Structure in Orchards

We prefer to select a good site which has a desirable orchard soil with adequate depth. If the soil is heavy or wet, then seek methods to alleviate problems. These include subsoiling and mixing, moldboard plowing (effective down to 1-1.5 ft deep). The objective is to provide good mixing of A and part of B horizon. The effects on rooting are long lasting. Deep plowing or mixing using slip plows is possible at a cost of $500 or more per acre. Installation of a tile drain system can provide relief for heavy wet soils, but only if designed correctly. Raised beds is another effective method, but requires much earth moving. This technique has a long history practiced by the Romans.
Our experience is fairly positive but we found that single row beds dry too fast and are less effective than wide beds. There are over 750,000 Acres citrus on beds in FL. We evaluated this technique for cherry, peach and apples from 1981-1990. Peach and Sour Cherry trees had improved productivity and survival after 10 yrs on medium size, wide bed (30 cm high, 2 m wide). Apples on MM 106, were not affected by bed treatments.

Soil Preparation and Management for Planting an Orchard

In preparation to establish a site the following spring, subsoil when dry, during the previous summer. If mechanical planters are used for apple, plant so that the union is set at a minimum of 4 - 6 inches above ground line. If holes are prepared using an auger, set the tree so that the union is at a minimum of 6-8 inches above ground line. Expect more settling following planting with augered holes. Do not fertilize until mid summer. Roots can and should be pruned back to fit a hole / furrow. Keep root systems moist and back fill with soil to remove air pockets. For apples on dwarfing clonal rootstocks, if you must error in depth, make it on the side of shallow planting and not deep plant. Scion rooting, common in apples (not in stone fruit), can mean disaster later, resulting in extreme vigor for the spacing. Use a 2"X4" (2-4 ft long) piece of wood to help as a reference. Place the 2X4 on its edge adjacent to the planted tree (perpendicular to the row) to check its depth. The union should clearly appear above the edge of the board indicating that it is at least 4" high. A 2X6" board may serve best for where the desired union height is for 6 ".
The same 2X4 or 6 can be used for union height reference for stone fruit if the board is placed on its flat side so that the union height appears 1-2 " above ground level.

To suppress the impact and population of Dogwood Borers, we have been recommending to growers to form a berm of soil above the union during the first 2-3 growing seasons. Once burr knots, commonly formed on dwarfing rootstocks, have extended into the soil (berm), larval infestation is largely avoided.

Research on Plum Curculio & Apple Maggot: Latest Developments

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This presentation will cover findings from our experiments in commercial apple orchards in 2003 on use of odor-baited "trap trees" for monitoring plum curculios and use of odor-baited pesticide-treated spheres for directly controlling apple maggot flies.

Plum curculio (PC).

PC adults overwinter in border areas adjacent to orchards. They immigrate into orchards during April, May, and June. Over the past decade, we have developed and evaluated several kinds of odor-baited traps aimed at capturing immigrating PC adults and correlating rises and falls in adult captures with rises and falls in injury to fruit. None of the traps has proved useful for this purpose. Therefore, in 2003 we bypassed use of traps and instead decided to bait perimeter-row apple trees themselves with attractive odor. Such odor-baited "trap trees" could aggregate incoming PC adults and thereby aggregate injury to fruit. To assess the occurrence of fresh injury in an orchard as a trigger for insecticide application, a grower or consultant could restrict fruit sampling solely to trap trees, saving time and enhancing accuracy.

In 2003, we conducted trap tree experiments in more than 80 blocks of apple trees in Massachusetts, Vermont and New Hampshire. Trap trees were baited with our most powerful odor combination: the synthetic fruit volatile benzaldehyde (BEN) and the synthetic pheromone grandisoic acid (GA). We found the following:

GA released at 1mg per day plus BEN released at 40 mg per day performed as well as or better than trap trees baited with greater or lesser amounts of these attractants in combination. The distance over which a trap tree baited with such odor was effective in aggregating damage to fruit extended to at least 31-33 meters (maximum evaluated) along a perimeter row. Trap trees at corners of orchard blocks were as effective as perimeter-row trap trees midway between corner trees. Within the canopy of a trap tree, damage to fruit did not tend to be localized in the vicinity of the odor source but tended to be rather evenly distributed among various sectors of the canopy. Finally, among three candidate thresholds evaluated as a trigger for insecticide application, a threshold of 1 freshly-injured fruit proved better than thresholds of 2 or 4 freshly-injured fruit out of 50 fruit sampled on a trap tree in assuring that orchard-wide damage would remain below a pre-set economic injury level of 1%. Our findings lead us to suggest that after a whole-orchard application of insecticide to apple trees shortly after petal fall, subsequent applications of insecticide against PC can be confined to peripheral-row trees and be driven by a provisional threshold of 1 freshly injured fruit out of 50 fruit sampled on a perimeter-row trap tree baited with above odor.

Apple Maggot Flies (AMF)

AMF build into large numbers on abandoned apple trees outside of commercial orchards. They immigrate into orchards during July and August. Very few originate within commercial orchards.

AMF can be controlled very effectively using organophosphate insecticides, whose long-term future use under FQPA remains uncertain. For over a decade we have been evaluating an alternative that we have developed as a substitute for whole-orchard spraying of insecticide to control AMF. It involves placement of odor-baited red spheres on perimeter-row apple trees to intercept immigrating AMF before they lay eggs in apples. In 2003, we conducted 2 experiments in 18 commercial apple orchard blocks in Massachusetts aimed at improving the effectiveness and simplicity of using traps for AMF control.

In our first experiment, we surrounded 1-acre blocks of apple trees with sticky-coated red spheres baited with a 5-component blend of attractive odor. The spheres were placed different distances apart on perimeter-row apple trees. Distances between traps were pre-programmed to vary from 5 to 15 meters apart according to the architecture of the orchard. Orchard blocks having small trees (M.9 rootstock), well pruned trees, AMF-tolerant front-row cultivars (e.g., McIntosh) and open terrain or sprayed apple trees as bordering area received traps 15 m apart (equivalent to 55 traps per 10-acre block). Orchard blocks having large trees (e.g., M.7 rootstock), trees in need of pruning, AMF-susceptible front-row cultivars (e.g., Gala) and hedgerow or woods as bordering area received traps 5 m apart (equivalent to 160 traps per 10-acre block). Orchard blocks having intermediate characteristics received traps 10 m apart. Results showed that adjusting distance between traps according to orchard architecture gave excellent AMF control (equivalent to 3 organophosphate sprays) in 8 of the 12 experimental blocks. Control using traps was less effective in 4 of the blocks, all characterized by large trees and less than ideal pruning.

In our second experiment, we compared sticky (tangletrap) on the sphere surface as AMF killing agent with 2 kinds of plastic spheres that received pesticide as killing agent plus feeding stimulant to induce AMF to ingest pesticide. In each of 6 commercial orchards, we surrounded _-acre blocks of apple trees with above-type spheres. Results showed that plastic spheres capped with a 200-gram rodent-proof disc containing sugar (feeding stimulant), paraffin wax (to meter out the sugar) and Entrust (= Spinosad) as toxicant gave AMF control equal to that of plastic spheres coated with latex paint containing Provado (= Imidacloprid) as toxicant and capped by sugar-paraffin discs. Control by each type of sphere was equal to that provided by sticky spheres or 3 organophosphate sprays. AMF that alight on pesticide-treated spheres feed on the sugar that drips down from the sugar-paraffin disc atop the sphere and in so doing ingest pesticide.

Together, results from these 2 experiments suggest that effective AMF control can be obtained by placement of pesticide-treated odor-baited spheres on perimeter-row apple trees at distances prescribed by orchard architecture. Pesticide-treated spheres should be available for sale by a West Virginia company along with EPA-approved use for commercial orchards by the 2005 growing season.

Recent Developments in Apple Disease Control

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In this presentation, I will review our current thinking in New York State concerning the best approaches for controlling the major diseases of apples. The material that I am presenting is derived from the work of many colleagues at Cornell and at other institutions, but I am especially indebted to Dr. Wolfram Koeller (Cornell-Geneva) and his students who have generated most of the available information on fungicide resistance to apple scab.

Apple Scab Fungicides: Don't Depend on Post-Infection Activity!

Resistance to SI fungicides (Rubigan, Nova, Procure) is now fairly common in apple scab populations in New York State. The fruit entomologists in NY completed a detailed study of pest damage on apple fruit from 15 orchards across the state in fall of 2002. Much to our surprise, four of those orchards had high incidences of fruit scab with 8% to 50% of fruit affected. Subsequent testing by Dr. Koeller showed that three of the four problem orchards had scab populations that were resistant to the SI fungicides. I have noted similar SI-related scab control failures in several other orchards in eastern NY during the past two years. In most cases, failures are occurring where growers have consistently used 3-5 applications of SI-fungicides per year for 10-12 years.

Now for the bad news: resistance to SI fungicides appears to be linked to loss of activity in several other fungicide classes. Dr. Koeller has found that when apple scab becomes resistant to SI fungicides, it also loses some sensitivity to the anilinopyrimidine and strobilurin fungicide groups. The anilinopyrimidines include Vangard and the not-yet-registered Scala. Sovran and Flint are strobilurin fungicides. In orchards with SI resistance, Sovran and Flint continue to work as protectants, but their post-infection activity is compromised. Resistance to the protectant activity of Sovran and Flint is likely to develop in the future as it already has in Europe, but resistance to the protectant activity of Sovran and Flint has not yet been detected in the U.S. Resistance to benzimidazole fungicides (Benlate, Topsin M) and to dodine (Cyprex, Syllit) has been widespread in NY orchards for many years. There are no new fungicides in university trials that can be used to replace the SIs. Thus, when an orchard develops SI-resistance, the grower will probably be left for the foreseeable future with only fungicides that have no post-infection activity.

Dodine resistance and SI resistance can lurk undetected in some orchards for many years. If dodine is used only at green-tip and/or half-inch green, loss of activity will not be noticed until a year in which that activity is really needed. In many years, there are no significant infections prior to tight cluster. Or the levels of inoculum in the orchard may be so low that no sprays are really needed prior to tight cluster (e.g., as predicted for orchards with a very low predicted ascospore dose or PAD). Similarly, the contact fungicides that are routinely tank mixed with the SI fungicides may mask the fact that the SI fungicides are no longer working until a really bad scab year over-whelms the low rate of the contact fungicide that is included in the combination.

How can growers know which products are still effective in specific orchards? The best solution would be to test scab samples from individual orchards to determine which fungicides are still working. However, no simple test is available. As a result, it is currently impossible to tell whether or not dodine, the SI fungicides, or the strobilurin fungicides will provide post-infection activity in any given orchard.

Scab has never developed resistance to copper, captan, mancozeb, or metiram (Polyram). Therefore, these products remain effective in all orchards if applied as protectants. They will also arrest developing infections if applied within 12 hours from the start of a warm wetting period (>60 °F), within 18 hr at 53 °F., or within up to 40-48 hr from the start of infection periods with mean temperatures below 43 °F.

Current Recommendations for Controlling Apple Scab

1. Forget most of what you learned about scab control over the past 20 years and revert to conservative, protectant fungicide programs during the prebloom period. Even in orchards where SI-resistance seems unlikely, a conservative program is the best way to further delay resistance, thereby preserving the post-infection activity (read: emergency activity) that the SIs can provide. In orchards with resistance to dodine and the SI fungicides, just a little bit of prebloom scab can turn into a season-long management nightmare if the summer is cool and wet, so do everything possible to avoid further selection of isolates resistant to these fungicides.

2. Start protectant fungicide programs at green-tip unless a PAD assessment in the fall verifies that the start of the spray program can be delayed. The concept of delaying sprays in low-inoculum orchards was developed and tested using only protectant fungicides, so this program should still work in orchards with dodine and SI resistance. However, even when the PAD is low, the delayed spray program is riskier in orchards with dodine and SI resistance. Without an effective post-infection fungicide, the PAD/delayed spray system has no built-in redundancy to cover any errors in calculating PAD or to eliminate the occasional lesion that might arise as a result of inoculum blown in from external sources.

3. The protectant fungicide program should start with a copper spray at green-tip. Copper fungicides are just as effective as mancozeb for controlling scab. Copper applied at green-tip may help to suppress superficial cankers caused by *Botryosphaeria* species (black rot, white rot) that sometimes develop on trunks and scaffolds in older orchards that have been consistently sprayed with only mancozeb and SI fungicides during the scab season.

4. Protectant fungicides should be renewed at roughly 7-day intervals or just prior to predicted rains if intervals are greater than 7 days. Forget about the routine 10-12 day spray intervals that were promoted with SI fungicides.

5. In orchards containing large trees or high levels of carry-over inoculum, tank mixed combinations of mancozeb (3 lb/A of formulated product) plus captan have proven more effective than mancozeb applied alone. In this combination, captan can be used at the rate of 1.5 to 3 lb/A of Captan 50W, or an equivalent rate of a different captan formulation. Of course, captan cannot be included near oil sprays whether used alone or in combinations.

6. The anilinopyrimidine fungicides are not recommended for scab control. Vangard has rarely performed better than mancozeb used alone at 3 lb/A. Given our inability to predict where SI resistance may be lurking, and given the apparent linkage between SI resistance and resistance to the anilinopyrimidines, we see no reason to use this class of chemistry on apples.

Controlling Powdery Mildew

SI fungicides are less effective against apple powdery mildew today than when this chemistry was first introduced, but the SI fungicides are still provide good mildew control in most orchards when applied at appropriate rates and timings. Bayleton provided good control of mildew at rates as low as 1.5 oz/A when it was first introduced many years ago, but today most growers need at least 3-4 oz/A to achieve the same levels of control. Nova applied at rates recommended for scab control still provides excellent mildew control in most orchards. Sovran and Flint are also effective mildewcides, especially if control programs are initiated at pink or bloom. Sovran and Flint are somewhat less effective if control programs are not initiated until petal fall.

The absolutely critical sprays for controlling powdery mildew are the petal fall and first cover sprays. In years when the prebloom and bloom periods are warm and humid (but without significant rainfall to wash away mildew spores), a pink or bloom spray may also be essential.

Never leave mildew-susceptible cultivars unprotected at petal fall. Applying the first mildewcide spray at first or second cover (or when extensive secondary infections are already evident) should be classified as "revenge spraying." Such delayed sprays seldom provide acceptable mildew control, but they do provide strong selection pressure for development of fungicide resistance within the large mildew population that is usually present within several weeks after petal fall.

Controlling Fire Blight

Anyone growing pears or blight-susceptible apple cultivars should be using either MaryBlyt or Cougar Blight to predict when fire blight blossom infections are likely to occur. These models are very helpful for proper timing of streptomycin sprays during bloom. Fire blight outbreaks in Quebec in 2002 and in New York's Champlain Valley in 2003 are reminders that fire blight can destroy orchards even in colder climates where this disease is occurs only sporadically.

Honeycrisp is very susceptible to fire blight. As with other blight susceptible cultivars, the greatest losses are likely to result from blossom blight control failures in orchards that are 3 to 6-years old. In such immature orchards, blight frequently spreads to the rootstock and kills entire trees. McIntosh growers who are switching to Honeycrisp should be aware that fire blight poses a much greater risk to Honeycrisp than it did to McIntosh. Thus, streptomycin sprays may be warranted for Honeycrisp in geographic regions where fire blight was never considered a serious threat in the past.

Controlling Flyspeck and Sooty Blotch

Ascospores of the flyspeck fungus are released during or soon after the petal fall stage on apples. However, this primary inoculum is probably more important in non-orchard hosts than in sprayed orchards where the apple scab fungicides prevent infection. The flyspeck fungus can grow on numerous wild hosts in woods and hedgerows. Primary infections on the non-orchard hosts produce conidia later during summer, and the conidia cause most of the infections on apple fruit.

Brown and Sutton, working in North Carolina, determined that after flyspeck spores land on apples, 270 hours of wetting are required before those infections become visible on the fruit surface. Observations of flyspeck development on unsprayed trees at the Hudson Valley lab suggest that most flyspeck infections on apple fruit are initiated only after at least 270 hr of accumulated wetting have occurred after petal fall. This corresponds with the time that would be required for primary infections on wild hosts to mature and begin releasing conidia. Flyspeck is more severe in wet years when conidia become available earlier in the season because wet years allow more time for apples to become infected and also the potential for more secondary cycles to be completed.

More than four inches of rain was recorded for 1-2 September 2003 at the Hudson Valley Lab. Growers who opted not to re-apply a fungicide after that rain reported a flush of flyspeck symptoms appeared on fruit at the end of September. A total of 275 hr of wetting was recorded during September. This series of events provided indirect verification that 270 hr of wetting are required for symptom development of flyspeck: The rain on 1-2 September eliminated all fungicide residues and initiated infections. Flyspeck became evident in numerous orchards almost exactly after 270 additional hours of accumulated wetting. In most years, fungicide sprays are not necessary after mid-August. However, in 2003, a September spray was essential for preventing flyspeck in varieties harvested in October.

Topsin M, Sovran, and Flint are all very effective for controlling flyspeck. All three of these fungicides provide some post-infection activity and may control infections that have accumulated less than 100 of the 270 total hours of wetting required for symptom development.

The major limiting factor for controlling flyspeck during August is probably poor spray coverage. Getting complete spray coverage can be almost impossible in poorly pruned trees or where fruit are clustered. In orchards with dense canopies, summer pruning that reduces canopy density and hand thinning to break up fruit clusters may be essential for achieving flyspeck control in a wet year.

Controlling Summer Rots on Honeycrisp

Honeycrisp is more susceptible than most other cultivars to summer fruit rots caused by *Botryosphaeria obtusa* (black rot), *B. dothidea* (white rot), and *Colletotrichum* species (bitter rot). Bitter rot is primarily a problem in regions with hot humid weather during August, and such climates are less than ideal for producing Honeycrisp. However, black rot and white rot are likely to occur to some degree anywhere that Honeycrisp is grown. This cultivar tends to retain fruitlets that are killed by thinning sprays, and these small fruitlet mummies harbor the fungi that later produce spores to infect maturing fruit during August.

Topsin M, Sovran, and Flint are all effective for controlling black rot and white rot. A combination of Topsin M plus captan applied approximately 28 and 14 days before harvest may be needed to control fruit rot diseases on Honeycrisp, especially if the preharvest period is especially warm. Flint can be applied on a similar preharvest schedule, but Sovran has a 30-day preharvest interval and therefore is not useful for late summer sprays on Honeycrisp.

Managing Insect Pests in New England Orchards
Yellow Mites, Green Pug Moth, and Rose Leafhopper

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Yellow Spider Mites

I've noticed several orchards in Rhode Island with pest spider mites that look like two spotted spider mites, but don't have spots. These mites are in fact a different species: yellow spider mites, *Eotetranychus carpini borealis*. The reason you should care about which species of spider mite you have is that the timing of the life cycle is different for TSSM and yellow mites. Both mites overwinter as adult females, but TSSM overwinter in the ground cover and yellow mites probably overwinter right on apple trees. So where we don't usually see TSSM until well into the summer, we can find yellow mites on apple leaves in the end of April or early May. I've seen large populations of yellow mites in early June.

Yellow mites cause the same kind of damage as TSSM. Spider mites feed on plants by piercing the leaf tissue with their mouthparts and sucking out cell contents. Injured leaves have lower rates of photosynthesis, increased transpiration, and lower chlorophyll contents. The injury causes mottling of the leaves and if the damage is severe enough, the leaves turn brown. The mites usually feed on the underside of leaves, near the main leaf vein, so damage is usually first seen along the mid-vein.

Yellow mites are a pest in the Pacific Northwest. There the mites attack many tree fruits including apples, peaches, nectarines, and pears. In the Pacific Northwest, yellow mites also attack raspberries; TSSM and yellow mites are the two most important mite species that attack raspberries. Yellow mites were reported for the first time feeding on raspberry leaves in 1992 in Washington state. So in only a few years, yellow spider mites have become a common problem in the Northwest.

Yellow mites have been found on apples in Rhode Island, Connecticut, and southern Quebec. Other researchers in New England and New York have not reported finding yellow mites, but it seems likely that they either could be there, or could be there soon. I have not found them on raspberries in Rhode Island, but I have looked in only a couple of raspberry plantings.

Predator mites that typically feed on TSSM and European red mites also feed on yellow mites. Speaking of predator mites, don't confuse yellow mites with *Zetzellia mali*, the predator mite. *Zetzellia mali* nymphs are bright yellow and the adults are yellowy-orange. The pest yellow mites are very pale.

Yellow mites seem fairly easy to control with miticides. I've seen yellow mite populations controlled with Acramite or Apollo as well as with Vendex mixed Tactic. In the Pacific Northwest they recommend using Agri-Mek, Acramite, Pyramite, Apollo, Savey, Kelthane, or Vendex, against yellow mites or TSSM on tree fruit.

Green Pug Moth

You have probably heard of green pug moth before, but since it is still a relatively new pest I want to review it. Green pug moth, *Chloroclystis rectangulata,* is a small moth native to Europe and Asia. It was first detected in North America in Nova Scotia in 1970. Since then it has spread throughout New England, New York and New Jersey. It was found in Maine in the early 1980's and spread to Connecticut by 1997. I found it in Rhode Island in 1998. It also occurs in the Pacific Northwest.

For a new pest, this isn't such a bad one. Even though the caterpillars feed directly on apple and pear buds and flowers, the feeding causes the flowers to abort rather than deform the fruit. The only economic damage that could be caused by green pug moth is if the insect is present in very high numbers and aborts too many flowers. I must admit that I've seen what I thought was a scary amount of damage during bloom, but it really didn't amount to too much loss in fruit set. Consider all the fruit you usually want to thin.

The green pug has one generation per year. The insect overwinters as eggs on the bark of twigs of apples and pears and at least 30 species of trees. The eggs hatch in April and the pale, green caterpillars feed upon buds, flowers, and developing leaves. The caterpillars bind flower parts or leaves together with silk to make a shelter. The caterpillars complete their growth by petal fall, at which time most large caterpillars have a burgundy stripe down their backs. The caterpillars grow up to 3/8-1/2 inch in length. Caterpillars pupate under loose bark of trees or in soil under trees. Two to three weeks later, small gray moths emerge and lay eggs for overwintering. The moths don't look very green and are not easily. I have seen green pug moths in only one orchard, though I've found larval damage in nearly every orchard I've scouted.

The caterpillars move in inchworm fashion and make small holes in developing flower clusters. During the pink bud stage, you may see small holes on petals and when you pull open the petals you find chewed up flower parts. A green pug moth caterpillar has eaten away at the anthers and pistol of the flower, sometimes completely hollowing out the flower. One caterpillar can damage several flowers. Often, when the culprit is actually found, it is inside the developing bud feeding on the anthers, well protected by the closed flower petals.

Nova Scotia fruit researchers recommend applying an organophosphate insecticide at tight cluster to early pink if you're finding six or more green pug moth larvae per 100 fruit clusters.

Leafhoppers

I think everyone knows that we deal with two species of leafhopper that look nearly identical, white apple leafhopper, *Typhlocyba pomaria*, and rose leafhopper, *Edwardsiana rosae*. It seems as though we always had white apple leafhoppers attacking apple trees, but then rose leafhopper started becoming a problem as well. In Rhode Island, it was 1992 when we decided something was different about the leafhoppers we were finding in orchards. I believe other New England states started noting a difference about the same year. It's difficult to say why rose leafhoppers started causing problems in orchards recently. Rose leafhoppers could have always been there, but in low numbers. It could be that there is more multiflora rose on more abandoned pastures now which has allowed more rose leafhoppers to develop. It doesn't appear to be a newly introduced species because rose leafhopper was found to be a pest of Northeast apple in the early 1900's.

I want to review these species because I think confusion still exists and it's important to understand the differences in the two species so that proper decisions can be made. Both species cause the same type of damage, stippling or chlorosis of leaves, and the spotting of fruit by the excrement of nymphs and adults. Nymphs feed more than adults and cause more damge. Another problem with leafhoppers, and perhaps the most significant, is that adult leafhoppers are a nuisance to apple pickers.

White apple leafhopper overwinters as eggs just beneath the bark on 1-5 year old wood. Hatching begins around late pink and is completed by petal fall. The pale, white nymphs feed on undersides of leaves and cause the typical stippling damage. The nymphs develop into adults by mid June and lay eggs for the second generation. The second generation eggs do not hatch until mid to late August; the nymphs develop into adults just in time for harvest and lay overwintering eggs.

Rose leafhopper overwinter as eggs on roses, primarily multiflora rose. Eggs hatch in early spring, nymphs develop into adults and then migrate to apples as well as other plants such as pear, peach, hawthorn, and raspberry. The migration takes place in early to mid June, so that the rose leafhoppers are arriving in orchards at about the same time as white apple leafhoppers are maturing into adults. Rose leafhoppers do not pause between generations as white apple leafhoppers do. The adults lay eggs that quickly hatch to start the next generation. There is a third generation that develops into adults just in time for harvest. These adults migrate back to roses to lay overwintering eggs.

You've probably heard that you can tell the difference between the two species when nymphs are mid to large size. The rose leafhopper nymphs have rows of small, dark spots on their backs. You need a hand lens to see the spots.

You might say 'so what, what does it matter which species I have?' I think it's helpful to know which species you have so you know what to expect in your orchard and make more informed decisions. If leafhoppers appear well controlled at petal fall, but then you find adults in June, does that mean rose leafhoppers have emigrated into your orchard or that you missed controlling the white apple leafhoppers?

In mid June if you find many leafhopper adults, these could be from either species, but you can't tell which one. At this time you should look at the foliage. If the adults you are finding are white apple leafhoppers there will be leafhopper stippling damage on the oldest foliage. The nymphs developed on the trees and the damage will be there for you to see. If mid June leafhopper adults are present and there isn't any foliar damage, the leafhopper is rose leafhopper which has recently emigrated to your trees. So if you decide the leafhoppers are rose leafhoppers and you don't treat them, you'll be plagued with leafhoppers all summer long. If you decide they are white apple leafhopper, once the adults die you won't find them again until August. Of course, there is always the possibility that you have both species.

Rose and white apple leafhoppers are resistant to organophosphate insecticides. Pesticides that do control leafhoppers include Sevin, Thiodan, and Provado. Agri-Mek used at first cover against leafminers will also control leafhoppers. Sevin used as a thinner will control white apple leafhoppers nymphs, provided it is used at the higher rate. I had always heard that sprays should be aimed at small leafhopper nymphs because they are easier to kill at this stage. They probably are easier to control at this stage, but the larger nymphs and adults are not difficult to control with the proper insecticide. Recently, researchers from New York have been recommending controlling the adults just before harvest. Since the damage by leafhoppers is primarily a nuisance to pickers, it may be better to wait until close to harvest and apply Sevin or a low rate of Provado. For a low rate, New York is recommending 1/2 ounce per 100 gallons. Also, it may be that attacking the adult stage of insects with insecticide, rather than the immature larval or nymphal stage, is a technique to reduce insects becoming resistant to insecticides. Perhaps knocking down the adults just before harvest is a good method to get rid of the nuisance of leafhoppers and also reduce the chance they'll develop resistance to the chemicals that do control them.

High Plant Populations and Plasticulture Techniques Increase Winter Squash Yield

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Trials were undertaken in 2001 and 2003 at Cornell University's research farm in Eastern New York to identify optimal in-row spacing and nitrogen fertilization rates for acorn and butternut squashes grown on raised beds using black plastic mulch and drip irrigation. The in-row spacing treatments evaluated in this trial were 12, 24 and 36 inches. A between-row spacing of 72" was used in 2001 and 60' was used in 2003. In 2001, all treatments received a broadcast fertilizer application that provided 40 lb nitrogen (N)/acre. Fertigation treatments included an additional 15, 30 and 45 lb of liquid N/acre in 15 lb incremental applications. The materials and methods used in this trial can be found in footnotes to the tables. In 2003, no broadcast fertilizers were used; a full-spectrum fertilizer designed to deliver 30 lb/acre each of N, P and K was injected into the drip irrigation system.

The 2001 study.
The two winter squashes responded differently to the nitrogen treatments (Tables 1 and 2). The 40 lb pre-plant N application plus two fertigation applications (of 15 lb N/acre each), providing a total of 70 lb N/acre, generated the greatest yields of butternut squash. Lower yields were achieved when N was applied at the lower rate of 55 lb/A, and fertilizer in excess of 70 lb N/A failed to appreciably increase the number of butternut fruit or average fruit weight. Acorn squash yields were not influenced by the N rates investigated in this trial. The acorn squash, which matured about three weeks earlier than the butternut, was probably unable to utilize the nitrogen provided by the last two fertigation applications.

Table 1. Butternut squash yield responses to three nitrogen fertilizer rates

Nitrogen Fertilizer (lb/A)	Fruit Number (No./30' of row)	Fruit Weight (lb/30' of row)	Average Weight/ Fruit (lb)	Yield per Acre (lbs)
55	27.7	82.8	3.0	18,500
70	33.4	101.0	3.0	22,500
85	31.9	100.3	3.1	22,300

Table 2. Acorn squash yield responses to three nitrogen fertilizer rates

Nitrogen Fertilizer (lb/A)	Fruit Number (No./30' of row)	Fruit Weight (lb/30' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
55	36.1	72.6	2.3	16,200
70	35.3	73.1	2.2	16,300
85	37.5	75.4	2.3	16,800

To our surprise, the 12" in-row spacing provided the greatest yields of marketable fruit in both butternut and acorn squashes (Tables 3 and 4). The 24" in-row spacing, which is probably the most commonly used in-row spacing, also produced good results. Differences were most pronounced in the acorn squash trial, where the yield of medium to large fruits was 30% greater in the 12" than in the 24" spacing. Jumbo fruits yielded marginally less in the closer spacing. The greater yield from the close in-row spacing was attributable to the increase in fruit set that was coincident with the increase in plant density.

From our 2001 study, it appears that growing acorn and butternut squash using raised beds, black plastic mulch and drip irrigation, is best done using a 12" in-row spacing and a total of 55 and 70 lb N/acre, for acorn and butternut squash, respectively.

Table 3. Butternut squash yield responses to three in-row spacings

In-Row Spacing (inches)	Fruit Number (No./30' of row)	Fruit Weight (lb/30' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
12"	33.1	99.5	3.0	22,200
24"	30.1	95.9	3.2	21,400
36"	30.6	92.6	3.0	20,600

Table 4. Acorn squash yield responses to three in-row spacings

In-Row Spacing (inches)	Fruit Number (No./30' of row)	Fruit Weight (lb/30' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
12"	42.6	83.3	2.2	18,600
24"	35.6	72.4	2.3	16,100
36"	31.8	66.6	2.3	14,900

Notes: Plots were 30' long and replicated 3 times. Seeds were sown on 5/25/01 into 72-cell flats and transplanted on 6/19/01 into black plastic with drip irrigation. We used Waltham butternut and Taybelle acorn varieties (Siegers Seed Company). All plots received 40lbs actual N-P-K using 15-15-15, applied through mulch layer at time of bedding. Plots were harvested on 9/11/01. Fruit was graded, counted and weighed on 9/13/01. Nitrogen applications were made in 15 lbs/acre increments on 7/9, 8/3, and 8/17. Plots were chemigated for striped cucumber beetles on July 24, 2001with Admire at a 16 fl oz/acre rate. No fungicides were used.

The 2003 study.

In 2003, an in-row spacing of 24" was used throughout the trial. The acorn squashes exhibited a yield response only at the very highest rate of N (Tables 5 and 6). The highest N rate (75 lb/A) increased the number of fruits produced per plant, which, in turn, increased yields. Interestingly, 'Table Ace,' the older variety of the two acorn squashes, was more responsive to the N rate than 'Autumn Delight,' a relatively new, powdery mildew-tolerant variety. The selection of acorn squash variety is clearly as important as selecting a fertilizer rate: yields of 'Autumn Delight' using 30 lb N/A were greater than those of 'Table Ace' using 75 lb N/A.

Table 5. 'Autumn Delight' yield responses to four nitrogen rates

Nitrogen Rate (lb/A)	Fruit Number (No./16' of row)	Fruit Weight (lb/16' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
30	21.3	37.8	1.8	20,600
45	19.1	33.7	1.8	18,300
60	20.2	33.3	1.6	18,000

75	24.2	42.1	1.7	22,900

Table 6. 'Table Ace' yield responses to four nitrogen rates

Nitrogen Rate (lb/A)	Fruit Number (No./16' of row)	Fruit Weight (lb/16' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
30	18.0	29.7	1.7	16,200
45	16.2	25.9	1.6	14,100
60	15.8	26.1	1.7	14,200
75	24.2	34.6	1.4	18,800

In 2003, the butternut squashes mimicked the pattern seen in the acorn squashes (Tables 7 and 8). A yield response to increasing N rates was in evidence in both varieties, as was the case in 2001, but the bigger response came from the older variety, 'Waltham.' In addition, 'Avalon,' the newer variety, out-yielded the older 'Waltham', even when 'Avalon' was given the lowest rate of N and 'Waltham' was given the highest rate.

Table 7. 'Avalon' yield responses to four nitrogen rates

Nitrogen Rate (lb/A)	Fruit Number (No./16' of row)	Fruit Weight (lb/16' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
30	14.0	40.8	2.9	22,200
45	13.6	35.0	2.6	19,000
60	11.8	31.7	2.7	17,200
75	15.2	43.9	2.9	23,900

Table 8. 'Waltham' yield responses to four nitrogen rates

Nitrogen Rate (lb/A)	Fruit Number (No./16' of row)	Fruit Weight (lb/16' of row)	Average Fruit Weight (lb)	Yield per Acre (lbs)
30	10.2	25.1	2.5	13,700
45	12.8	28.8	2.3	15,700
60	11.7	27.9	2.4	15,200
75	14.2	37.4	2.6	20,300

Notes: Plots were 16' long and replicated 3 times. Seeds were sown on 6/5/03 into 98-cell flats and transplanted on 6/20/03 into black plastic with drip irrigation. All squashes in this trial were grown using a 24' in-row spacing. Plots were harvested on 10/1/01. Nitrogen applications were made in 15 lbs/acre increments on 7/20, 8/10, and 8/30.

These studies suggest that high yields of acorn and butternut squashes grown using plasticulture techniques may be obtained by selecting good varieties, using high plant populations, and by choosing modest fertilizer rates. It appears that yields might be increased above those seen here by increasing fertilizer applications.

Transplant Size and Sowing Date for Cucumbers

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Materials and Methods

Cucumber seeds (cv. "Calypso") were seeded in the greenhouse at Highmoor Farm, the Maine Agricultural Experiment Station in Monmouth on 11 June and 26 June 2002 to allow transplanting to occur 15 days and 30 days after seeding. The seeds were started in four different transplant containers, including 7.6 cm (3 inch) diameter x 7.6 cm deep round peat pots, 5 cm (2 inch) diameter x 5 cm deep round peat pots, 6 cm diameter x 5.9 cm deep round plugs (24 count), and 3.8 cm diameter x 5.9 cm deep round plugs (72 count). All containers were filled with a peat/vermiculite mix (Redi-Earth) and fertilized twice with liquid 16-32-16. Seedlings were hardened-off by being placed outdoors from 7 a.m. to 3:30 p.m. for three days prior to being transplanted into plots outdoors on 11 July, 2002. All plots were covered with black plastic mulch, and all transplants received liquid starter fertilizer (15-30-15) at planting.

Results & Discussion:

It should be noted that this experiment was originally designed with the intent of using muskmelon (cv. "Earliqueen") as the test plant, as well as an earlier transplanting date (29 May). However, a prolonged period of cool wet weather killed more than 50% of the seedlings following transplanting, and the experiment was restarted using, by necessity, a shorter season cucumber variety ("Calypso"). It is interesting to note however, that in terms of survival during the early inclement weather, the older (34 day) melon plants in the large (7.6 cm) peat pots were far better than any of the other treatments. In that situation, it was clear that the largest plants were best able to deal with the stress of cold and soil saturation.

Seedlings started in the large (7.6 cm) peat containers had the largest plants at the time of transplanting for both the 18 and 34 day seeding dates (Table 1). These plants had significantly greater fresh weights, dry weights and more leaves than any of the other treatments. However, it is interesting to note that seedlings started in the large peat pots had noticeably slower germination than all of the other treatments, probably as a result of cooler media temperatures in these containers. Plants started in the 24 plug trays had the next largest plants by all parameters measured, followed by the small (5 cm) peat pots, which tended to dry out quickly in the greenhouse, making them more challenging to manage. The 72 plug trays showed the quickest germination, of all the treatments, but produced the smallest plants.

All transplants established well and produced acceptable harvests of marketable fruit. There were no significant differences between seeding dates on early or total yield among any of the container types (Table 2). Therefore, in this experiment, allowing seedlings an additional 15 days of growth in the greenhouse did not significantly affect the number or weight of fruit the plants produced.

Transplants from the 24 cell trays produced the greatest early yield and total yield, regardless of seeding date, although there were few significant differences across the container types. The small peat containers and the 72 plug trays had very similar yields, slightly less than the 24 plugs. The large peat pots had the lowest overall yield, but this may have been due in part to plot placement, which, although random, exposed this treatment to more weed competition than other treatments.

While container size did affect transplant size in this trial, these differences had little impact on yield once the plants became established in the field. This suggests that using small to medium size plug trays rather than large peat pots may provide a more efficient and economical way to produce cucumber seedlings, and that these seedlings require only a short growing period in the greenhouse prior to transplanting. However, earlier trials demonstrated that larger transplants are better able to survive under conditions of environmental stress, which are typical of the early growing season in the northeastern United States. Therefore, while smaller transplants may be suitable for mid to late season production, larger transplants may be a better option for early season production.

Table 1. Cucumber transplant characteristics at planting as a result of container size and days from seeding in the greenhouse, Monmouth, Maine, 2002.

Treatment	Sub Treat.	Plant Fresh Weights (g)	Plant Dry Weights (g)	Number of Leaves
3" Peat	18 days	5.79	0.39	3.0
3"Peat	34 days	14.63	1.06	5.4
2" Peat	18 days	2.98	0.20	2.0
2" Peat	34 days	4.20	0.35	3.4
24 Plug	18 days	4.15	0.28	2.6
24 Plug	34 days	7.82	0.73	4.0
72 Plug	18 days	2.70	0.16	1.8
72 Plug	34 days	2.86	0.30	2.6
LSD 0.05		0.976	0.08194	0.6478

Table 2. Cucumber yield characteristics as a result of transplant container and size, Monmouth, Maine, 2002.

Treatment	Sub Treat.	Early Yield (kg)	Early No.	Total Yield (kg)	Total No.
3" Peat	18 days	12.27	74	22.72	151
3"Peat	34 days	14.96	81	30.90	195
2" Peat	18 days	12.94	81	32.66	208
2" Peat	34 days	11.65	76	29.03	196
24 Plug	18 days	16.83	101	35.18	229
24 Plug	34 days	17.11	105	37.25	237
72 Plug	18 days	10.95	68	33.89	233
72 Plug	34 days	11.74	74	28.98	200
LSD 0.05		3.47	23	11.42	73

Spray Recommendations and Cultural Practices for Disease Control in Cucurbits

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The keys for the successful control of cucurbit diseases are: 1) knowing the specific diseases that affect your crop (most common are listed below) (3); 2) exercising the most important cultural practices (host resistance, clean seed, crop rotation, no-till cover crops, and soil moisture management) (1, 2); and 3) choosing the most appropriate fungicides from the more than 20 fungicides covered in Table 1 (protectants vs. specific fungicides with a history or potential for fungicide resistance) (4).

Bacterial Diseases
<u>Bacterial Wilt</u>
<u>ID</u>: *Erwinia tracheiphila* is the bacterium responsible for bacterial wilt and replicates only in the xylem; wilt appears initially on leaves and then on one or more runners on a plant; look for vascular browning in the xylem by cutting at the grown level (crown of plant) (visible to the naked eye)
<u>Cultural Practices</u>: Beetles will aggregate on preferred varieties (due to cucurbitacins levels); this feature makes use of a susceptible variety as a trap crop.
<u>Chemical Control</u>: Imidacloprid (Admire) is the preferred material for striped beetle control, but others are registered.

<u>Angular Leaf Spot</u>
<u>ID</u>: *Pseudomonas syringae* pv. *lachrymans* Young spots are water-soaked and older spots may have holes in center; spots are usually limited by the main veins of leaves; circular water-soaked and then sunken spots appear on fruit. (both visible to the naked eye)
<u>Cultural Practices</u>: Use pathogen-free seed and rotate out of cucurbits for 2 years.
<u>Chemical Control</u>: Use copper or a mixture of copper (**Group M1**) plus maneb (**Group M3**); discontinue sprays during extended rain-free periods.

Oomycete Diseases
<u>Phytophthora Blight</u>
<u>ID</u>: *Phytophthora capsici* The blight phase starts in lower areas of fields with saturated soils; yeast-like growth may start on underside of fruit and spread to topside; (visible with the naked eye).
<u>Cultural Practices</u>: <u>Management is critical</u>; organism survives in the soil for many seasons; rotate at least 3 years out of susceptible crops (pepper, tomato, all cucurbits); avoid planting in fields with a history of standing water; provide adequate drainage by sub-soiling and disking in spray alleys during the season; provide means for water to exist fields away from surrounding susceptible crops.
<u>Chemical Control</u>: Acrobat (**Group 15**) tank mixed with a protectant fungicide labeled for the cucurbit of interest (chlorothalonil, maneb or mancozeb, **Groups M5 and M3**) may provide some suppression of the disease.

Downy Mildew
ID: *Pseudoperonospora cubensis* Chlorotic spots appear on the upper leaf surface and purplish or gray spores form on these spots on the lower leaf surface. (visible with a hand lens)
Cultural Practices: None available; use the downy mildew forecast web site from the North Carolina State University http://www.ces.ncsu.edu/depts/pp/cucurbit/ to monitor movement.
Chemical Control: Consider using Acrobat (**Group 13**) tank mixed with a protectant labeled for the cucurbit of interest (chlorothalonil, maneb or mancozeb, **Groups M5**, and **M3**) and alternated with Ridomil Gold Bravo or Ridomil Gold Copper (**Group 4**) or Gavel (**Group 22**) (only labeled on C, M SS, W) and use Bravo and maneb in alternate weeks; or consider Aliette (**Group 33**) or Phostrol or ProPhyt (**Group 33**), combined or alternated with a protectant fungicide.

Fungal Diseases
Powdery Mildew
ID: *Podosphaera xanthii* (formerly *Sphaerotheca fuliginea*) and *Erysiphe cichoracearum* Produces white powdery colonies on upper and lower leaf surfaces, on stems and petioles. (visible with the naked eye)
Cultural Practices: Choose PM tolerant varieties for cucurbit of interest if available.
Chemical Control: Management of chemicals use for control is critical; refer to **Table 1** and make sure to tank mix protectant fungicides (**Group M5, M3, M1** or other chemicals (chlorothalonil, maneb, mancozeb, copper, oil, sulfur, etc.) with a strobilurin (**Group 11**); or with demethylation inhibitors (**Group 3**) or thiophanate-methyl (**Group 1**) and follow alternation protocol. If resistance to Quadris occurs in the area, you must use a fungicide from different fungicide group.

Gummy Stem Blight and Black Rot
ID: *Didymella bryoniae* Leaf symptoms are infrequent unless plants are infected during a wet growing season; lesions if they develop are circular and may have black pepper-like specks which are pycnidia; pycnidia also occur on lower stems and on fruit; fruit lesions may be water soaked and purplish in color before turning black; field infections often appear as a dry "petrified wood" beige semi-circular lesion with pycnidia. (visible with naked eye)
Cultural Practices: Use fungicide-treated seed, as organism is seedborne; rotate two years out of all cucurbits.
Chemical Control: Bravo (**Group 5**) used alone or combined with Topsin M (**Group 1**) will reduce chance for resistance from developing.

White Mold
ID: *Sclerotinia sclerotiorum* Look for white, cottony growth on stems and especially fruit; raisin-shaped black sclerotia appear within this growth. (visible with naked eye)
Cultural Practices: Rotate 3 or more years out of susceptible crops, choosing crops like sweet corn and grass cover crops.
Chemical Control: For farms with short rotations, consider the biological product Contans for incorporation into the soil prior to planting.

Fusarium Crown and Fruit Rot
ID: *Fusarium solani* f. sp. *cucurbitae* Crown of plant may be girdled and the dark brown decayed area covered with white or pinkish colored fungal mycelium; tan or white circular lesions appear on side of fruit touching the ground. (visible to naked eye)
Cultural Practices: A soilborne fungus that survives in the soil for at least 2 years; rotation out of cucurbits for 3 years.
Chemical Control: None available

Plectosporium Blight (formerly Microdochium Blight)
ID: *Plectosporium tabacinum* (previously *Fusarium tabacinum*) Light tan lesions that are spindle shaped develop on the underside of the leaf, which may lead to leaf distortion; spindle shaped lesions also appear on stems, petioles and fruit stems and also on fruit shoulders, where it appears a white, tan or silver russeting. (visible to the naked eye)
Cultural Practices: A soilborne pathogen recently introduced into Massachusetts and Connecticut, which in a moist season can result in considerable loses for pumpkin and summer squash. The fungus prefers a depth of 2-4 inches; use of a no-till cover crop can reduce disease levels compared to bare ground culture.
Chemical Control: The protectant fungicide chlorothalonil (Bravo) (**Group M5**) should be included in the spray program when fruit begin to set.

Alternaria Leaf Spot or Blight
ID: *Alternaria cucumerina* Lesions first appear on the older crown leaves as circular brown spots; as lesions expand they develop concentric rings; more common on muskmelon than pumpkin or winter and summer squash. (visible to the naked eye)
Cultural Practices: Follow a 2-year rotation out of all cucurbits.
Chemical Control: Can be controlled with most protectant fungicides (**Groups M5, M3 and M1**) and used in alternation with strobilurins (**Group 11**) fungicides.

Anthracnose
ID: *Colletotrichum orbiculare* More likely to occur on muskmelon, watermelon and cucumber. Appears as tan or brown oval lesions on upper leaf surface; raised acervuli (often salmon-colored) with hair-like setae (whiskers); lesions with fruiting bodies will also appear on fruit. (visible with a hand lens)
Cultural Practices: Use disease-free seed; follow a 2-year rotation out of cucurbits. Be mindful under moist conditions and high humidity for 24 hrs.
Chemical Control: Apply Bravo (**Group M5**) alone or in combination with Topsin M (**Group 1**) in alternation with **Group 11** fungicides (Quadris and Cabrio). If resistance to Quadris occurs in the area, you must use a fungicide from different fungicide group.

Septoria Leaf Spot
ID: *Septoria cucurbitacearum* Initially appears as very small water-soaked spots which turn beige or white in color; pycnidia (small black-pepper-like spots) appear inside the leaf and stem lesions; raised rash-like white spots also appear on fruit of pumpkin and winter squash. (visible with naked eye or hand lens)
Cultural Practices: Following a 2-year rotation will eliminate most disease carryover. Requires cool temperatures and summer rains to spread to fruit.

Chemical Control: Disease is controlled with a good fungicide program that includes Bravo (**Group M5**).

Scab
ID: *Cladosporium cucumerinum* Young lesions are water soaked but when older turn tan with a yellow halo and eventually crack and fall out; fruit lesions vary as cavity or erumpent lesions on fleshy fruit (summer squash) or sunken dry and corky lesions on hard fruit (pumpkins and winter squash. (visible to the naked eye)
Cultural Practices: Use disease-free seed; follow a crop rotation out of cucurbits for 2 years.
Chemical Control: Control is achieved with protectant fungicides like Bravo (**Group M5**) and is especially needed during cool and wet springs and summers.

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Perimeter Trap Cropping for Summer Squash and Cucumbers

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Definition & function

Webster's Dictionary (Guralnik 1980) defines "perimeter" as the outer boundary of a figure or area and as "a boundary strip where defenses are set up". Perimeter trap cropping (PTC) involves planting a more attractive trap crop so that it completely encircles and protects the main cash crop like fortress walls. The effectiveness of this trap crop system can usually be improved by adding other perimeter defenses, such as border sprays or with biological, mechanical and cultural controls. PTC functions by intercepting pest migration, regardless of the direction of attack. It then concentrates the pest population(s) in the border area, where they can be retained or killed, thus preserving natural enemies and reducing disease spread in the main crop.

Introduction

Over the past 2-3 years we have been investigating the efficacy of summer squash PTC both in small-plot trials at the University of Connecticut Plant Science Research Farm and on commercial fields (1/4- to 8-acre fields) around the state. In 2003, we initiated similar studies for cucumbers. Results of trap crop variety trials and efficacy studies have been very informative and promising. Thus far, implementation on commercial farms has exceeded our expectations and those of the growers who have tried this novel pest management system.

Identifying the "best" trap crop

In variety trials, we have compared many potential trap crops to see which might be the best at protecting the main crop. The cucurbit varieties tested were listed in the literature or suggested by growers. We quickly learned that although "Turk's Turban" was the most attractive to the beetles, there were other important considerations, as 93% of the plants of this variety perished before harvest from bacterial wilt infection. It is extremely important that the variety chosen as the trap crop in a PTC system not be a disease reservoir, or you may win the battle against the insects only to lose the war to disease. In other words, any beetle that made it through the perimeter to feed on the main crop would be a disease vector, and you may dramatically lower the number of beetles on the main crop, but suffer reduced yields due to bacterial wilt. We chose "Blue Hubbard" as the trap crop for the cucurbit PTC systems, as it was highly attractive to beetles, but had a much lower incidence of wilt than other varieties tested.

Small-plot results on summer squash

In our first year of small-plot trails, we attempted to stop cucumber beetles, bacterial wilt and other pests with a perimeter trap crop and different combinations of supplemental controls in the border area (i.e. trap crop on yellow plastic mulch). Over 94% of the cucumber beetles in the experiment were on plants in the perimeter of the plots. However, because 4 of our 5 treatments had "Blue Hubbard" in the perimeter, we "sucked" almost all the beetles out of the control plots and ended up with no significant differences for beetle numbers on the summer squash in the center of the various treatments. Despite the low beetle numbers in the plot centers, we still found that trap crop plots supplemented with border sprays or yellow mulch both had significantly reduced summer squash defoliation levels compared to control plots. We also found that spraying the perimeter trap crop reduced squash vine borer infestation on the unsprayed summer squash within by 88%. The SVB moth probably lands on the perimeter trap crop first, picks up a toxic level of insecticide, and never gets to lay eggs on the main crop in the center.

In 2002, center sub-plots with a sprayed trap crop around them had significantly lower beetle numbers and bacterial wilt mortality, and higher yields, than the centers of control plots consisting of all summer squash plants. Beetle numbers in the sprayed trap crop plots were reduced by 93% when compared with control plots. All treatments plots supplemented with border sprays showed reduced levels of defoliation in the centers.

In 2003, we evaluated a single trap crop row of Blue Hubbard, a border-row insecticide application, and a combination of the two strategies for protecting centrally-located unsprayed summer squash (or cucumbers) from cucumber beetles and bacterial wilt. Summer squash results were not yet analyzed at the time this proceedings article was prepared.

Small-plot results on cucumbers 2003
Although a delay in planting time due to wet conditions and cloudy weather during beetle counts, prevented us from finding significant differences in beetle numbers in 2003, the other cucumber results were very impressive. When the trap crop was sprayed it dramatically reduced defoliation on cucumber seedlings in the center and completely eliminated plant death due to direct feeding damage. Nine percent of the plants were lost directly to beetle feeding in the center of control plots. The sprayed trap crop barrier also dramatically reduced losses from bacterial wilt compared with the control plots. Total plant death (directly from defoliation and from bacterial wilt) dropped from 30% in the center of control plots to 14% for the cucumbers in the sprayed trap crop plots by final harvest. The sprayed PTC treatment increased yields by 33% or 148 boxes per acre.

Field implementation on commercial farms
Six CT growers using the technique on their summer squash and cucumbers, compared the PTC system to their former conventional management system, that relied on multiple full-field sprays to control cucumber beetles, and were quite impressed. In every case, the PTC system provided superior pest control compared to multiple full-field sprays and reduced insecticide use substantially. Growers estimated they saved almost 20% of their summer squash crop and a third of their cucumber crop by switching to PTC.

On most farms, insecticide sprays for cucumber beetles were limited to applications on the "Blue Hubbard" trap crop in the perimeter of the fields only. One of the growers stated on a post-season survey that: *It blew my mind to see the beetles flock to the perimeter rows*!

On one farm with extreme cucumber beetle populations, the grower applied an average of 1.5 perimeter sprays prior to bloom and 1.5 full-field sprays during harvest to his cucumber fields to regain control of this pest. The sprays at harvest were necessary to prevent cosmetic damage, where the beetles feed on the fruit rind and render the crop unmarketable. In past years, he normally applied 4 full-field sprays per field and still failed to harvest or market any cucumbers. He harvested and marketed a great crop of cucumbers in 2003 using PTC. When asked in a post-program survey to comment about the PTC system, this grower stated that: *I can not even get a crop of cucumbers on my farm without PTC*! This same grower was asked to plant a control field (without a trap crop) as part of the study. He made 4 full-field insecticide applications in the first 3 weeks and 60% of the plants showed signs of bacterial wilt before the plants even started to run. The crop was lost.

All but one grower said that they also saved time and money using PTC and found the new system simpler to use than multiple full-field sprays. All the program participants gave the PTC system high marks for reducing: pesticide use, spray time/expense, possible chemical residues at harvest, possible secondary pest outbreaks, risk of crop damage, and impacts on environment/land/water. They also gave the system high marks for improving farm profitability, for easier/faster pest detection (improved monitoring) and for easier picking/harvesting schedules (reduced REI/dh restrictions).

OK I get it, so how do I do it?
Growers wishing to try PTC should remember a few simple rules: 1) **Plant the trap crop on good ground**, so that it remains healthy and completely encircles the main crop, without large gaps in the perimeter. 2) Multiple rows (1-3) of trap crop **may** be needed if extreme pest pressure is expected, or along treelines where the heaviest pressure usually occurs as beetles colonize the field from overwintering sites. 3) **Spray the perimeter as soon as the beetles appear and begin to feed on the trap crop**. Do not wait for beetles to colonize the main crop or for a threshold level to be exceeded on the trap crop. 4) **Monitor the field continuously until bloom or harvest** and be prepared to make 1-2 additional perimeter sprays or, if necessary, full-field applications. Repeat perimeter applications are necessary if rain washes the insecticide from the plants prematurely or if more live beetles are found on the trap crop prior to bloom. Full-field sprays should be applied when pest pressure is excessive on a particular farm, causing a breach in the perimeter and substantial main crop infestation (>2 beetles/plant for summer squash and >2 beetle/plant for cucumbers). 5) **If the trap crop planting is incomplete** or has large gaps in it, for any reason, **treat the field as if it were a conventional planting** (i.e. spray the whole field as often as needed). You do not have an effective perimeter if you fail to plant along one side or wet conditions prevent emergence of most trap crop plants.

That's it! Its cheap, it's easy and almost anyone can do it! Go forth and conquer. May the force be with you!

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A Multifaceted Approach to the Management of Blueberry Diseases

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This presentation is the second part of a two-part discussion on blueberry diseases and their management. In the first part (in Blueberry I), Dr. Frank Caruso provides a description of the diseases most important to the region, their symptoms, the causal agents and some specifics on the epidemiology. This part will focus on multiple strategies for managing these diseases.

Introduction

The demand for blueberries worldwide continues to increase as the nutraceutical benefits of blueberries are becoming well known. However, blueberry growers continuously have to contend with a variety of insect pests and diseases that reduce yield and quality of fruit for the fresh as well as the processed market. Marketers and processors have high standards for blueberry quality, including a zero tolerance for mummy berry disease and certain insects, which means that an entire load can be rejected if one of these organisms is detected. Even though growers are keen to incorporate integrated pest management methods, highly effective alternatives may not always be available or cost-effective. In practice, blueberry growers rely heavily on chemical crop protection products to produce high yields of high quality blueberries. An integrated approach to disease management, where possible, will generally increase the level of control and reduce the need for chemical intervention.

General principles of disease management

In disease control, prevention is the magic word, because once you see symptoms, the infection cannot be stopped. The best way to prevent diseases from getting established is avoidance: choose sites that do not have a history of diseases and purchase plants that are virus-tested and disease free. The latter is a very important and worthwhile investment. Also make sure not to bring in soil or plant debris from infested sites on equipment or boots. One can also consider control of insect vectors of viruses a way of avoiding disease by killing or repelling the insects before they are able to transmit the viruses to plants.

Growers can also try to make their fields inhospitable to disease organisms. The easiest way to do this is to grow resistant varieties. If it is not possible to choose a resistant variety, at least avoid highly susceptible varieties to spare yourself an uphill battle for the lifetime of the planting. Since most fungi love moisture, anything that can be done to increase air flow and decrease humidity will be beneficial. For instance, choosing a site that is not surrounded on all sides by woods, using proper plant spacing, pruning bushes regularly to create a more open canopy, avoiding excessive fertilization, good weed control, and eliminating standing water by improving drainage. Limiting overhead irrigation or timing irrigation such that the plants stay wet the least amount of time (e.g., by irrigating during the night when dew may be present anyway) may also be helpful. Furthermore, you can help the plants defend themselves against pathogens by making sure they are not stressed. Stresses that can predispose plants to disease are drought stress, herbicide injury, waterlogging, improper soil pH, frost damage, etc. Some products on the market may help boost the plants' natural defenses, but results are variable.

Another very important disease control method is "sanitation" or the removal of pathogen inoculum from the field. For instance, in the case of Phomopsis canker, pruning out diseased canes and removing them from the field will reduce the abundance of fungus spores for future infections. Removing virus-infected bushes is very important, especially early in the life of the planting, to prevent any further spread of the virus. Another approach is to make the inoculum that is present ineffective, e.g., by covering it up with mulch or plowing it into the soil so that it breaks down quickly, killing the pathogen. This can be done, for instance, with mummy berry mummies.

Lastly, we can fight pathogens head on by using chemical fungicides which are toxic or biofungicides which are antagonistic to pathogens. Most of the time, when we apply chemical fungicides, we try to prevent the germination of fungal spores which land on the plant surface: these are protectant fungicides. There are some fungicides that can enter the plant and stop the infection process in the early stages: these are systemic fungicides. There are no fungicides which can kill a fungus in the later stages of the infection process, especially after symptoms have already begun to appear. The only exception to this the use of salts or oils to kill powdery mildew colonies which are exposed on the plant surface. Spray coverage is very important, especially for fungicides that are strictly protectants. This means that using appropriate spray equipment that delivers most of the spray to the target, higher spray volumes, slower driving speed, spraying more row middles, and having open canopies will aid disease control. Aerial application should be avoided unless the fields are inaccessible.

Knowing the critical periods when infection risk is highest can be very helpful in timing the applications of fungicides. Unfortunately disease prediction models are not available for most blueberry diseases, except for mummy berry in lowbush blueberries. Disease prediction models are based on environmental conditions (temperature, leaf wetness, relative humidity) that are known to favor infection and disease development. In the absence of disease prediction models, growers can still use weather forecasts as a “seat-of-the-pants” approach to estimating disease risk.

Lastly, I would like to stress that a correct disease diagnosis is very important for effective control. You first have to know what is wrong with your plants before you can do anything about it. An incorrect assessment can lead to a waste of money if unsuitable control methods are used and also to further losses. Possible control options for specific blueberry diseases are discussed below. Remember that the more control methods you integrate in your management program, the better control you are likely to achieve.

<u>Mummy berry</u>:

- Plant resistant or less susceptible cultivars
- Don’t plant in heavily wooded and shaded areas
- Remove mummies from field by raking or cover mummies with 1-2 inches of soil or mulch to prevent spore release
- Remove wild blueberries from vicinity
- Apply urea fertilizer on exposed mushroom trumpets in spring
- Create open canopy to reduce moisture and increase fungicide penetration
- Good weed control in the row to expose mummies to drying
- Use effective fungicides, particularly in period from green tip to the end of bloom
- Make sure plants are protected with fungicides during frost and right after frost events

<u>Botrytis blight</u>:

- Plant resistant or less susceptible cultivars

- Create open canopy to reduce moisture and increase fungicide penetration
- Prune out and destroy infected plant parts
- Time irrigation to overlap with dew events to reduce wetness duration
- Use effective fungicides, particularly in period from green tip to the end of bloom

Phomopsis twig blight and canker:
- Plant resistant or less susceptible cultivars
- Buy disease-free plants or remove dead twigs or branches from planting material before planting
- Prune out and destroy dead and diseased canes
- If bush-hogging pruned canes, try to work the debris into the soil
- Avoid wounding canes by equipment or herbicides
- Irrigate as needed to reduce plant stress, including during dry periods after harvest and before leaf drop
- Time irrigation to overlap with dew events to reduce wetness duration
- Good weed control in the row to reduce humidity around bases of canes
- Create open canopy to reduce moisture and increase fungicide penetration
- Use effective fungicides, particularly in period from green tip to petal fall. Application of fungicides after harvest may help to protect wounds caused by mechanical harvesting and protect newly forming fruit buds from infection

Fusicoccum (Godronia) canker:
- Plant resistant or less susceptible cultivars
- Buy disease-free plants or remove diseased canes from planting material before planting
- Prune out and destroy dead and diseased canes
- If bush-hogging pruned canes, try to work the debris into the soil
- Good weed control in the row to reduce humidity around bases of canes
- Use effective fungicides, particularly in period from green tip to petal fall.

Anthracnose:
- Plant resistant or less susceptible cultivars
- Prune regularly to remove canes with lots of old fruiting wood
- Time irrigation to overlap with dew events to reduce wetness duration
- Create open canopy to reduce moisture and increase fungicide penetration
- Use effective fungicides, particularly in period from green tip to petal fall. Applications when berries first turn blue and close to harvest may reduce post-harvest rot.
- Timely harvest and rapid cooling of fruit
- Sanitation of sorting line, maintain bleach concentration in tank

Powdery mildew:
- Plant resistant or less susceptible cultivars
- Create open canopy to reduce humidity
- Use fungicides only if disease is very severe, focus on period from bloom to harvest and possibly post-harvest

Phytophthora root rot:

- Select sites with good drainage or improve drainage by tiling or raised beds
- Plant tolerant cultivars
- Prevent movement of soil from affected blueberry fields and cranberry beds on equipment or by run-off; cultivate infected fields last
- Use effective fungicides in spring and fall; moderately to severely diseased plants cannot be revived
- Rotate out of blueberries for 5-10 years

<u>Armillaria root rot</u>:

- Do not plant in an infested site (survey site for dead trees and signs of the fungus before clearing)
- Remove all tree stumps including roots
- Remove infected bushes including roots
-

<u>Witches' broom</u>:

- Eradicate fir trees within 1500 feet of blueberries
- Remove or kill infected bushes with an herbicide
- Use effective fungicides

<u>Scorch</u>:

- Buy virus-tested planting stock
- Plant resistant or less susceptible cultivars
- Remove and destroy infected plants
- Practice good aphid control
- Wash harvesting equipment between fields to remove aphids
- Harvest infected fields last

<u>Tomato ringspot</u>:

- Buy virus-tested planting stock
- Plant resistant or less susceptible cultivars
- Fumigate affected areas before replanting with blueberries
- Remove and destroy infected plants, including non-symptomatic plants nearby
- Use nematicides to control nematode vectors

<u>Stunt</u>:

- Buy disease-free planting stock
- Remove and destroy infected plants
- Practice leaf hopper control

BLUEBERRY WINE PRODUCTION

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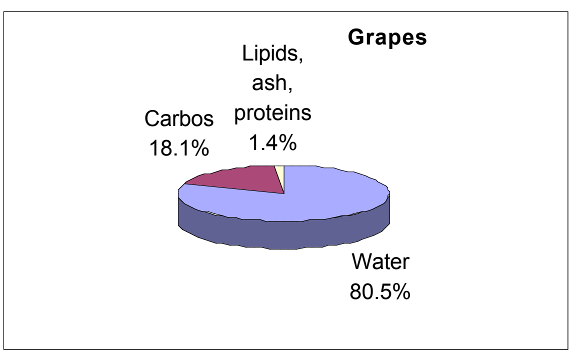
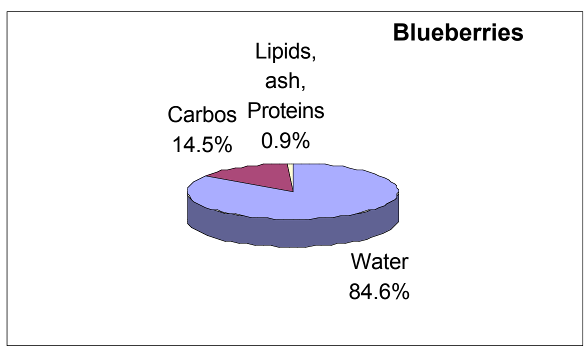
The Chester Hill Winery is the third smallest Winery in Massachusetts. We were founded in 1999 and last year we made about 900 cases of wine consisting of mostly Blueberry, with some Riesling and French Hybrid White Wines. To provide a sense of scale, we make in a year what Gallo makes in 54 seconds. But why blueberry wine, why not grapes? Aren't blueberries very different than grapes? Can blueberries create a decent wine? How is it made? Is this guy nuts?

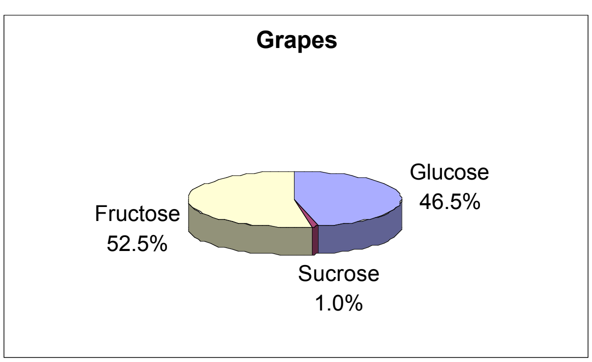
The winery is located in the middle of blueberry country, high up in the "Hidden Hills" of western Massachusetts. Our elevation, approximately 1,370 above sea level, is too high for wine grapes and cannot guarantee, on a consistent basis, the 150 frost-free days necessary for their maturation. Within a 5-mile radius of the Winery there are approximately 50-60 acres of highbush blueberries under cultivation. As an amateur, I had been making wine for about twenty years from many different fruits including grapes and blueberries. It was found that blueberries are high in tannins and acids, similar to a red wine grapes, and when made always clarified significantly faster than the grape wines.

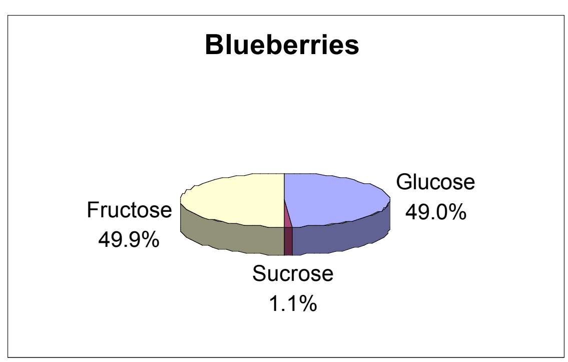
The USDA"s Human Nutrition Center has analyzed many foods for their nutritional components including wine grapes and blueberries. If we look at these components we find that they are not that different.





Also that their constituent sugars are quite similar as well:





Overall blueberries have a sugar content of 8-12% while wine grapes are in the order of 20-24% sugars. The conversion of the sugars by the yeast to alcohol is approximately 1.8 to 1. With naturally occurring sugars, blueberries would yield an alcohol content of from 5-6% with grape wine in the range of 10-14%. In order to preserve wine for long periods we need the alcohol content to be above 10%, so to make a blueberry wine of about 12% alcohol we need to add sugar. Sugar can only be metabolized by yeasts in its simplest form or glucose. Therefore, in order to get at the useable glucose the yeast must "invert " the sugars, or convert all existing forms into glucose. The major difference in grape and blueberry wine production is the addition of cane sugar at the rate of approximately 1 to 1.5 pounds per gallon. This sucrose is immediately inverted to glucose anyway so it is the writer's contention that there is in effect no material difference.

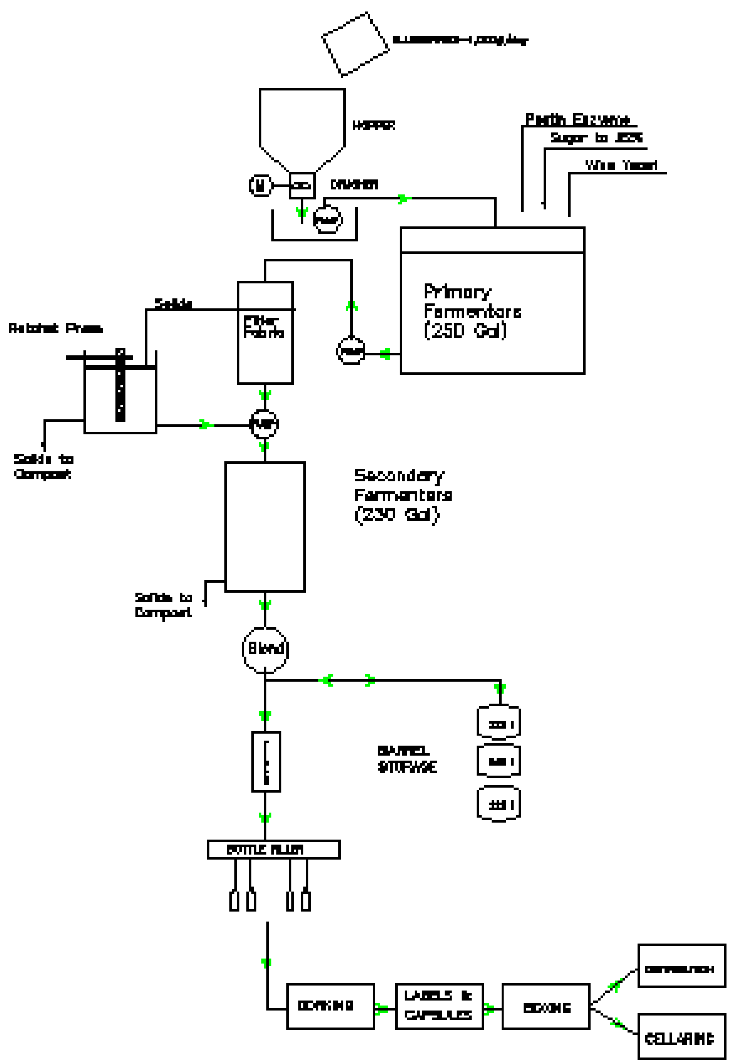
Starting a winery under any circumstances is a difficult and a time-consuming process. Therefore creating a winery producing a relatively unknown wine, a Blueberry Wine, would, no doubt, be particularly difficult. Luckily, most everyone loves blueberries, and once having tasted the wine, we think this will apply to Blueberry Wine as well. The wine can be made into a variety of product styles ranging from a fruity off-dry after dinner wine to a full bodied dry red wine with an oak finish. We have created three unique blueberry wine styles:

1. ***OFF-DRY BLUEBERRY WINE*** – Our original pioneer wine is in the nouveau style with a minimum of vinification, thereby intensifying the fruity characteristics of the wine. This wine is targeted for quick release from the current year's harvest, bottled in October and released in November in time for the holiday season. This is the perfect wine for ***Thanksgiving…An American Wine for an American Tradition***. This product is 12% alcohol with 1.5% residual sugar and is our **"NEW BLUE."** It goes great with spicier foods like chili and Italian red sauces.

2. ***FULL BODIED BLUEBERRY*** - A wine vinified in the classic method and bulk aged in American oak barrels for four to six months for character addition and bottle aged for at least six months with release in mid summer after the harvest. This product is 12 % alcohol with less than 1% residual sugar and is termed our **"BEST BLUE."** This goes well with hearty meats and cheeses including roasts, salmon, steaks and game dishes.

3. ***BLUEBERRY PORT STYLE WINE*** - An oaked blueberry wine to which grape brandy has been added to produce an alcohol content of approximately 18%. This is a sweet after dinner wine with 6% residual sugar and definite aging capabilities. This product is placed in 375-ml bottles and has been named our **"BAY BLUE."** Serve with cheesecake or any dessert with the word chocolate in it.

The basic wine making process for both the semi-dry and the full-bodied blueberry wine is the same. The berries are hand picked to minimize stems and leaves. They are lightly crushed and deposited into the fermentation tanks where sulfur dioxide and pectin enzymes are added. Blueberries have a lot of naturally occurring pectin that needs to be removed prior to fixing the alcohol, or else clarifying problems could occur. After a “cold soak” of about a week, the temperature goes up to 80 Deg F. Then, yeast, sugar, organic chemicals to aid in fermentation are added. After primary fermentation is complete, in about two weeks, the wine is separated from the lees on a free run basis with the residual material being lightly pressed for juice extraction. At this point, the wine is returned to the storage tanks after fining material is added. The settled wine is then either placed in American oak barrels for additional aging for the full-bodied wine or filtered and placed in bottles for the off-dry type. A certain percentage of the wine is fortified with grape brandy to create the port style wine. The Winery also produces white grape wine from juice delivered from the Finger Lakes Region of New York. It is the only portion of the products produced from a non- Massachusetts source. White wine is stored in stainless steel tanks to prevent oxidation.



SCHEMATIC DIAGRAM

The wine making equipment consists of high density polyethylene or stainless steel fermentation and storage tanks, American oak barrels, lab equipment, press, filters, pumps, automatic filler, manual corker, labeler and bottling equipment. Outside are some storage areas for the primary fermentation tanks, crusher, wine press and portable wine making equipment. The attached sketches describe the various production areas and equipment to be utilized.

Blueberry wine is a unique product. There is a certain amount of sales resistance because the general public, and even those who should know better within the wine industry, expect it to be sweet. Blueberries are not sweet, but are sweet and tart at the same time, yielding a range of taste components that lend themselves to the production of a complex wine. Some say “It doesn’t taste like blueberries.” Who among us have tasted a merlot grape and can say, with any amount of certitude, that the Merlot wine tastes like the grape. Whether or not blueberry wine is worthy of your consideration, well, you may just have to try some.

White Grub Management in Blueberries

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Insects that feed on blueberry roots

The principal insects that feed on the roots of blueberry plants are white grubs, the larvae of scarab beetles. The adults of our most common scarabs: Japanese beetle, oriental beetle, European chafer, and Asiatic garden beetle, are easily identified. Japanese beetles have copper-colored wing covers, white patches of hair near the end of the abdomen, and a green head and prothorax. Japanese beetles feed extensively during the day. Oriental beetles are the same shape and are slightly smaller than Japanese beetles. They usually are a drab tan with darker brown splotches on the wing covers. Their color is variable though, and some are nearly black overall. Oriental beetle adults feed very little as adults. European chafers are the largest of these species. The adults have a roughly rectangular shape, are a yellowish brown, and do not feed. Asiatic garden beetles are a VW beetle shape and are a cinnamon-brown color. Adult Asiatic garden beetles feed extensively on foliage at night. The larvae of white grubs have six legs, which distinguish them from root weevils (See my article 'Black vine weevil management in strawberries'). Large numbers of white grubs can compromise the function of roots, which then leads to plant stunting, induced nutrient deficiencies, wilting, and occasionally plant death. Blueberry foliage is a favored food for adult Japanese beetles. Since Japanese beetles are active at the same time as when blueberries ripen, they can be a nuisance while harvesting, and become a fruit contaminant among mechanically harvested blueberries.

There are differences between these species that point toward oriental beetle becoming the dominant species in blueberry fields. Oriental beetles prefer laying their eggs in moist, high organic matter soil, which describes the environment of the mulch area around most blueberry plantings. Japanese beetles are very specific in requiring grasses to stimulate egg laying. Therefore, Japanese beetle grubs feeding on blueberry roots probably result from larvae moving from a grassy strip between blueberry rows, or from grassy weeds growing within the row. European chafer and Asiatic garden beetle preferences for egg laying habitat is not well known, but these species have not yet been implicated as being damaging to blueberries.

Being able to determine which species of larvae are feeding on your blueberry roots is important. Effective control measures may differ among these species, so an option for controlling one species may not work for controlling another. White grub larvae are identified by using a 10x hand lens to look at the shape of the anal slit and the pattern of bristles on the underside of the grub at its posterior end. Japanese and oriental beetle larvae resemble each other in size and in having a straight, transverse (side-to-side) anal slit. The pattern of bristles for Japanese beetle is shaped like a "V", whereas for oriental beetle the rows of bristles are arranged as two parallel rows. European chafer has a "Y" shaped anal slit and is larger than either Japanese or oriental beetles. Its bristles are arranged as parallel rows that diverge to form a "Y" at the end of the abdomen. Asiatic garden beetle larvae are the smallest of these species. The anal slit appears to be vertical, and the bristles form a crescent across the abdomen.

Monitoring methods. To determine whether your plantings have problems with white grubs, use a shovel to dig a square core of soil from within the root zone of the blueberry plant.

Sift through the soil with a trowel to observe how many larvae are present. If you cut a standard-sized core (e.g., a 6 inch cube of soil) and record your data, you can compare different areas of fields to each other, or compare one year to the next. I am not aware of economic thresholds having been established for white grubs on blueberries, so each grower has to correlate grub counts to loss of plant vigor. Obviously, this kind of sampling will injure the shrub to some extent, so limit sampling to a few shrubs per planting.

Control Strategies

Foliar sprays to kill adults. The only scarab species that feed on foliage to any significant degree are Japanese and Asiatic garden beetles. Foliar sprays may kill feeding beetles, but may not kill immigrating adults landing on the soil to lay eggs. This is especially true of Japanese beetles, which move from adult host plants to lay eggs elsewhere around grasses. Foliar sprays to kill adult scarabs may also kill beneficial insects and mites, making management of spider mites and aphid pests more difficult. In short, a foliar spray program to manage white grubs cannot be expected to be successful.

Chemical control of larvae in soil. Imidacloprid has an excellent 10-year track record for control of most species of white grubs in a number of different environments. The exception is Asiatic garden beetle, in which only about 50% mortality can be expected. To be effective, imidacloprid (1) must be applied to the soil at the time of adult flight or during the first larval instar, and (2) must be watered into the soil (because it breaks down quickly on exposure to sunlight). Before using imidacloprid, the yields from blueberries between 1993 and 1997 in NJ ranged from 3,890 and 4,550 lb/ac, with an average yield of 4,420 lb/ac. After the introduction of imidacloprid, yields in 1998 and 1999 (the only additional years for which I have data) increased to 4,800 and 5,200 lb/ac. This represents a yield increase of ~20% associated with white grub control.

In 2002, Connecticut followed New Jersey's lead in obtaining a Section 18 (emergency use exemption) for applying imidacloprid (Admire) for controlling white grubs in blueberries. In 2003, registration via a new Section 3 label was expected for blueberries, and a Section 18 for blueberries was not pursued. When the label was published, virtually every berry crop was included but blueberries. The inclusion of blueberries on the Admire label doesn't look as though it will be coming soon.

> "Blueberries have not yet been added to the Admire label. EPA temporarily withdrew consideration of establishing tolerances for imidacloprid on blueberry. As you know, use of imidacloprid on blueberry, and the Bushberry Crop Sub-Group was an IR-4 initiative and was to be included with all the minor-use crop tolerances that were approved this summer.
>
> "According to EPA, the removal of blueberry from this package was because of negative comments received by the EPA from the Natural Resources Defense Council (NRDC) over a year ago. These comments related to concerns over children's safety that could be at risk with the Agency's issuance of a Section 18 exemption for the use of

imidacloprid on blueberry. Although EPA is working on satisfying NRDC's concerns, they have not been able to address all of them. Once this happens, the EPA will be able to establish tolerances and grant registration on blueberries. However, at this time there is no indication as when this is likely to occur."

Karen Cain, State Regulatory Affairs Team Lead, Bayer CropScience, 10/24/2003

Another controversial subject regarding the imidacloprid is its impact on pollinators. Sunflower growers in France claim that seed treatment of sunflowers with imidacloprid caused honeybees to become disoriented and to not return to hives. Also, Bayer removed pre-bloom uses of imidacloprid from tree crop labels to avoid bee toxicity and pollination problems. Controlled studies recently showed that foliar-applied residues of imidacloprid can interfere with bumblebee foraging behavior on clover, but imidacloprid washed into soil following foliar application (equivalent to a soil-directed systemic treatment) had no impact on their foraging or the health of the hive. The reasonable conclusion from these studies and from NJ blueberry yield data is that imidacloprid applied to the soil for control of white grubs is safe with respect to pollinator behavior.

Biological control to suppress larval populations. Please read the abstract for 'Black vine weevil management in strawberries' for more information on the biology of insect pathogenic nematodes. Biological control of white grub larvae with insect pathogenic nematodes (EPNs) is not likely to be as effective an option as it has been for control of root weevils in strawberries. White grubs have many defenses against infection by insect pathogenic nematodes, including structures that protect against entry of nematodes into their spiracles (the openings to their respiratory system), a high defecation rate, which prevents nematodes from entering through the anus, and grooming behaviors that remove nematodes.

Species of nematodes belonging to the genus *Heterorhabditis* are claimed by their producers to be able to infect white grubs, because they possess a tooth that can permit direct entry through soft cuticle. Laboratory and field studies demonstrate that infection with *Heterorhabditis* species is possible, but the dosage of nematodes required to overwhelm the grubs' defenses is too high to allow cost-effective use of these nematodes against white grubs. Furthermore, species of white grubs vary in their susceptibility to infection by nematodes. Japanese beetle is relatively easy to infect with *Heterorhabditis* spp., oriental beetle and Asiatic garden beetle are fairly difficult, and European chafer is nearly immune to infection.

One potential solution for using insect pathogenic nematodes would be to find a species that is more virulent to white grubs. This would permit application of fewer nematodes to effect control. Albrecht Koppenhöfer, at Rutgers University, found a species now named *Steinernema scarabaei* that is exceptionally virulent to all our non-native species of white grubs, but surprisingly is relatively ineffective against the native northern masked chafer. This species can provide exceptional control of oriental beetle in blueberries, but is not yet available commercially.

Two other factors may affect how well insect pathogenic nematodes may work in blueberries. (1) The root system of blueberries is quite deep, so nematodes would have to move

through a larger volume of soil, and into deeper, cooler soil, to contact the entire white grub population. Trials of nematodes with deeply rooted crops generally have had poor results.
(2) The soil needs to be maintained with moderate moisture to permit nematode migration to hosts. Blueberries are often irrigated with a drip system, which may provide too uneven a distribution of water to permit optimal nematode dispersal. Nematodes should not be applied through drip irrigation (because they settle in the tubes). If overhead irrigation is not available, application of nematodes has to be done in the rain to guarantee that they have an opportunity to move into the soil.

Pheromones and white grubs. Sex attractant pheromones have been identified for both Japanese beetles and for oriental beetles. For both of these species, females produce a chemical odor that attracts males from a distance. Males fly upwind during the day within an odor plume to contact its source (the female), whereupon they mate. With Japanese beetles, this sex pheromone can be combined with floral attractant odors, so that both males and females are captured in traps. Do not use Japanese beetle traps in plantings where you want to eliminate their populations. Japanese beetles are behaviorally programmed to land on any edible foliage while flying in an upwind flight to the floral attractant odors. If they start eating this foliage, this becomes increasingly attractive for other beetles to land in their proximity. Yes, you may catch beetles in the trap, but you'll also end up with increased feeding activity of beetles in foliage anywhere downwind of the trap!

Feeding attractants are not known for oriental beetles, so the attractant used for this species will only trap males (to monitor the population levels). The pheromone has also experimentally been applied in a microencapsulated formulation and in dispensers over test areas to determine whether mating can be disrupted. Male beetles flying in an area with lots of pheromone are unable to home in on an authentic calling female, and the two sexes cannot mate. Trials in 2003 (in New Jersey) demonstrated dramatic reductions in larval counts in areas treated with oriental beetle pheromone. Mating disruption has a higher chance of success with oriental beetle than with Japanese beetle, because oriental beetles tend to lay eggs close to where they emerge as adults. Therefore, this minimizes the chances that mated females will fly in to lay eggs in a blueberry planting from surrounding areas. However, in a drought situation, female oriental beetles will travel some distances to lay eggs where there is adequate moisture, and we can anticipate greater problems with the mating disruption technique during dry summers.

Summary

There is currently an unfortunate situation for blueberry growers in which we know that white grubs are damaging, we know how we may be able to manage their populations, but the tools are currently unavailable for effecting control. A Section 18 registration for Admire might be possible, but if NRDC's concern is related to excessive residues in fruit, then the US EPA cannot grant a tolerance and the Section 18 becomes unavailable. The nematode option would be an excellent and possibly long-term solution for white grub problems, but the inability of researchers to mass-produce this nematode puts this out of reach. Pheromone disruption of oriental appears to be the most accessible option if a manufacturer produces dispensers for this material. Removable pheromone dispensers (like twist tie formulations used to control codling moths) are exempt from EPA registration. The mating disruption strategy, however, would probably only be practical where oriental beetle is the dominant white grub species.

Enhancing Organic Research
Update From the Northeast Organic Network (NEON)

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Organic agriculture is slowly entering mainstream U.S. agriculture for several reasons, including expanding markets, improved profitability and concerns for the environment. Currently, there are between 10,000-15,000 farms working more than 1 million acres of crop and grazing land in the U.S (Lipson, 1997). While this only represents about 0.2% of all U.S. crop land as certified organic, acreages are steadily increasing. Many growers are considering organic production since these products generally receive 20% higher price in the market. Organic farming has been shown to be more profitable for small farmers – even without premium prices that organic crops generally receive. Organic agriculture is also well suited for high value crops (vegetables and herbs) where increased labor costs are more readily justified. Large-scale production of organic grains (for both livestock and human consumption) continues to be a rapidly growing sector. In addition, the recent creation of a National Organic Program and Standards is expected to increase acres undergoing transition (for details on the full rule, please see http://www.ams.usda.gov/nop/).

Domestic sales of organic products have increased at 20% per year for each of the last seven years. Food production in the US retail food sector is $756 billion, and organic production is valued presently at 1% of this total, but is growing. The Hartman report found that 90% of American consumers were either buying or considering buying organic products – and this figure is up from 60% two years ago. Organic food products' retail value was $0.5 billion in 1990, $4 billion in 1996 and is estimated to be $8 billion in 2000. Conventional food processors and distributors are linking with organic producers (Small Planet Foods and Hain Foods). Although the business climate for organic agriculture is more favorable, there is also greater pressure from outside the region (e.g. California and Mexico) to meet the increased demand. It has been estimated that >75% of the food consumed in the northeastern U.S. is imported from other regions, and the same is probably true for organic products marketed in the region.

Organic farming's potential, particularly as an alternative strategy for small farms, remains largely undeveloped. More research, extension and educational efforts are needed to fulfill the promise of organic agriculture. Historically, inadequate support has hindered organic agriculture's development. During 1995-6, the National Organic Research Policy Analysis (NORPA) project conducted a study to identify federally-funded organic agriculture projects. Of nearly 30,000 summaries of research projects examined through the CRIS database, only 34 were identified as focused on organic systems or methods (for full report, see http://www.ofrf.org/publications/oword/oword.html). Since this represents only about 0.1% of USDA's research portfolio, NORPA's report states, "The national agricultural research system has failed to recognize…[or] help improve the performance of organic farming systems."

Despite insufficient federal funding, organic agriculture has been able to survive primarily through the efforts of dedicated producers, their grassroots organizations, and foundation support for the organic mission. Focused efforts, especially partnerships with private and public entities, are urgently needed to develop strategies to overcome biological and social constraints facing organic agriculture. In addition, creative crop-marketing initiatives would assist producers. Resources within the Land Grant Universities can help organic producers manage their production and marketing practices, but this must be done in a coordinated and collaborative fashion, with strong partnerships and shared leadership between the private and public sectors.

The Northeast Organic Network, or NEON, is just such a collaborative of farmers, researchers, extension educators and grassroots nonprofits working together to improve organic farmers' access to research and technical support. Funded by a $1.2 million grant from the USDA's IFAFS in 2001, this multi-state, multidisciplinary team has been conducting research and extension and education programs on organic agriculture throughout the Northeast. NEON is hosted by Cornell University, but collaborators are located at universities, agriculture experiment stations, organic farms and organic nonprofit organizations throughout the northeastern U.S. Unlike OAC, NEON's focus is on improving understanding of established organic farms, and defining conditions under which a transition to organic may be feasible to enhance small farm viability. NEON has three main target outcomes:

1. NEON will strengthen collaboration among growers, non-profit organizations and Northeast academic institutions to facilitate research, extension and educational programs on organic agriculture.
2. We will develop enterprise budgets and farm business management information that focuses on established organic farms in the Northeast, to evaluate current farm success, based upon farmer goals and objectives.
3. Targeted applied research will address specific knowledge gaps in current soil fertility, crop and pest management practices to develop decision support tools to improve organic farming management. Specific questions included:
   - What are the contributions of various organic amendments to nutrient balances on organic farms, and in which cases might we be over-applying?
   - How can crop rotations, crop diversity and cover crops be used to reduce severity of insects, diseases and weeds in organic crops?
   - How effective are organically accepted 'rescue treatments' at reducing crop losses from pests?
   - What new cover crop species may be well adapted to organic farms in the Northeast?

A major effort within NEON is our study of 11 exemplary organic farms in the Northeast. We call this our Focal Farm Project. These farms were nominated by their peers and are recognized as innovative and highly successful operations. These farms are participating as NEON partners to profile each farm's cropping system, production, weeds, insects, soils, and economics. The farms, the farmers and crops being focused on at each farm are:

- Fair Hills Farm, Ed Fry, Chestertown, MD.
  - Silage corn, alfalfa, rye
- Paradise Organics, Chris Petersheim, Paradise, PA.
  - Salad greens, lettuce, spinach, kale, collards, peppers, tomatoes
- Spiral Path Farm, Mike and Terra Brownback, Loysville, PA.
  - Lettuce, summer squash, tomatoes, peppers, salad greens
- Watershed Organic Farm, Jim Kinsel, Pennington, NJ
  - Tomatoes, broccoli, potatoes, winter squash, lettuce, strawberries
- Beech Grove Farm, Anne and Eric Nordell, Beech Grove, PA

    - Garlic, storage onions, lettuce, potatoes, carrots
- Blue Heron Farm, Lou Johns and Robin Ostfeld, Lodi, NY.
    - Lettuce, tomatoes, potatoes, strawberries
- Mary-Howell and Klaas Martens Farm, Penn Yan, NY.
    - Spelt, soybeans, field corn, processing snap beans & cabbage
- Myer Farm, John Myer, Ovid, NY.
    - Soybeans, spelt, field corn, winter wheat, alfalfa hay
- Kestrel Farm, Tom and Merrilee Harlow, Westminster, VT.
    - Lettuce, parsnips, sweet corn, green beans
- New Leaf Farm, Dave and Christine Colson, Durham, ME.
    - Salad greens, tomatoes, summer & winter squash, brassicas
- Upper Forty Farm, Kathy, Bennett and Andy Caruso, Cromwell, CT
    - Green beans, winter squash, peppers, sweet corn

In its first two years, the NEON Focal Farm field research will gather information describing the production system, pest pressures, and yields of sample beds or fields of key crops on each focal farm. Guided by the farmer and each farms' cropping system, representative beds of key crops will be sampled throughout the season for yield, weeds, pests and beneficial insects. Economic profiles will be prepared during the winter.

Together, we seek answers to these questions about organic farms:

- What are the production strategies & yields of key crops?
- What are the weed problems and how are they managed?
- What are the problem pests for key crops and how are they managed?
- What practices are used on the farm to manage soil health & fertility?
- How do farmers determine the crop mix and how do they evaluate the business profitability?
- What are the financial benchmarks for profitable organic farming operations?

To address the multitude of systems research questions facing organic agriculture in the longer term, the focal farm study is a first step to developing a better overall collaborative approach to meet the specific research needs of organic agriculture.

**NEON is funded by a USDA Integrated Future of Agriculture and Food Systems grant administered by Cornell University. Through NEON, the following institutions and organizations have committed to collaborative research in support of organic agriculture in the Northeast: Connecticut Agricultural Experiment Station, Cornell University, NOFA-NJ, NOFA-NY, the New England Small Farm Institute, and the University of Maine.

Two Organic Farms—A Contrast in Styles

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As part of the Northeast Organic Network (NEON) Project, 11 outstanding organic vegetable and cash grain farms were studied in some detail over the 2002 and 2003 seasons. I'm going to present some of our findings on two of these farms which I feel show instructive contrasts.

Spiral Path Farm and Beech Grove Farm are in southern and northern central Pennsylvania, respectively. They are both set in isolated locations with hilly terrain and well-drained soils. Both owner couples choose to farm with organic methods. But from there, the styles of the farms diverge.

Mike and Terra Brownback, owners of Spiral Path Farm, felt that their local market could not support an organic farm that would provide a good living. So they put their contoured, relatively steep hillside fields into vegetables and geared up for the wholesale organic market in the early 1990's. They now grow 60 acres of organic crops, about 20 of which are double-cropped. They have been able to succeed in the difficult organic wholesale market through excellent management, good planning, and hard work. Meanwhile, they have improved their sloping soils.

Eric and Anne Nordell had similar goals, with important differences, when they established Beech Grove Farm in the early 1980's. They wanted to use draft horses as their main power source, and they wanted to keep the workload down to a level that the two of them could handle alone. So they took 7 relatively flat acres and established vegetable fields. The rest of their open land is in pasture. Their main markets are now restaurants and the Farmer's Market in Williamsport, about 20 miles away. Their cover crop program and excellent weed control are legendary among organic growers.

What makes these farms tick?

Spiral Path, a medium-sized, intensive vegetable farm

Spiral Path Farm supplies seasonal, high quality produce grown efficiently and cost-effectively to Northeast markets. They are able to get on their fields early, and use raised beds, black plastic and row covers to start harvesting lettuce and greens in May. About 25 acres of successive lettuce and salad greens are their most profitable crop targeted for the wholesale markets. This is followed in value by significant acreages of staked tomatoes, peppers, eggplant, cucumbers and summer and winter squash. They also grow smaller amounts of a diversity of brassicas, alliums and other vegetables and have serial plantings of important crops, to offer wholesale accounts "one-stop shopping."

Most of the 25 acres of early lettuce and greens are promptly replanted after harvest to squash, peppers, or tomatoes. The plastic is pulled, the beds subsoiled, disced and re-formed, and plastic laid again. Sometimes additional compost is applied.

Their crew of Mexican workers, along with Mike and a couple field managers, quickly and skillfully establish the second crop. The tomatoes, for instance, are transplanted, pruned and staked. The field is in production again as their early field tomato plantings are winding down. According to NEON data, in 2002 a field of these late double-cropped tomatoes yielded over 60,000#/A of marketable fruit.

Similar purposefulness marks their approach to other crops. Yearly applications of twenty tons per acre of mushroom compost have boosted soil fertility to high levels. The fields are always plowed throwing the soil uphill, in the never-ending fight against gravity on this farm. They have a 125 HP IH 1066 for such heavy tillage; also a plastic layer designed for sloping contour fields.

Mike and Terra have invested in such well-chosen equipment and also in an excellent packing facility and a half-acre gutter-connected glass greenhouse for early tomato and transplant production. All of their crops are irrigated if necessary, most with drip under plastic. A 300-gallon per minute well supplies the water.

Twenty- to 40-foot wide mowed grass strips alternate on contour with the 40-60 foot wide vegetable strips, to help control erosion. These grass strips are also used as spray and harvest lanes, plus they provide habitat for beneficial organisms.

Pest management at Spiral Path ranges from lettuce (no sprays) to tomatoes and squash which each received several insecticide and fungicide sprays in 2002. Regular copper hydroxide sprays on the tomato crop undoubtedly contributed to its excellent yields in 2002, as early blight and other diseases were minimal through the season. Crop families are rotated through the fields on a regular basis, helping with pest control.

Not everything is perfect at Spiral Path Farm, of course. Deer get some of the lettuce; in the wet 2003 season, black rot hit the butternut squash pretty hard. Overall, about 65% of their total lettuce crop was sold in 2002—some lost to deer and heat, some left in the field unsold.

One long-term problem may result from too much a good thing. Looking at Table 1, nutrient levels look good—in fact, really good. However, extrapolating the nutrient increases into the future indicates that at some point, excessive values will be reached. Already, P values are getting high. These are the sorts of problems that a network such as NEON can help to overcome. Other NEON farmers and researchers are finding ways of maintaining high fertility and organic matter levels in an equilibrium situation. One farm, for instance, is incorporating wood chips into its compost to give long-term organic matter benefits without carrying many nutrients. NEON researchers are also looking at vegetable farm nutrient budgets and rotations that require less compost inputs. These joint farmer-researcher efforts can enable the trend of nutrient accumulation to be remedied before it becomes a problem.

Spiral Path Farm is successful at producing large volumes of high quality organic vegetables while providing a good income and quality of life.

Beech Grove, a small-scale extensive vegetable farm

In spite of their relatively small acreage, the Nordells put 3 of their 7 acres in cover crops each year. And in spite of the common notion that draft horses are inefficient, imprecise, and uneconomical, this is an extremely well managed farm from many standpoints.

Eric and Anne have evolved a crop rotation that has profound effects on weed management and soil quality and fertility. They call it "extensive", rather than intensive, vegetable farming. Their 6-acre upper main field is divided into 12 sections of about _ acre each (roughly 8000 row feet per section at their 32" spacing). Each section alternates over the seasons between cash crops and cover crops with a fallow.

Between cash crop seasons, the Nordells use a combination of cover crops for enhancing soil nutrients and quality, plus a bare fallow period to kill flushes of weed seedlings. For instance, typically they might have seeded rye the preceding fall after their cash crops. The rye would be mowed twice in the following May and June, then plowed in. A bare fallow period of about 4-6 weeks is maintained by harrowing with a springtooth about every 10 days. Then oats and field peas are planted. These will winterkill, and be easy to till under for next season's cash crop.

Over the years, this alternating cash crop/fallow system has resulted in a remarkably low weed seed bank. For instance, 24 weed samples taken in 2002 lettuce crops at harvest showed an average of less than 10 lb fresh weight of weeds per acre in their fields. The lettuce had been cultivated but received no hand weeding.

There is no irrigation source for the upper field—all crops are grown on the 32" spacing, which tends to allow for a large volume of soil to be provided for each plant, so that more rainfall is available for the crop. It is crucial for soil quality to be high so all rainfall can be captured in place and stored.

Beech Grove Farm specializes in cool-weather crops such as lettuce and spinach grown throughout the season, plus root crops like potatoes, carrots, and onions. Yields of some crops might be expected to be low on this farm, since all crops are planted on a 32" row spacing. However it is interesting to note that lettuce on a 9"x 32" spacing (21780 plants per acre) compares favorably with 4-row beds spaced at 12" between plants, with beds on 7' centers (24890 plants/A). The Nordell's small scale and flexible marketing enable them to sell almost 100% of their marketable lettuce heads (93% of their total stand in 2002). On the other hand, per acre carrot, onion, and beet yields are significantly reduced because of the wide spacing.

Few pesticides are used on this farm. Bt is sometimes used on cabbage family crops, and sometimes a pesticide is sprayed against flea beetles, cucumber beetles, or potato beetles. But most of the crops receive no sprays. The Nordells have focused on cultural management for some troublesome pests. Crop rows are interspersed rather than planted in blocks so that the fields are heavily intercropped. Buckwheat strips are repeatedly planted throughout the fields so that there is continuous bloom, serving as a trap crop for tarnished plant bug. They have reduced the amount of legume cover crop that gets mowed in midseason, also to prevent TPB migration onto crop plants. In the hot, dry season of 2002, thrips became a problem in their onions. Eric and Anne are working on how they might change their winter grain cover crop management to reduce this source of onion thrips.

They employ a novel technique to reduce slug populations that are encouraged by their high levels of cover cropping and residues.   Chickens are fenced for several weeks into areas slated the following year for crops such as lettuce in which slugs are a serious problem. From their observations, the chickens greatly reduce slug pressure there early the next season.

There are special and rather subtle aspects of this system—for instance, which cover crops are best to prepare for early vs. late-planted crops the following season? Also, the Nordells are looking to enhance their soil quality further by reducing tillage closer to a no-till system. They are using ridge tillage to increase the to soil temperature in mostly untilled soil. The Nordells have adapted their horse drawn equipment to create ridges and handle them with reduced tillage seedling and cultivation.

One drawback of this system is that it depends on an extremely high level of skill and knowledge on the part of the farmers. The diversity of tasks with animals and vegetable crops keeps things interesting, but makes for a heavy workload for two people.

I have contrasted these farms to make them more instructive. However, they have many things in common: Both are known for excellent quality production; both extend their season with greenhouses or hoophouses; both use equipment adapted or modified to their specialized systems; all four of the owners work long hours. These farms are on the cutting edge of organic farming, and provide important insights on how to manage a successful organic vegetable farm in the Northeast.

Table 1. SPIRAL PATH SOIL TESTS

	FIELD A4 1998	FIELD A4 2000	FIELD C10 1998	FIELD C10 2000
pH	6.9	7.1	7.1	7.2
OM	1.4	4.1	3.3	4.1
P-Bray 1	60	114	41	65
P-Bray 2	89	240	69	161
K	215	273	161	178
Mg	234	217	130	149
Ca	1740	2100	1440	1600

Table 2. 2002 Yields (wet spring, dry summer)

	Beech Grove 2002 Yield #/A	Spiral Path 2002 Yield #/A	NYS Average Yield #/A
Carrot	18,400		26,000
Onion	8,800-12,000		35,000
Lettuce	1550 doz	780 doz	25,000
Tomato		30,000-61,000	20,000
Winter Squash		19,000	30,000

Promising New Materials for Organic Pest Control

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The Organic Materials Review Institute (OMRI) is a non-profit organization established in 1997 for the purpose of reviewing products and ingredients used as inputs for organic production and processing. OMRI publishes a frequently updated list of products that are compliant with the USDA National Organic Program regulations, available in hard copy from OMRI and freely accessible on the OMRI website (www.omri.org).

Organic farmers face limitations established in the organic regulations regarding permitted materials. Growers may only use a synthetic substance if it appears on the National List (7CFR 205.600-607) for the specific application. The National List includes only a few permitted synthetic substances including soaps, copper and sulfur compounds, narrow range oils, hydrogen peroxide, potassium bicarbonate, sticky traps and pheromones. Natural materials, such as microbials (including *Bt*, *Beauvaria, Trichoderma*) and botanical pesticides such as rotenone and pyrethrum are also permitted without specifically appearing on the National List. In addition, all inert (non-active) ingredients in formulated products must either be non-synthetic, specifically included on the National List, or appear on EPA's List 4 – as an inert ingredient of minimal concern. Products must be reviewed for compliance with the USDA regulations, as many formulations do contain prohibited inert ingredients.

The OMRI list provides information about what products are permitted, and many new products have been added in the last two years. There is not a great deal of information available, however, about the efficacy of these materials for specific pest and disease problems. OMRI is participating in a joint research project to produce a set of fact sheets about different materials available for pest and disease control of organic crops. These fact sheets will include information on the source of the active ingredient, mode of action, application guidelines, effects on the environment and human health, available formulations, and efficacy based on literature review. A separate section of guidelines will provide management information regarding major vegetable crop families that describes the pest and disease complex and various options for control in organic systems, including preventive and cultural methods.

Fact sheets in development include *Bt*, spinosad, *Beauveria*, neem, pyrethrum, potassium bicarbonate and *Bacillus subtilis*. Information developed to date on these topics will be presented, including charts rating efficacy against various pests. The project completion date is scheduled for May 2004 with publications available some time after that.

Project collaborators include Eric Sideman of the Maine Organic Farmers and Gardeners Association, Brian Caldwell of NOFA-NY, and Tony Shelton and Chris Smart of Cornell University, with funds from the Northeast SARE program, as well under the Northeast Organic Network program funded by CSREES-IFAFS.

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Expanding Organic Highbush Blueberry Production

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Four significant developments have occurred that amplify opportunity for certified organic growers to successfully grow organic highbush blueberry and to increase or transition acreage. First, there is the recent USDA national organic standardization that defines organic production practices and crop labels that creates clarity and evens competition. Second, we have the continued increase of smallfruit and vegetable sales related to nutritional and human health reasons that strongly contribute in creating today's $40,000,000 highbush blueberry market in NJ. Future agribusiness gains are promising through the "organic certification" market segment. This organic designation appeals to today's consumer as an even higher market value and creates a separate market segment above the fresh market mainstream. Third, new tools are becoming available to organic growers that reduce the risk from pest problems such as the recent organic registration of Spinosad – now known as Entrust in the organic market. Finally, the Rutgers Blueberry Research Working group has made considerable progress in refining standard IPM practices and in helping develop new tools and holistic approaches for organic production systems. Our "Work in Progress" is establishing alternative approaches to some current agricultural practices in soil building, fertility, cultural approaches and pest management.

When blueberries were first selected and cultivated in the early 1900's, the traditional culture of this native small fruit was essentially organic in nature. Currently, perhaps 2/3's of what "conventional" growers do horticulturally is directly applicable to organic production. Some examples include selection for resistant varieties, pruning for canopy ventilation to reduce disease incidence, adding organic amendments in building soil such as peat and humus, mulching for weed control and water conservation, raised mounds, rogueing of infected plants and the use of natural plant protection products like Bt, Pyrethrum and Spinosad which are safe to natural enemies.

In contrast to other fruits that have been introduced from other countries, the blueberry is one of the few native American fruits that has relatively good natural resistance to diseases and insects as well as an inherent vigor because it has been domesticated for less than 100 years. Thus, there is this strong historic baseline for succeeding in the return to organic production although some key risk factors remain to be solved. To achieve this comprehensive vision of an integrated organic production system, specific obstacles are being addressed by a team of collaborating specialists supported by RCE administrators Dr. Nick Vorsa of the Phil Marucci Blueberry and Cranberry Research Center and Jack Rabin of the NJ Agricultural Experiment Station as follows:

<u>Varietal Selection</u> – Dr. Mark Ehlenfeldt comparative work for the USDA breeding program suggests using early maturing varieties to escape later season blueberry maggot attack like Weymouth, Bluetta and Earlyblue. Mark continues research with new and better varieties resistant to pathogens that are essential in initiating any organic enterprise.

Fertility – Dr. Gary Pavlis has demonstrated the importance of pH in maximizing plant health through the enhanced availability and uptake of nutrients as the ammonium nitrogen form. Gary has also demonstrated the water conservation benefits of trickle irrigation. Dr. Joe Heckman points to a listing of organic based fertilizers to include nitrogen, phosphorus and potassium sources such as rock phosphate, greensand, bone meal, fish meal and composted manures to restore depleted soils. Check out recent and previous editions of the Rutgers Extension newsletter - Blueberry Bulletin.

Mulching – Dr. Barbara Rogers is researching the impacts of organically approved mulches for soil benefits and weed control. Barbara's investigations with Dr. Uta Krogmann include the recycling of composted cranberry fruit and leaves, municipal leaf blends with available manures, wood chips and plastic mulch.

IPM Scouting – Our state fruit IPM specialist Dean Polk has provided timely pest population data that is GIS positioned within a blueberry field to allow spot spraying as needed based upon economic thresholds. Dean's extensive scouting program utilizes direct pest assessment, pheromone trapping systems and colored sticky boards for decision-making.

Entomological Research – Dr. Sridhar Polavarapu has emphasized pruning of old cane to reduce scale infestation, clean cultivation to suppress cranberry weevil and plum curculio and using OMRI approved insecticides as *Bacillus thuringiensis* (Bt), azadirachtin (neem plant extract), rotenone, pyrethrum and spinosad. Spinosad should handle the difficult to control aphid complex and other economically important insect pests. Sridhar's research on baited toxicant sphere attractant traps for blueberry maggot and pheromone trapping approaches for oriental beetle are quite promising for commercialization.

Phytopathology Research – Dr. Peter Oudemans has stressed the importance of sanitation in the field to minimize pathogen entry and spread, use of certified free nursery stock, rogueing of virally diseased plants, pruning of bacterial or fungal infected stems and the promotion of rapid drying of leaf and fruit surfaces. OMRI certified fungicides as oxidate are part of his efficacy evaluation program as have been the natural minerals sulfur, lime and copper and bordeau mixture, kaolin clay and urea. Mechanical cultivation and new biological controls appear promising for Mummyberry suppression in the soil.

Weed Control – Dr. Brad Majek provides weed species identification and essential information as to the life cycle of these annual, biennial or perennial grass and broadleaf weeds. Brad's advice helps plan for a weed control program which includes trying various mulching practices and treatments.

Commercial Organic Grower – John Marchese, Emery's Berry Farm. John's progressive approaches to planting, weed control and fertility from an organic underpinning have been extremely helpful in establishing commercial utility. His comparative use of the Weed Badger rotary hoe, flaming, cover cropping, mulching and alleyway establishment and other methods are pointing out some ways for economically solving problems specific to large-scale organic production.

Commercial Conventional Grower – Bobby Galletta, Atlantic Blueberry. Bobby and his family continue to share their legendary experiences and extensive knowledge in blueberry production in efforts to expand the industry and maintain profitability.

Certification & OMRI Information – Karen Anderson - Erich Bremer – NOFA-NJ. The Northeast Organic Farming Association of NJ has been actively involved in certifying acreage for organic production and in explaining to growers the approved practices and materials that are essential to maintaining compliance. Through NOFA, growers can connect with other growers as to successful farming practices and can gather current information on plant protection materials and fertilizers through OMRI: Organic Materials Resource Inventory. Call 609-737-6848.

Final Comments –Currently, about 7,500 acres of blueberries are grown in NJ with less than 2% (approximately 110 acres) produced organically. The authors believe that the agribusiness situation is that of an advanced market ahead of agricultural research; demand ahead of supply. The price of a flat of organic blueberries has ranged from $18 to $28 over the last three years while conventional production prices have generally ranged between $8 to $14 per flat. Any growers interested in transitioning to organic blueberries may feel free to contact the author for advice and connection to the team of leading experts referred to in this article. 732-431-7260 or e-mail sciarappa@aesop.rutgers.edu

Stand Establishment, Spacing and Fertilization to Maximize Pumpkin Yield

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Acreage of pumpkins has grown considerably in the United States over the past twenty years. The majority of these pumpkins are grown solely for Halloween sales and are for decoration only and not for human consumption. Americans now spend more on Halloween – 2 billion dollars – than any other holiday except Christmas. With the increase in acreage, production practices have also changed. At one time, pesticide inputs were very limited. Recent studies, however, indicate that an effective disease control program may significantly increase the yield and quality of the crop . Weekly fungicide applications alone may cost growers $300 - 500 per acre annually. In an effort to maximize profitability, growers are exploring ways to increase yield per acre in order to save on land, pesticide, fertilizer, labor, and machinery costs.

I. Stand Establishment

With the increase in hybrid seed costs, some growers have looked at transplanting single plants rather than direct seeding a high number of seeds to ensure a good stand. In addition, transplanting may aid in cucumber beetle and weed control. In 2001, a field study was conducted in Geneva and Riverhead, NY, which compared direct seeded and transplanted plots.

Table 1. 2001 Stand establishment trial parameters.

Variety	*Planting Treatments*	*Planting Date*
Magic Lantern	24 Cell - 118 cm^3	Geneva - 6/14, bare ground
	38 Cell - 76 cm^3	Riverhead – 6/25, plastic and trickle
	Direct seeded	Transplants 3-4 weeks old

- Planted on 6 foot centers with 4 feet between plants, one plant per hill
- 50 lbs/A N added at planting; 50 lbs/A N sidedressed when vines begin to run

Transplants were quick to establish compared to the directed seed plots. At Geneva, female flowers were first observed on July 6, and the first fruit set on July 13, one month after planting. Fruit in the transplanted plots were ready for harvest about two weeks before the seeded ones. At both locations, yields were significantly greater using transplants (Table 2).

The research summarized in this report could not have been completed without the financial support of the Pennsylvania Vegetable Marketing and Research Program, the NYS Vegetable Growers Association and Friends of Long Island Horticulture. Also, thanks to cooperating growers, Saulpaugh and Sons, Richard Ball, and Burton Metice. Finally, special thanks to research/extension colleagues Dale Riggs, Dale Moyer and Peter Nitzsche.

Table 2. Yield of transplanted and direct seeded pumpkins at two locations in 2001

	Riverhead, NY			Geneva, NY		
Treatment	No./A	Tons/A	Avg. Wt. (lbs)	No./A	Tons/A	Avg. Wt. (lbs)
Direct Seed	1958	10.2	10.1	1771	9.0	10.4
Cell Size 24	2302	14.5	12.7	2189	12.4	11.4
Cell Size 38	2232	13.0	11.4	2347	13.7	11.7

Smaller transplants would be more economical. In 2002, a study was performed at both Geneva and Riverhead, NY, to determine the effect of planting date and variety on the yield of direct-seeded and transplanted pumpkins.

Table 3. 2002 Stand establishment trial parameters.

Variety	*Planting Treatments*	*Planting Date*
Magic Lantern	50 Cell - 66 cm^3	Geneva - 6/10, 6/24 bare ground
Gold Bullion	98 Cell - 23 cm^3	Riverhead – 6/6, 6/20, plastic and trickle
	Direct seeded	Transplants 3-4 weeks old

Table 4. Yield of transplanted and direct seeded pumpkins at two locations in 2002

	Riverhead, NY			Geneva, NY		
Treatment	No./A	Tons/A	Avg. Wt. (lbs)	No./A	Tons/A	Avg. Wt. (lbs)
Direct Seed	4176	24.1	11.6	1588	6.6	8.3
Cell Size 50	5304	29.9	11.3	2070	10.0	9.3
Cell Size 98	4896	28.1	11.6	2240	10.4	9.5

Consistently, transplanted pumpkins out yield directed seeded plots. There seemed to be no advantage in using larger transplants as even the smallest ones used in this study yielded no differently than the largest. With a yield increase of 25% to 50% in tons per acre, cost of transplants should more than pay for their additional cost.

II. Plant Spacing

Grower practices vary in terms of spacing to optimize pumpkin yields. With cucumbers and watermelons, closer spacing has led to an increase in fruit per acre along with a smaller fruit size. The effect on tons/A seems to vary, resulting in either no effect or a significant increase. This trial was conducted to determine the effect of spacing on two pumpkin varieties, Howden, a large vining type, and Wizard, a semi-bush type.

Pumpkins were planted on 6 foot centers with in-row spacings of 1, 2, and 4 feet. Plants were thinned to a single plant per hill. At both locations, closer in-row spacings significantly increased the number of pumpkins/A while decreasing the average weight per fruit. At one location, despite the smaller fruit, the increase in fruit numbers resulted in a significant increase in tons/A (Table 5) while in the second location, the tons/A was not increased. Why the difference? The location in which we saw increased tons/A was irrigated while the other location was not. Apparently, to take maximum advantage of increased plant populations, growers need to ensure that water is not limiting.

Table 5. Yield of pumpkins at 6 foot between-row spacing and three in-row spacings.

Plant Popn./A	In-Row Spacing (ft)	No./A	Tons/A	Avg. Wt. (lbs)
1815	4	1491	8.1	10.9
3630	2	2368	12.2	10.1
7260	1	3566	14.1	7.8

Growers have two options when increasing plant populations: either within-row spacings or between row spacings can be decreased. From our previous trial, we know that changing in-row spacing significantly affects yield. For pumpkin growers, a wider between-row spacing may be better, allowing for easier access to fields for the purpose of cultivation, pesticide, or fertilizer applications. A trial was conducted comparing the same plant populations on 6 and 12 foot centers. For 6 foot centers, in-row spacings of 2, 4 and 6 feet were used. For 12 foot centers, in-row spacings of 1, 2, and 3 feet were used.

For both the 6 and 12 foot centers, we saw an increase in yield as within-row spacing decreased and population increased (Table 6). Row width had little effect on any aspect of yield with the exception of the number of fruit/A. Six foot centers resulted in a significant increase in fruit numbers at both locations (Table 7). The greater number of fruit did not result in increased tons/A as the average fruit size declined slightly with the narrow spacing.

Table 6. Yield of pumpkins at 6 and 12 foot between-row spacing and three in-row spacings.

Plant Popn./A	In-Row Spacing (ft)	No./A	Tons/A	Avg. Wt. (lbs)
1210	12x3 or 6x6	1540	15.0	20.7
1815	12x2 or 6x4	2250	19.1	17.6
3630	12x1 or 6x2	2804	21.9	16.3

Table 7. Yield of pumpkins at 6 and 12 foot between-row spacing.

Between-Row Spacing (ft)	No./A	Tons/A	Avg. Wt. (lbs)
6	2440	19.7	17.4
12	1990	17.7	18.9

The data indicate that row width may become more important at higher plant populations (Table 8). The highest plant population resulted in greater fruit number and tons/A. The effect is significant, however, only when spacing between rows is narrow. The narrow row width provides each plant a more square area of land than did wider spacings at the same population. Plants are spread out more evenly in the field and may be less likely to compete in this arrangement. The effect was seen for both a large vining variety (Howden) as well as a semi-bush type (Wizard). This effect may be more pronounced when yields are maximized with optimum inputs of fertilizer, irrigation, and pesticides.

Table 8. Yield of pumpkins at 6 and 12 foot between-row spacing and three in-row spacings.

	6 Foot Between-Row		**12 Foot Between-Row**	
Plant Popn./A	**No./A**	**Tons/A**	**No./A**	**Tons/A**
1210	2040	18.4	2010	22.2
1815	2200	21.0	2120	22.3
3630	3350	31.2	2480	23.3

Some growers have traditionally kept two or three plants per hill in the belief that this increases yield. It is also good insurance in case a plant is lost to insect or disease. Based on previous studies, it would seem that two or more plants per hill would not increase yield. In 1997, a trial was conducted in which pumpkins were grown on six foot centers with 2, 4, or 6 foot in-row spacings. Each hill contained either one or two plants. As in the other studies, Howden and Wizard were the varieties grown.

Doubling the number of plants per hill had very little effect on yield (Table 9). At one location, there was an increase in fruit number/A and a decrease in average fruit size with two plants. Most of the significant increase in yield was all due to the closer in-row spacings which resulted in more fruit/A and more tons/A, with a typical decrease in fruit size.

Table 9. Yield of pumpkins with one or two plants per hill.

	Geneva			**Albany**		
Plants/Hill	**No./A**	**Tons/A**	**Avg. Wt. (lbs)**	**No./A**	**Tons/A**	**Avg. Wt. (lbs)**
1	1895	13.3	14.6	2884	24.2	16.8
2	2662	14.0	10.9	3145	26.2	16.7

III. Nitrogen fertility

Trials conducted at two locations in 1995 demonstrated that there was little difference in the yield of two pumpkin varieties (Howden and Wizard) as nitrogen rates were increased from 60 to 140 lbs/A. There was a trend towards slightly larger fruit size with higher rates of N but this was not consistent (Table 10). These tests were conducted on silt loams with relatively good nutrient holding capacity so greater amounts may be useful on sandy or gravely soils. Higher amounts may lead to more foliage which could lessen fruit set. Based on these tests, 60 to 100 pounds N/A seems to be adequate.

Table 10. Yield of pumpkins with 60, 100 and 140 pounds of nitrogen.

Between-Row Spacing (ft)	**No./A**	**Tons/A**	**Avg. Wt. (lbs)**
60	2368	10.0	8.4
100	2470	11.4	9.2
140	2590	12.7	9.8

Selecting the Right Pumpkin For Your Market
2003 Jack-O-Lantern and Pie Pumpkin Variety Trials

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Pumpkins come in all shapes, sizes and colors these days and sometimes it can be hard to determine which ones are suited for your market. What some retailers are looking for is not what wholesale growers are growing and vice versa. In our experience, wholesale growers are generally looking for a 20 to 30 pound pumpkin or bigger. Although theses are popular at retail stands, I believe the 12 to 18 pound pumpkin is also very popular. When it comes to pie pumpkins, there is more consensus between wholesalers and retailers with 2 popular size classes: 6 to 10 pound and 2 to 5 pound fruit. There is also the mini and munchkin class of small ornamental pumpkins in the 1 pound or less that are very popular.

There can be no substitute for first hand experience with what varieties do well at your own farm and market, but variety trial reports can be of help by allowing one to see many different varieties grown under similar conditions. This way, a grower can see and compare varieties to one another and decide which one may work for their particular market. In 2003, we evaluated 15 Jack-O-Lantern types and 11 pie types including industry standards and experimental lines from seed companies and university breeding programs. A Jack-O-Lantern in this trial is described as having a minimum average weight of 12 pounds and is further broken down into small (12 – 15 lbs), medium (16 – 19 lbs), and large (20 lbs +) fruit size. Pie types are those with a maximum average weight of 10 pounds or less. This trial also included one specialty mini pumpkin weighing less then a pound. Total marketable yield and average fruit size can be found in Table 1. Descriptive characteristics such as shape etc., can be found on the next page.

This variety trial was located in Rensselaer County at the Wertman Farm in Melrose, NY, which is about 15 miles east of Albany. Plants were seeded in the greenhouse on June 5, 2003 in 48 cell packs. The selected field was marked using a water wheel transplanter on six foot centers with four foot in row spacing and planted by hand on June 24, 2003. Each plot contained 2 rows with 10 plants per row for a total of 20 plants per plot, which was replicated twice for a total of 40 plants per variety. Initial transplant growth was very slow and was associated to very hot dry weather at the time of planting. As seen by the “Number of Plants Harvested” column in Table 1, transplant survival for most varieties was not 100%. In mid July, plants were sidedressed with 300 lbs per acre of urea. The fertilizer with the addition of some rainfall improved plant vigor and vines started to close in the rows. This trial received two systemic fungicide applications in late August tank mixed with a protectant. Plots were harvested on October 10, 2003.

Wholesalers, retailers, u-pick operations etc. are all in the market for the perfect pumpkin. But what is the perfect pumpkin? We hope the information in this report can be of help, but remember that first hand experience with a variety on your own farm is still the most important trial of all. Don’t be afraid to try something new, but I recommend starting out with your own small trial and taking good notes not just yield and fruit characteristics, but how it sells once it gets to your market.

Jack-O-Lanterns:

Aladdin (115*): newer pumpkin variety (was HMX 6689) that is overall very attractive - large fruited, mostly tall to round tall in shape with a beautiful, very dark-burnt orange color, slight to moderate ribbing - a long, but thin handle that is slightly rubbery, may be too small for the size of fruit – variety also has Powdery Mildew tolerance

Gold Medal (90): decent yielding attractive large pumpkin that is mostly tall round, nice dark orange color with numerous, moderate to deep ribs – handles are thick, well anchored and appropriately sized for this fruit.

Gold Gem (100): decent yielding pumpkin, slightly larger then Howden, mostly round to tall round shape and good dark orange color and a bumpy appearance to skin, moderate ribbing and fairly strong, well anchored handles.

Gold Standard (90): very uniform, medium sized fruit are mostly round squat with a very attractive dark orange color, uniform medium ribbing, with long, thick, well anchored strong handles that tend to hold their green color for quite a while.

Howden (100): this is still regarded as the industry standard for Jack-O-Lanterns and is still one of the most commonly grown varieties – fruit are large, shape is variable, mostly being tall rounds with some round squats occasionally – medium to dark orange color with medium to deep ribs - handles are thick and well anchored.

Howdy Doody (90): attractive medium sized Jack-O-Lantern that is variable in shape from tall round to squat round with a medium to dark orange color – most have slight to medium rib and short to medium length handles that are strong and well anchored.

Magic Lantern (115): very attractive – medium-large fruit - excellent yielding, mostly tall to round tall in shape with a beautiful, very dark-burnt orange color, slight to moderate ribbing – handles are long, but thin that is slightly rubbery – smaller version of Aladdin – variety also has Powdery Mildew tolerance.

NH 1757 (na): small sized Jack-O-Lantern that looks very similar to Racer – very attractive dark orange color, round squat shape with medium to deep ribs – dark green, medium long thick handles that are well anchored.

NH 1765 (na): large warted fruit that are mostly tall round with dark orange color and medium to deep ribbing – handles are very thick, strong and well anchored – excellent looking variety except for the large bumps or warts on the fruit – they do turn orange but maybe a negative overall for the variety

Racer (85): very uniform, very attractive medium sized fruit, mostly round round to squat round with a dark orange to burnt orange color – handles are long, very thick, well anchored and very sturdy – excellent yielder, color, stems and uniformity – also has a restricted vine growth habit and is quick to mature.
RPX 03508 (na): large fruited variety that are mostly tall rounds – color is variable from yellowish orange to medium dark orange and medium ribbing – handles were thin, dried up and brittle – poor handle quality overall.

RPX 03512 (na): medium large Jack-O-Lantern with a very attractive shape – mostly round tall with variable color, medium orange - and medium ribbing – handles were thick well anchored and well sized for the fruit but dried up and brittle.

RPX 03511 (na): small to medium sized Jack-O-Lantern with a round shape – medium to dark orange color, medium orange color and medium ribbing – handles were thick well anchored and well sized for the fruit but dried up and brittle.

Sorcerer (115): very attractive – medium-large fruit - mostly tall to round tall in shape with a beautiful, very dark-burnt orange color, slight to moderate ribbing – handles are long, but thin that is slightly rubbery – very similar to Magic Lantern, but no Powdery Mildew tolerance.

Trojan (110): potential for very large Jack-O-Lanterns, but variable in shape and size – med orange color with medium ribs – mostly tall shaped fruit – handles are thick, but become somewhat brittle when dried

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Pie Pumpkin Types

Baby Pam (100)**:** very attractive and uniform – productive, 2 to 3 pound fruit – round squat in shape and medium to dark orange color – handles are long and nicely sized for the size of the fruit – handles are also durable even when dried down – has a slight to medium rib.

Hybrid Pam (90): very attractive and productive medium large pie with exceptional dark orange color – shape is round squat, but is somewhat tall as well - medium deep ribs - has a long, thick, well anchored, strong, dark green stem – one of the nicest pie types in the trial. This variety is also a restricted vine type.

Mystic Plus (105): very attractive large pie type with a unique dark burnt orange color with slight to medium ribbing – round but tall shape but is somewhat unique because it is more rounded at the top then others - handles generally remain dark green and are long and thick.

NH 1754 (na): very attractive large pie pumpkin type – almost a small Jack-O-Lantern – very uniform, dark orange color with medium deep ribs – handles are very short but dark green, very strong and well anchored.

NH 1759 (na): excellent yielder and attractive, but hard to determine where it belongs – could go as either a large pie or a small Jack-O-Lantern – similar to NH 1754 - dark orange color, round squat shape, medium to deep ribs and a short, strong, well anchored dark green stem.

NH 1755 (na): medium sized pie with dark orange color with numerous but slight ribs – handles are very short, but very thick, strong and well anchored and stay a dark green color – has good potential for a 4 to 5 pound pie pumpkin.

NH 1770 (na): very attractive and uniform large pie type fruit with dark orange color and deep numerous ribbing, with a high round squat shape – short, strong, dark green handles that are again well anchored.

NH 1771 (na): very attractive, productive and uniform pie type fruit slightly smaller then NH 1770 - dark orange color and deep numerous ribbing, with a round squat shape – short, strong, dark green handles that are again well anchored.

Orange Smoothie (90): very unique pie type in that the shell is very smooth with very little ribbing – excellent for painting – stems are short and dry down to a tan color, but remain strong – has a light orange color that can have a slight roughness to the touch – generally round in shape and quite productive.

Spooktacular (85): very similar to Baby Pam in size, shape and color – very productive and fairly uniform – medium to dark orange color with a slight to medium rib – handles are much shorter compared to Baby Pam, but are strong and dry to a tan color – very attractive.

Trickster (85): small pie type that is very productive, yielding dark orange fruit with slight to medium ribbing – fruit are squat round with long, thin handles, well suited for the size of the fruit- very attractive.

Specialty Mini Pumpkin:

RPX 03102 (na): very similar to Wee-Be-Little- small specialty type mini pumpkin – light orange to yellow in color with a slight rib – handles are short and actually quite thick for the size of the fruit – shape is more tall round then round squat- had a fair number of green striped fruit.

* Numbers in parenthesis are the relative days to harvest as given by the seed companies when available

Table 1 : 2003 Jack-O-Lantern and Pie Pumpkin Yields.				ADDENDUM: BORNT				
Variety	**Source**	**Days to Harvest**	**Total # of Plants Harvested**	**Total # Marketable Fruit**	**Marketable Fruit Weight (lbs)**	**Average Fruit size (lbs)**	**Average # Fruit per Plant**	**Yield per Plant (lbs)**
Pie and Specialty Pumpkin Types								
RPX 03102	Rupp Seeds	na	16	78	72.2	0.93	4.88	4.51
TRICKSTER	Rupp Seeds	85	39	128	300.4	2.35	3.28	7.70
SPOOKTACULAR	Rupp Seeds	85	16	34	99.25	2.92	2.13	6.20
BABY PAM	Rupp Seeds	100	25	65	190.8	2.94	2.60	7.63
ORANGE SMOOTHIE	Rupp Seeds	90	36	100	409.3	4.09	2.78	11.37
NH 1755	Univ. New Hampshire	na	17	36	158.7	4.41	2.12	9.34
HYBRID PAM	Seedway	90	30	67	305.35	4.56	2.23	10.18
MYSTIC PLUS	Harris Moran	105	32	61	345.35	5.66	1.91	10.79
NH 1771	Univ. New Hampshire	na	10	14	121.3	8.66	1.40	12.13
NH 1770	Univ. New Hampshire	na	23	38	386.65	10.18	1.65	16.81
NH 1759	Univ. New Hampshire	na	19	48	521.4	10.86	2.53	27.44
NH 1754	Univ. New Hampshire	na	18	18	202.6	11.26	1.00	11.26
Jack-O-Lantern Types								
NH 1757	Univ. New Hampshire	na	20	30	372.75	12.43	1.50	18.64
RACER	Johnny's	80	33	58	733.7	12.65	1.76	22.23
RPX 03511	Rupp Seeds	na	32	30	410.55	13.69	0.94	12.83
GOLD STANDARD	Rupp Seeds	90	21	25	347.65	13.91	1.19	16.55
HOWDY DOODY	Rupp Seeds	90	12	12	175.15	14.60	1.00	14.60
RPX 03512	Rupp Seeds	na	27	32	480.85	15.03	1.19	17.81
SORCERER	Harris Moran	115	32	41	637.6	15.55	1.28	19.93
MAGIC LANTERN	Harris Moran	115	23	37	662.05	17.89	1.61	28.78
HOWDEN	Harris Moran	100	25	26	509.65	19.60	1.04	20.39
NH 1765	Univ. New Hampshire	na	12	23	482.7	20.99	1.92	40.23
ALADDIN	Harris Moran	115	18	17	357.5	21.03	0.94	19.86
GOLD GEM	Rupp Seeds	100	22	29	626.75	21.61	1.32	28.49
RPX 03508	Rupp Seeds	na	18	22	507.45	23.07	1.22	28.19
TROJAN	Seedway	110	22	22	558.2	25.37	1.00	25.37
GOLD MEDAL	Rupp Seeds	90	30	18	627.85	34.88	0.60	20.93

We would like to thank our trial host Rich and Debbie Wertman of Wertman Farms, Melrose, NY and the above seed companies for their support.
Varieties were seeded in the greenhouse on June 5, 2003 in 48 cell packs, field planted on June 24, 2003 and harvested on October 8 and 10, 2003.

Getting a Handle at Harvest Time

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Pumpkin breeding at UNH

My introduction into breeding pumpkins began in 1979, but not in the traditional sense. For some years I had been interested in improving the productivity of hull-less (edible) seeded pumpkins as a food crop. Lack of being able to acquire research support for such a project had precluded my development of a pumpkin breeding program. However, in 1979 I was fortunate enough to get funding for a graduate student, Susan Stuart, through the Genetics Program at UNH. Susan was interested in basic research on the biochemical genetics of the hull-less trait, but nonetheless, provided me with summer research assistance to begin a pumpkin breeding program that has been very fruitful (no pun intended). I was eventually able to get some industry support that kept the project viable during the mid-1980s. Along the way, I recognized that in addition to breeding hull-less seeded pumpkins which might have limited use in the Northeast, there was need for improved varieties of jack-o'-lantern pumpkins. The focus of this paper will be on jack-o'-lantern pumpkins, and in particular, how to achieve better handle strength both through breeding and management.

My entry into variety development in pumpkins has been successful largely because of my recognition that hybrid varieties, because of their greater uniformity and adaptability, would likely begin to occupy a larger share of the commercial pumpkin market. F_1 hybrids result from the crossing of two parental, inbred lines. Production of hybrid pumpkin seed is most easily accomplished by using a bush strain as the female parent. The bush line can be converted to all female flowering by spraying plants with an ethylene-releasing compound (ethephon). Hybrid seed can then be produced by inter-planting rows of the female and male parents and letting the bees do the cross-pollination. By the early 1990s I was fortunate enough to have developed some bush lines with good handle strength, good resistance to fruit rots, and good seed yields. In cooperation with several seed companies, I have been able to combine some of my lines with their proprietary lines to create some new hybrids with desirable traits. I some instances, both parents of a hybrid have come from my breeding program, and all but one (Gold Medal) of the hybrids produced to date are the result of a bush x vine or bush x bush cross. The F_1 hybrids from such crosses have more restricted vine growth and can be planted with closer row spacing (6-7 ft.).

Table 1 lists all of the commercially available pumpkin varieties emanating from the UNH pumpkin breeding program during the past 12 years.

Table 1. Pumpkin varieties released through the NH Agricultural Experiment Station during the past 12 years. The source of male and female parents is also given, along with known vendors of the varieties and the producers of the seed.

Variety	**Size (lbs.)**	**Female parent**	**Male parent**	**Known vendors**	**Seed prod.**
Big Rock	15-25	UNH	Johnnys	JS	JN
Gold Fever	13-18	UNH	Rupp	RU	RU
Gold Standard	12-16	UNH	Rupp	JO, RU, SW	RU
Gold Medal	20-35	UNH	Rupp	RU	RU
Howdy Doody	12-16	UNH	Rupp	RU, SW	RU
Hybrid Pam	4-7	UNH	Seminis	SW, HA, JO, RU	SM
Neon	8-14	UNH	UNH	JO, RU, ST, SW,	HO
Orange Smoothie	4-8	UNH	UNH	JS, RU, ST,	SM
Pik-a-Pie	3-6	UNH	UNH	JO, RU, SW	RU
Racer	12-16	UNH	Johnnys	JS	JN
Schooltime	8-12	UNH	Seminis	new release	SM
Snackjack	1-3	UNH	UNH	HA, JO, RU, ST, SW	SM
Trickster	2-4	UNH	Seminis	JO, RU, ST, SW	SM
NH1041	2-3	UNH	UNH	new release	SM
NH1747	2-5	UNH	UNH	new PMT release	RU

HA = Harris Seeds; HO = Hollar Seeds; JS = Johnnys Selected Seeds; JO = Jordan Seeds; RU = Rupp Seeds; ST = Stokes Seeds; SW = SeedWay

Important attributes of a good pumpkin

Pumpkins come in all sorts of shapes, sizes and variations in orange hues. Each grower and each customer has his or her own preference for what constitutes the best pumpkin. There are now over 50 commercial pumpkin varieties, so growers have a large choice from which to select varieties that are best adapted to local growing conditions and meet the marketing needs and the demands of the customers that purchase pumpkins at roadside retail outlets. There is one common attribute, however, that all growers and customers like in a jack-o'-lantern pumpkin, and that is "good handle appearance and integrity." The handle or stem of a pumpkin, technically called the peduncle, must not only look attractive, but also should not shrivel excessively or deteriorate following harvest, and should generally be strong enough so that the fruit can be picked up by the handle and transported short distances without breaking. To understand how to best manage a pumpkin crop or select varieties with good handles, it is useful to understand how the fruit and stem of a pumpkin develop. Melanie Berg, a graduate student in Plant Biology at UNH, has been conducting research during the past three years on the developmental physiology of pumpkin peduncles. Her research is helping to provide answers to questions on what constitutes a strong handle, when do handles reach maturity, and when should pumpkins be harvested to maintain the strongest handles.

Fruit development in pumpkins

Pumpkins produce both male and female flowers; the male flowers are produced near the crown of the plant and female flowers are produced further out on the vines. Fruit growth actually begins when the ovary of female flowers starts enlarging. Flowers open in the morning and are only receptive for pollination for a few hours. And by the time the female flowers open, most of the cells that will comprise the pumpkin fruit have already been produced. Therefore, most pumpkin growth after flowering is due to cell enlargement. The time-course for fruit development is given in days after flower opening (anthesis). Pumpkin fruits expand quite rapidly and reach near maximum size by 20 to 25 days after anthesis (DAA). The most rapid period of expansion is between 10 to 20 DAA. Warm temperatures and ample moisture during this period of rapid growth are thus conducive to attainment of maximum fruit size. The solids or dry matter content of the flesh (mostly starch) also begins to increase during this period, and peak dry matter contents are attained by 30 to 35 DAA. High dry matter contents of the fleshy part of the fruit (the mesocarp) are associated with good eating quality in squash, but in ornamental pumpkins the flesh in usually not used. Nonetheless, the dry matter in fruit stems shows a similar pattern of increase as the flesh, and the dry matter accumulated in the stem of the fruit contributes to development of secondary wall molecules that provide stem strength and integrity. With higher stem dry matter, there is potentially greater accumulation of molecules such as lignin, cellulose and hemicelluloses that give stems the hard, woody structure.

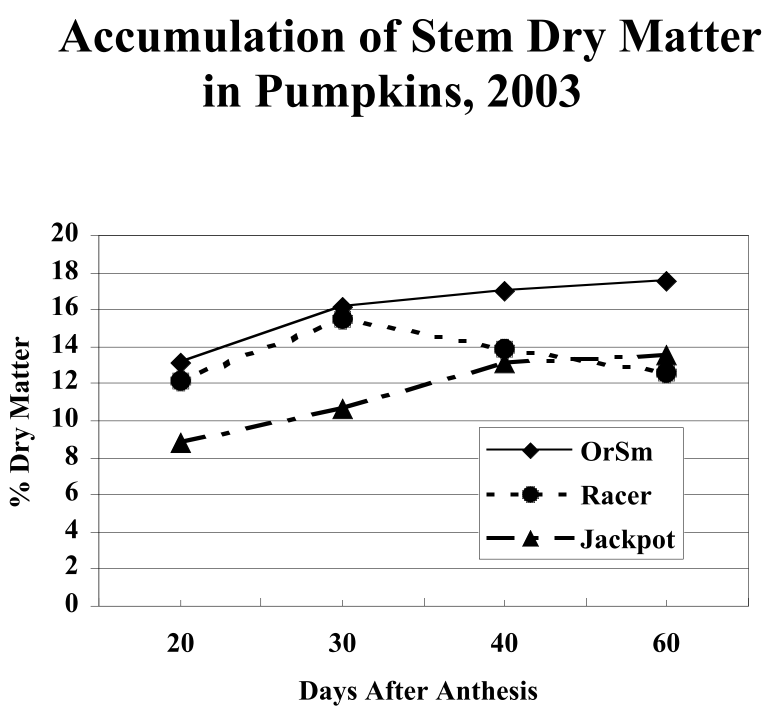

Figure 1. Acumulation of stem (peduncle) dry matter in pumpkin fruits of three varieties at different times after pollination. OrSm = Orange Smoothie

There are varietal differences in stem dry matter and differences in the rate at which stems accumulate dry matter. For example, Melanie Berg found in her pumpkin stem research that the variety "Orange Smoothie" has high stem dry matter (Figure 1), and in some years accumulates moderately high levels of stem dry matter as early as 20 DAA. As a result Orange Smoothie stems show much less shrinkage or shriveling than some larger fruited varieties at different harvest times (Figure 2). In other varieties such as "Jackpot", most stems never accumulate high levels of dry matter and the stems tend to deteriorate badly even if the pumpkins are harvested when fully colored. In general, if stems show 50% or less shrinkage, stem integrity is adequate, especially in the smaller-fruited varieties where stem strength is less important.

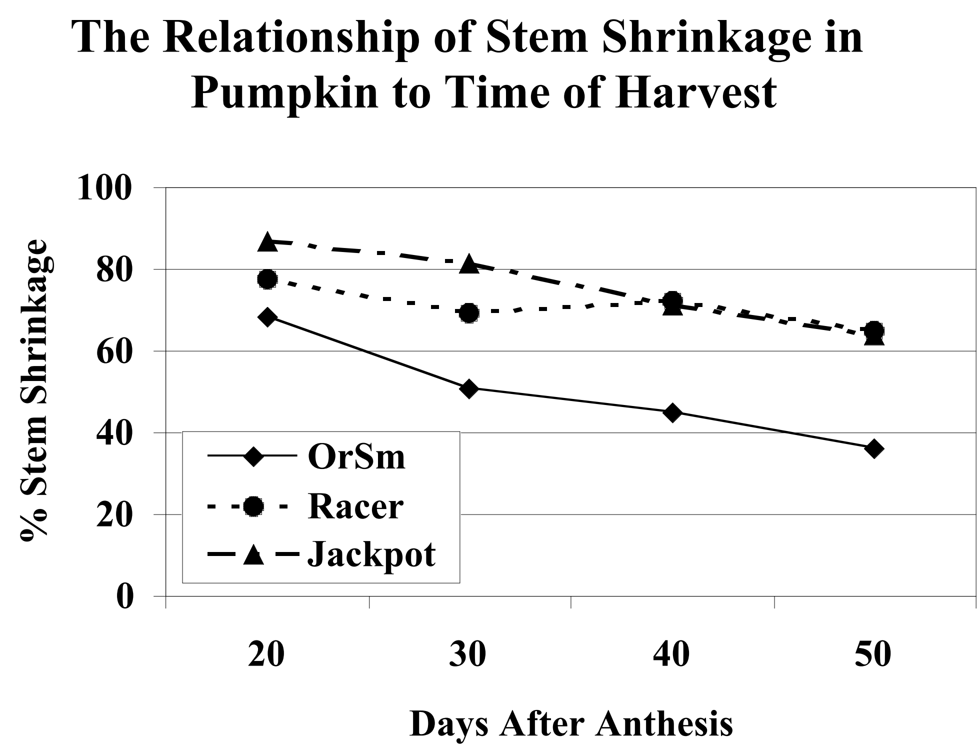

Figure 2. Stem shrinkage in 3 varieties of jack-o'-lantern pumpkin in relation to time of harvest. OrSm = Orange Smoothie.

The rind of pumpkins will usually begin to change from green to orange at about 25 to 30 DAA, and will be completely orange by 35 to 45 DAA. The exact point at which a pumpkin changes color will vary from year to year and among varieties. Technically, a pumpkin is not mature when the rind changes to orange, but when the seeds within the fruit mature. Maximum seed fill usually occurs between 50 to 60 DAA. However, because near peak stem dry matter is reached by 30 to 35 DAA, if pumpkins can be harvested at this time stems should become about as strong as if they were left on the vine until the seed matured. That does not mean that stem development is complete by 30 DAA. But if the building blocks are in place in the stem by 30 DAA, then subsequent synthesis of molecules such as lignin that give stems strength and rigidity can continue after the pumpkin is harvested. Currently, we have not identified the precise period during which the stem strengthening polymers are synthesized. However, stem hardening is apparent by 20 DAA, and based on the stem shrinkage results, may continue until the fruit reaches full maturity as long as the vine bearing the fruit has not died.

Plant growth and aging can affect stem strength

Growth of fruiting vegetable crops can be subdivided into vegetative and reproductive phases. In strictly determinate plants such as maize, the vegetative and reproductive phases are distinctly separated. However, in pumpkins vegetative growth continues after flowering and fruiting commences. In semi-bush or bush strains of pumpkins, especially those that produce large fruits, vegetative growth is markedly decreased or may even halt once the fruit begins to expand rapidly. This phenomenon is caused by the fruit being a more dominant sink for photosynthates produced by the leaves than are the growing points of the plants from which new leaves are initiated. It is important that pumpkin plants develop sufficient vegetative growth prior to fruit development so there are ample sugars produced by photosynthesis to support dry matter accumulation in the fruits and stems. If pumpkin handles do not accumulate sufficient dry matter by 30 days after flowering, then they are destined to shrivel badly or lack adequate strength once the pumpkins mature. Inadequate vegetative growth tends to be more of a problem in semi-bush than in vine varieties, so they have to be managed more carefully to insure good stem development. If photosynthates are inadequate for both vegetative growth and fruit development, premature senescence or death of the plant may occur.

When a plant begins to die or senesce, many of the reserve constituents in the leaves and stems are broken down and transported to the developing fruits and seeds. The control of this remobilization is not fully understood, but involves the production of enzymes that break down the reserve materials into sugars, simple nitrogen compounds, and a few other small molecules that can be transported through the conducting tissues of the stems and into fruits or other sinks (such as tubers in potato). I have observed that when pumpkins are left on the vine as the stems and leaves deteriorate, deterioration of the pumpkin handles occur. This has been viewed by many experts as a problem caused by an infectious disease invading the fruit peduncle. However, this phenomenon seems to occur even in senescing plant vines showing no visible disease symptoms. I believe that if pumpkins are left on a plant when the vine of the plant dies, a “senescent” signal is sent to the pumpkin stem, inducing it to begin the processes that result in degradation of such molecules as cellulose and hemicellulose that contribute to stem strength. Although this hypothesis remains to be proven, pumpkin handles will deteriorate if the vines are dieing, so **my advice** is to harvest pumpkins before the vines die.

Summary

There is a diversity of opinions as to what constitutes the most attractive pumpkin, but most everyone would agree that it is desirable to have an attractive, strong handle. Varieties vary considerably in handle size and strength. Because people tend to carry pumpkins by the handle, it is desirable to have larger and stronger handles for larger-fruited varieties. The dry matter content of the handle contributes to its capacity to synthesize secondary cell wall materials that contribute to stem strength. Because stem dry matter peaks at 30 days after pollination, it is recommended that pumpkins not be harvested until after this time period. Most pumpkins turn completely orange about 40 to 45 days after pollination, and it is recommended that they be harvested at this time or shortly after before the vines begin to deteriorate. Vine deterioration is associated with deterioration of pumpkin stems. Some of the new semi-bush varieties are adapted to closer row culture and easier weed management than the spreading vine varieties, but they must be managed well so that they produce ample vegetative growth before fruit are produced. A good vegetative, leaf canopy helps insure that a pumpkin plant can provide enough photosynthates for optimum fruit and stem development.

Growing Pumpkins Using Zone-tillage

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I grow all my pumpkins using Zone-tillage. I have 5 reasons why I use Zone-tillage. I would like to tell you about each of these points.

The first is that this method is just easy. To establish the crop, I make 4 trips through the field. The first is with my sprayer spraying Round-up. the second is with my zone-till cart. This rototills the soil in the seed zone and adds a mix of liquid fertilizer to either side of the row. The third trip through the field is with the planter. The planter places the seed into the zone and adds dry fertilizer to the zone. The last trip is again with the sprayer, spraying Gramoxone just before the plant comes out of the ground.

The second reason that zone-tillage is good for us is that it is so consistent in producing a quality crop of pumpkins. I can get the crop in quickly and it grows well. Using Zone-tillage has other benefits that allow us to increase management practices. These include scouting for weeds and insects and timely sidedressing.

The next reason that Zone-tillage is successful for us is that it is so good for the soil. I use Zone-tillage for pumpkins on all types of soil. When we start fields new to us, I often start them with pumpkins. I kill the existing sod with Round-up in the fall and follow the same routine as other fields that have been in our rotation program for years. Starting a field with Zone-tillage shows a quick response to the benefits that can take four or five years to show up when you change from a tillage program to a no-till or Zone-till system.

The soil benefits from Zone-till are many but include a big reduction in erosion. The increased soil quality from using Zone-till is substantial. The structure of the soil is a big part of this. When soil structure is in large aggregates, it has more benefits. These large aggregates allow better water absorption. Root growth is easier for the plants. The exchange of oxygen into the soil is much more rapid with large pores. The benefit of crop residue on the soil surface is beneficial to water retention during dry spells. When harvesting pumpkins and sweet corn, we keep all vehicles on the spray rows to help with getting through wet fields and to avoid compaction.

The fourth reason I like growing pumpkins using Zone-tillage is that they fit very will into our rotation program. All of our crops are no-tilled or Zone-tilled. Our rotation goes like this: one year of cucurbits, two years of sweet corn, one year of winter rye. The rye is grown for seed and straw but we leave at least 8 inches of stubble, and usually enough seed escapes the combine so that we do not need to reseed the rye to get a stand to aid in weed control for our following crop.

This rotation works well for a number of reasons. The first is weed control. Having crops of broadleaf, cool-season grass and corn, a warm season grass makes a good mix to rotate herbicides and other weed control measures. Having different types of crops offers us a chance to use herbicides with different modes of action. This keeps weeds under control with minimum rates of herbicides and avoids build-up of problem weeds. We definitely see a big advantage since going to a four-year rotation in all matters, especially in disease control for cucurbits. This has worked so well that I am now experimenting with growing forage soybeans. These have potential to help in weed control and plant nutrition if grown between the cucurbits and the sweet corn.

The fifth and last reason that Zone-tillage works so well is that the system works to pull all the components together. This point is almost a recap of all the other reasons I have cited. This system works to benefit all components of our cropping system and help our farm overall. If I look back at what I set out to accomplish in 1988 and successive years, the original goals that I was looking to make work better were time management and erosion. As I learned how to make these goals work with no-till, I transformed my system to one of Zone-till. By 1995, I also learned of the other advantages I have told you about and many others. In 1995, I was confident enough to purchase a Rawson Zone-Till Cart. I now can't imagine spending time on a tractor plowing, harrowing and picking rocks.

One of the benefits that you may be interested in is the dramatic reduction of tractor use and wear and tear on them. A tractor lasts much longer now. Over the last few years I've put more hours on my sprayer tractor than all others.

Overall, growing pumpkins using Zone-till is the best system for me.

Effective Pollination in Pumpkins

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Pollination of pumpkins was never a subject of great concern among growers in the Northeast, but weather conditions in recent years, and the threat of low honeybee populations due to bee diseases and predators have encouraged us to pay attention to a neglected topic.

Pumpkins are members of the cucurbit family of crops, and have separate male and female flowers. In order for fruit to be set, pollen from the male flowers must be transferred to the female flower. This is usually done by bees, either the common honeybee, or by several other species such as bumblebees or the native squash bee. Honeybee hives may be placed in or near the pumpkin fields during the flowering period, or the grower may depend on wild or feral colonies nesting in hollow trees or old buildings. If bee hives are used:

- Make sure that the colonies are vigorous and active
- Place hives in the sun, off the ground
- Face hives south or east
- Use one hive for every one to three acres

In observations on Long Island, and parts of upstate New York, we have had strong indications that squash bees and bumblebees are more important pollinators of pumpkin than honeybees. We compared fields furnished with hives and others without honeybee hives in the Capital District of New York in the mid-1990's, and could find no difference in fruit set between them. This was during a period when bee diseases and bee mites had sharply reduced the number of wild bee colonies.

The native squash bee is very prevalent in the Northeast, and can commonly be found visiting pumpkin flowers during the growing season. It has a life style quite different from the honeybee, in that it is solitary, and nests in the ground in tunnels from 3 to 24 in. deep. The new adults emerge from their nests in mid-July, at a time that the pumpkin is starting to flower. Both male and female squash bees visit the flowers to gather nectar and pollen, and thus bring about pollination. By late August to early September, the current squash bee population dies, but the new brood is developing in the ground nests, nourished by the pollen and nectar furnished by the adults.

The squash bee nests can be found in or near pumpkin fields, and the bees should be protected from damage by these simple measures:

- Spray pumpkins and adjacent fields only in late afternoon or later, after the flowers have closed, and the squash bees are in the nests
- Plant pumpkins or squash every year so that the squash bees have a source of food
- Protect the nest sites from deep plowing and from flooding

More information on the habits and management of squash bees can be found in the Pumpkin Production Manual, recently published by NRAES (see http://www.nraes.org/publications/nraes123.html).

Pumpkin flowers typically open early in the morning, and close by noon, so bee activity must occur in the morning to be effective. Generally, the squash bee tends to be active early, before the honeybee starts flying.

The pollen grains of pumpkin and squash are relatively large and sticky, requiring several visits to the flowers to transfer enough pollen for successful fruit set. Our studies indicate that about 1500 to 2000 pollen grains are needed for good fruit set. Since individual bees carry about 250 pollen grains per visit on average, at least 6 to 8 visits will be needed for each female flower.

During the hot summers of 1999, 2001 and 2002, another problem appeared that may have adverse effects on pumpkin production. During hot weather (high's in the 90's F, with night temperatures in the 70's lasting nearly a week), the flower buds that will form female flowers turn yellow, shrivel and die. We first became aware of this problem in a grower's field of 'Howden' in 1994, but have duplicated the disorder in the greenhouse and in variety trials in Maryland and Florida since then (Table 1).

Table 1. Small-plot variety trials of pumpkin varieties grown during summer in three locations in 1996.

Variety	Yield, Tons/Acre		
	Ithaca, NY	Queenstown, MD	Bradenton, FL
Howden	34	20	4
Wizard	23	19	6
Rocket	38	29	18
Appalachian	31	24	16
Prizewinner	49	49	44

The female flowers don't open, and the plants continue to produce leaves and male flowers, but the formation of fruit is much delayed. In the case of the Bradenton planting, in which temperatures averaged 82 F during most of the growing season, normal female flower production and fruit set was delayed until cooler fall conditions, but too late to produce marketable yield for the Halloween season. Although there were differences among varieties in the response, additional work is needed to identify superior lines with heat resistance.

In the wet summer of 2003, growers reported poor fruitset, especially during periods of rainy weather. We suspect that if the inside of pumpkin flowers get wet, fruitset may be inhibited. We have started some greenhouse experiments in fall, 2003, to check this out, and hope to report preliminary results by the time of the meeting.

I want to thankfully acknowledge that the findings reported above includes the work of the following colleagues: Roberta Glatz, Suzanne Stapleton, Maria Vidal, Dale Riggs, Marzena Masierowska, Don Maynard and Charles McClurg.

Deer Habitat and Behavior

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White-tailed deer (*Odocoileus virginianus*) have made a miraculous comeback in Connecticut, increasing in number from an estimated 12 in 1889 to over 76,000 in 2001. White-tailed deer were hunted close to extinction through much of their range by the end of the 1800's. A major factor that contributed to the recovery of deer is that by 1900, thousands of marginal farms in Connecticut had been abandoned, and these abandoned agricultural lands then converted back to forests. Connecticut now has over 60% forest cover, with suburban communities bedded within these wooded areas. Residential communities in forest fringes are particularly attractive to white-tailed deer because they provide year-round access to food. Thus deer densities in such areas are usually high. There are few natural regulators of deer numbers in suburbia - coyotes are the only predators in Connecticut capable of taking down adult deer. However, they have little effect on the overall deer population in an area.

Reducing browse damage to landscapes

High deer numbers in suburban areas have led to browse damage, resulting in the destruction of landscapes and gardens. It is relatively easy to identify deer browse damage -- deer have no upper incisors, hence they tear vegetation using their lower incisors and their upper palate. The resulting browsed fragment has a jagged edge. Male deer also damage trees and saplings by rubbing them with their antlers, resulting in bark being scraped off trees. Damage control options depend on factors such as deer density in the area, the type of deer damage (buck-rubs or browse damage), the season when damage is most noticeable, and the location of high-use areas by deer. Often, a combination of control options work better in areas with large numbers of deer. Deer damage control is more effective when implemented before the growing season. Some methods of controlling deer damage include the use of scare devices, using fencing or other physical barriers, and using repellents. Scare devices and repellents are limited in use to areas of low to moderate deer density.

Choosing a deer management plan

The choice of a deer management plan should depend on annual monitory loss and annual pattern resulting from deer damage. Patterns of deer damage change from year to year depending on weather, availability of food, deer density and other factors. Growers have often used repellents successfully from 2-3 years, and then lost their entire crop as a result of deer damage after a severe summer or winter. It is best to plan a deer damage control program that is based on the most severe instance of damage in the past five years. Seasonal patterns of damage must also be evaluated over a period of years. Deer have definite food preferences that vary seasonally. In general, summer damage is less extensive than winter damage, because other sources of preferred foods are often available. This fact is especially important to fruit growers, foresters, and nursery operators. It is difficult to change seasonal deer feeding habits after they have begun, therefore, damage should be anticipated and the appropriate controls applied before the damage begins.

Deer damage control using fences

The most effective method of preventing browse damage is fencing the entire property. Design is crucial if the fence is to be effective in excluding deer. Fences have to be high enough to prevent deer from jumping over, or the fence can be constructed using a combination of height and depth to keep deer out. It is also important to make sure that the bottom of the fence in no more than 1 foot from the ground. Deer are in fact more likely to crawl under the fence than jump over. A single/double strand electric fence coupled with peanut butter bait is often sufficient to keep deer out. It is best used for gardens, nurseries, orchards and field crops that are subject to moderate deer pressure. To construct a peanut butter fence, a single strand of 17-gauge wire is suspended about 30 inches above the ground using 4-foot fiberglass rods. To bait the deer, 4x4 inch aluminum foils are attached to the wire and the underside of the flags is baited with a 1:1 mixture of peanut butter and vegetable oil. The smell attracts the deer, which touch or sniff the flags and receive an electric shock. The flags should be re-baited every 4 to 8 weeks, depending on weather conditions.

Another option is the plastic mesh fencing. Plastic mesh fencing has some residential and landscape applications. The fencing is lightweight, high-strength, and virtually invisible, so it does not detract from the appearance of the property it protects. The fencing consists of a 7.5-foot black plastic mesh with an expected life of 10 years. This type of fence can be attached to existing trees or hung on pressure treated posts. The light weight of the material minimizes the need for many posts.

Wire mesh fences can be used for year-round protection of crops in areas of high deer density and damage. These fences have the disadvantage of being very expensive and difficult to construct, but are highly effective. Although a fence may last for 20 years or more, its initial cost of $2 to $4 per linear foot. These fences also have the advantage of requiring very little maintenance.

Psychological control of deer

In areas of low deer density where damage is light or occasional, deer browse damage can be controlled using psychological methods. Psychological methods are not effective in areas with a high deer population or where deer have already begun to do moderate damage. Deer are naturally nervous and alert to danger. Psychological methods play on this nervousness, making deer uncomfortable to feed on the property. Some examples of this technique include the sonic and ultrasonic deer repellents. The ultrasonic deer repellent is similar to that used on vehicles to deter deer. These have the advantage that humans are not disturbed when the devices are activated. Unfortunately, there is no evidence that deer are in fact deterred by ultrasonic or sonic sounds. One example of a scare device is the propane gas exploder. Gas exploders set to detonate at regular intervals are the most common scare devices for reducing deer damage. They are effective for only a few weeks and should be used only for temporary control. The other major problem with these devices is that these noise-making devices are very annoying to humans, especially at night when deer are most likely to be active.

Deer damage control using repellents

There are two kinds of repellents - contact repellents and area repellents. Contact repellents are applied directly to plants; their taste repels deer. They are most effective on dormant trees and shrubs. Contact repellents may reduce the palatability of forage crops and should not be used on parts destined for human consumption. Area repellents deter deer by odor and should be applied near plants you want to protect.

There are a wide variety of deer repellents on the market. Some of the more common repellents have been described below. Hinder is a deer repellent made from fatty acid soaps. It is an area repellent that smells like ammonia and is one of the few registered for use on edible crops. Applications can be made directly to vegetable and field crops, forages, ornamentals and fruit trees. Its effectiveness is usually limited to 2 to 4 weeks but varies because of weather and application technique. Hot sauce is a taste repellent and is registered for use on ornamental, Christmas and fruit trees. Vegetable crops also can be protected if sprayed before the development of edible parts. Coyote urine and other predator urines such as mountain lion and wolf are also available, however, are not very effective. Another repellent found in the market is Deer –Away. This is made from egg solids, and is often effective when working in areas of moderate deer density. This contact repellent smells and tastes like rotten eggs. It has been reported to be 85 to 100 percent effective in field studies. It is registered for use on fruit trees before flowering, ornamental shrubs and Christmas trees. Other repellents include Tree-Guard (containing bitrex), which is a taste –based repellent. Ropel is another taste-based repellent. Ropel also repels deer with its extremely bitter taste. Both these repellents cannot be used on edible crops.

Deer population management

Another method to reduce deer damage to an area is by reducing the number of deer in the area. Regulated hunting is the most widely used method of white-tailed deer control. While hunting can be effective in controlling deer numbers, it comes with some limitation. The most important limitation of hunting is that it is often not feasible or safe in some suburban areas due to high human densities. Intermediate to low levels of hunting may result in improved overall deer health and reproductive output, because hunting often reduces competition for the surviving deer, which then have access to more food, resulting in more fawns.

Regulating the reproductive output of deer

Currently, experimental methods of reproductive control are being explored to reduce deer numbers in suburbia. By suppressing reproduction in a population to a level below that of natural mortality, it is possible to achieve a decrease in population size. Most of the research on reproductive control has focused on females. Two reproductive control methods that have been tested extensively on deer are immunocontraceptives and contragestation agents. The major problems with these techniques are that they are expensive and since the effect of the treatments are not permanent, requiring repeated treatment of the target individuals each year.

The Connecticut Agricultural Experiment Station is also testing a method of deer reproductive control by focusing on sterilizing large males. The technique does not affect the production of hormones, thus the behavior of the treated individual is not significantly altered as a result of the treatment. By retaining treated males in the population, these individuals will continue to use resources and participate in mating behavior, reducing the reproductive output of females. The major advantage of this technique is that the effects of the treatment are permanent. All reproductive control techniques should be viewed as a long-term solution. The function of reproductive control research is not to find a technique that is cheaper than hunting, but to provide alternatives to communities that are looking for other options.

Woodchuck Ecology and Management

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Woodchucks, a.k.a. groundhogs, are common suburban mammals occurring throughout NH. In general, woodchucks prefer open woodland and the surrounding wooded or brushy areas adjacent to open land. Burrows are located in fields and pastures, along fence rows, stone walls, roadsides and near building foundations or the base of trees. The woodchuck's compact, chunky body is supported by short strong legs that can move up to 200 pounds of soil per year. Occasionally woodchuck burrowing and feeding activities conflict with human interests. Woodchucks are strictly plant eaters consuming over a pound per day and, like most garden pests feed on a wide variety of species. They prefer, beans, carrots, peas, greens, alfalfa, clover and grasses. They will also consume tomatoes, broccoli, squash and other garden plants. Fruit trees and ornamental shrubs are damaged by woodchucks as they claw or gnaw woody vegetation. Excavated burrow systems present hazards to farm equipment, horses and livestock. Gnawing and burrowing activity has caused damage to underground cables, causing power outages and damaging navigational aids at airports. Burrowing can weaken earthen dams, dikes and foundations. Human health and safety is also a concern as raccoon rabies has been confirmed in woodchucks.

Woodchucks make their subterranean homes near their food source, which might be a vegetable garden. Non-lethal methodologies to reduce woodchuck garden damage include: exclusion (fencing), habitat modification, trapping, frightening devices and repellents. Woodchucks may be removed through trapping, gas cartridges or shooting. Control is typically enhanced through an integrated approach which incorporates multiple strategies. Fencing may be electric, non-electric or a combination. As woodchucks can climb, electrified fencing will provide the best non-lethal protection, placing a minimum of two wires approximately 4 and 8 inches off the ground. Battery and solar powered chargers are available and both are quite portable. Non-electric barriers, using traditional fencing material should be at least 3 feet tall bending the top foot outward, consist of a tight and strong wire mesh and be buried up to a foot deep forming an outward "L" to prevent burrowing under. Adding a single electric wire 4 inches off the ground and the same distance from the non-electric fence has proven to enhance effectiveness and be an effective burrowing deterrent.

Live-trapping is a possibility however, the potential of exposure to rabies as well as probable death to a translocated woodchuck should be considered. Placing a trap baited with apples, carrots, lettuce and preserves directly at a burrow entrance using materials to funnel the woodchuck into the trap is the most effective live-trapping methodology. Early spring, prior to females giving birth and when alternative food sources are scarce is the optimal time to conduct live-trapping. Suitable habitat to translocate a woodchuck must be identified and landowner permission secured. Although a popular recommendation, translocation of wild animals is not a biologically sound practice in many situations given low survival rates, stress and animal movement. Furthermore, the AVMA, National Association of State Public Health Veterinarians and Council of State and Territorial Epidemiologists oppose relocation of mammals because of the risk of disease transmission.

Harassment and frightening devices provide only temporary relief at best. Scarecrows and other effigies can provide some relief if moved frequently. Pyrotechnics are ineffective and no repellents for woodchucks are registered with the EPA. Predator urine (bobcat or coyote) may provide some relief. Habitat modification or the removal of brush and thinning of wooded or overgrown areas is recommended to reduce the attractiveness of denning sites adjacent to gardens.

A common method of woodchuck control is the commercial gas cartridge. Gas cartridges are ignited, placed in burrow systems, and all entrances sealed. As the gas cartridge burns, carbon monoxide and other gases are produced that are lethal to woodchucks. As other animals will utilize woodchuck burrow systems inhabitant confirmation should be conducted prior to treating a burrow. Woodchucks are not protected in NH and may be removed by shooting. Extreme caution and safety are required, and local shooting ordinances must be adhered to. Conibear traps are effective in some situations. Conibear traps are body gripping devices that kill an animal that attempts to walk through it almost instantly. Sizes 160 and 220 are appropriate for woodchucks. Care must be taken to avoid non-target capture. Do not assume that Should further assistance regarding a woodchuck conflict be required contacting a nuisance wildlife control operators that specialize in wildlife damage management is recommended

Bramble Production Basics
& Variety Notes

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Many people have tried growing raspberries as a commercial venture in the Northeast, yet few seem to have been able to sustain a long-term success. What goes wrong?

First and foremost, a raspberry planting requires a lot of planning, attention and labor. Failure in any of these areas will likely jeopardize its success. People who start raspberry plantings often do not fully consider the true costs and potential pitfalls this crop entails. However, those who have, and also possess good management skills, have found that raspberries can be a very profitable, albeit demanding crop. Some basic requirements for success are reviewed below.

Choosing a site
Site selection is critical to successful raspberry production. The wrong choice will generate chronic problems which, at the very least, will tax management skills and reduce profits, and may result in a failure of the planting.

A good raspberry site should have an excellent soil. It must be well drained. A site that holds too much water will reduce the vigor of the plants and greatly increase the probability of *Phytophthora* root rot infection. Avoid soils heavy with clay. A sandy loam with acceptable levels of organic matter will provide the greatest chance of success. The site should receive full sunlight and have good air circulation. This will encourage a dry microclimate within the planting which will reduce the incidence of fungal diseases.

Preparing the soil
Have the soil tested to determine what amounts of nutrients need to be added to the soil to encourage optimum growth of raspberries. Applications of lime to adjust the soil pH and fertilizers should be made according to soil test recommendations. Prior to planting, organic matter levels can be increased by incorporating compost, animal manures and/or plowing down cover crops. The use of cover crops prior to planting can also be an effective technique to reduce weeds and improve the nutrient status of the soil. Cover cropping should be carried out for at least two years to effectively reduce weed populations and improve soil conditions.

Planting Raspberries
Raspberry plants are often started from dormant one-year-old canes, however, plants are now also available as tissue-cultured, virus-free plantlets from several nurseries. Although the cost of plants propagated this way is somewhat higher (50-100%) than conventionally propagated

plants, the exceptional vigor and uniformity of these plants, in addition to virus indexing, may make them a worthwhile investment for the commercial grower.

Raspberries are best planted in the early spring, usually from mid-April to early May. Fall plantings are possible, but usually experience higher plant mortality, prolonging the time necessary for the planting to reach its full production potential.

Plants should initially be spaced two to three feet apart within rows, with a minimum of ten feet between rows. Spacing rows too close together is a common mistake. There must be adequate room between the rows to allow equipment through once the planting has reached its full size. Wide row spacing will also encourage air circulation, which will reduce disease problems.

Irrigation and Mulch
Trickle irrigation should be put in place immediately after planting. A well-designed trickle irrigation system will greatly speed the establishment of the planting and encourage consistently good growth and yields. If tissue-cultured plants are used, they should be mulched immediately after planting with a three-inch layer of straw. This will help to conserve soil moisture and reduce the germination of weed seeds in the soil, both critical to a quick establishment of the raspberry plants. The straw should be removed early the next spring to prevent root rot. A permanent mulch, such as wood chips or shavings can be applied at that time to provide long-term benefits. As the plant rows become established, they should not be allowed to become wider than one and a half feet. Wide rows will not allow enough light penetration for healthy fruit buds to form in the row centers, and will increase disease problems due to poor air circulation.

Trellis
Summer-bearing raspberries should be trellised. Current research indicates that a "V" type trellis optimizes yields and fruit quality and is relatively simple to manage. The idea is to train the fruiting canes out from the center of the row at approximately a 30-degree angle. This is accomplished by tying fruiting canes to wires supported by posts set in the ground at the appropriate angle. Two strands of wire are run along the posts, one approximately one foot above the ground and the second at three to four feet above the ground, depending on the expected height of the canes. Spreading the fruiting canes out in this manner encourages new cane growth to come up from the center of the row, rather than the edges. Spraying, harvesting and pruning are simplified because the fruiting canes are limited to the outside of the row. Increased light penetration and air circulation within the row as a result of the V trellis may also reduce the incidence of diseases such as gray mold and spur blight.

Pruning
Pruning should be given special attention. Every season, regularly prune out any first year canes that emerge outside of the desired one and a half foot row width. This opens up the planting to encourage growth of the other first year canes, which are setting fruit buds for the next season. Dormant pruning should be left until the late winter or early spring. All canes that fruited the previous summer should be pruned out. Any canes that are outside of the desired row width or showing signs of insect or disease injury should also be pruned out. Only the most vigorous

canes, those with the greatest height and basal diameter, should be left in the row. Thinning should continue until the desired cane density of four to five canes per foot of row length is attained. The remaining canes should be attached to the trellis wires. Finally, all of the prunings should be removed from the field. These may harbor diseases and insects that may attack the healthy canes.

Everbearing Raspberries
Consider putting part of your planting into everbearing (primocane fruiting) varieties. These will bear a crop on first year canes in the late summer. The canes can then simply be mowed down late in the winter, eliminating the need for selective pruning. This technique also nullifies the danger of winter injury to the canes and may reduce the threat of several diseases and insects that use the canes as over-wintering sites. Although this practice also eliminates the conventional second year crop from two-year-old canes, many growers prefer this method to reduce labor and risk while still providing profitable yields. Allow plants to become established for at least three years before beginning to mow them. This will allow the plants time to establish a healthy root system and reduce stress caused by mowing. Most everbearing varieties mature their fall crop late in the season, making it susceptible to frost. Select varieties that can successfully mature the primocane crop in your area.

Pest Management
It is critical that raspberry growers become familiar with the major pest species that effect their crop, including insects, diseases and weeds, and know what management options are available for each. Weeds and diseases are two of the most common reasons for the failure of raspberry plantings. A grower should be well aware of the pest situation in the planting at all times through frequent and regular monitoring.

In the end, it is the growers who take the time to educate themselves thoroughly in raspberry production, pest management, and business management who will be successful. This education should begin well before a plant is put in the ground and never stop.

Bramble Variety Notes

Red Raspberries, Summer-bearing

Boyne: From Manitoba. Ripens early, excellent winter hardiness, high yielding. Plants are spiny and produce many suckers. Fruit is small to medium in size, dark and soft, with fair flavor and good freezing quality. Susceptible to anthracnose. Highly recommended for colder sites.

Canby: From Oregon. Ripens midseason, only moderate hardiness. Plants are tall, nearly thornless, and moderately productive. Fruit is medium to large, firm, bright red with excellent flavor. Limited success in cold climates

Encore: Recent release form New York. Ripens late season, with long harvest season. Hardy and free suckering with vigorous, erect, nearly spineless canes. Fruit are medium-large and firm with good flavor. Encore shows a moderate tolerance to Phytophthora root rot.

Haida: From British Colombia. Ripens mid to late season. Hardiest of the Pacific Northwest types. Vigorous plants with moderate spines. High yielding. Fruit are medium-sized, with good flavor; berries are firm, sweet, and freeze well.

Hilton: A New York release. Ripens midseason, moderate hardiness. Plants are tall and vigorous, and moderately productive. Fruits are quite large, attractive, dark red, firm, with fair to good flavor. May be difficult to pick unless fully ripe.

K-81-6: From Nova Scotia. Ripens mid-late season, very hardy. Vigorous, tall canes. Medium-large, bright red fruit are firm with good flavor.

Killarney: From Manitoba, sibling of Boyne. Early ripening, slightly behind Boyne. Plants are very hardy, spiny, produce many suckers, and are susceptible to mildew. Plant is short to medium. Fruit is medium-sized, and bright red. Flavor and freezing quality are good, but berries may soften in warm weather. Susceptible to anthracnose. Highly recommended for colder sites.

Latham: A Minnesota release. Midseason ripening, very hardy. Plants are vigorous with few spines. Small fruit with good color, but crumbly with only fair flavor. Ripens over a long period of time. Less susceptible to viruses than some varieties. Recommended for colder sites.

Lauren: A recent release from Maryland. Mid-late season ripening, only moderate hardiness. Tall, vigorous canes. Fruit are very large and fairly firm with fair flavor.

Newburgh: From New York. Midseason ripening, hardy. Plants tall but not highly vigorous. Some spines. Partially resistant to common cane diseases. Fruits are medium in size, light red with good flavor. May be crumbly, and tends to ripen unevenly.

Nova: From Nova Scotia. Very hardy plants with good vigor and few thorns. Appears to be resistant to most common cane diseases. Fruit ripens midseason, is medium sized, firm, bright red, and somewhat acidic.

Reveille: From Maryland. Early ripening. Hardy. Plants are vigorous, producing many suckers. High yielding. Fruits are medium to large with good flavor, but very soft. Poor shipping and freezing quality.

Taylor: From New York. Late ripening. Moderately hardy. Plants are vigorous with some spines. Very susceptible to mosaic virus, leaf spot and fungal diseases. Fruit is medium to large with excellent flavor, good color and firmness.

Titan: From New York. Mid to late season ripening, only moderate hardiness. Large canes, suckers emerge mostly from the crown, i.e. slow spreading. Extremely productive. Plants have very few spines, but are susceptible to crown gall and *Phytophthora* root rot. Fruits are extremely large and dull red, with mild flavor. Difficult to pick unless fully ripe.

Red Raspberries, Everbearing (primocane-fruiting)

August Red: From New Hampshire. Earliest ripening of the primocane-fruiting types. Canes are short and spiny, with moderate vigor. Fruit size is medium-sized, somewhat rough, and mildly flavored.

Autumn Bliss: From East Malling, Scotland. Early ripening primocane crop. Moderately vigorous canes with few spines, suckers develop near the crown Productive. Fruit is large and highly flavorful.

Autumn Britten: East Malling, Scotland, similar to Autumn Bliss. Early ripening primocane crop. Limited cane production, close planting recommended. Medium to large fruit with very good quality.

Caroline: A recent release from Maryland. Mid-early ripening primocane crop. Vigorous with tall canes. Large, firm fruit. Ripens over a long harvest season. Moderately hardy for floricane crop.

Dinkum: From Australia. Similar to Autumn Bliss, early ripening primocane crop on moderately vigorous canes. Large, firm flavorful fruit.

Fall Red: From New Hampshire. Early ripening primocane crop. The medium to short canes are very vigorous, and produce many suckers. Moderately spiny. Fruit size is medium. Good flavor, but soft. Recommended for most sites in Maine.

Heritage: A New York release. Primocane crop ripens relatively late. Tall, rugged canes with prominent thorns. Very high yielding. Fruit size is medium. A good color and flavor, firm, good freezing quality. Due to the late ripening of the primocane crop, this variety is not recommended for regions with a short growing season, i.e. frost before September 30 or cool summer temperatures.

Prelude: A recent release from New York. Although everbearing, primarily grown for its very early ripening floricane (second year) crop. Plants are vigorous and sucker freely. Medium-sized fruit, dark red, good quality. Primocane crop ripens late.

Ruby (Heritage x Titan): New York. Primocane crop ripens slightly ahead of Heritage. Plants moderately vigorous, good productivity. Fruit is large, but flavor is mild. Susceptible to root rot. Suggested for fresh market or shipping in areas with longer, warmer growing seasons.

Redwing: From Minnesota. Primocane crop ripens earlier than Heritage in some years and sites. Canes not vigorous with moderate spines. Moderately productive with medium fruit size. Flavor is fair to good, but fruits tend to be soft.

Yellow Raspberries, Everbearing (primocane fruiting)

Anne: A recent release from Maryland. Mid to late season ripening primocane crop. Vigorous, tall canes. Medium to large light yellow fruit, variable quality.

Fall Gold: From New Hampshire. Primocane crop ripens relatively early. Canes very vigorous, produce many suckers. Fruit is medium-sized, yellow with a pink blush, soft, but with excellent flavor. Poor for freezing or processing.

Goldie: Yellow sport of Heritage and similar in ripening season, productivity and growth habit. Fruit actually are more of a pink color when ripe and are prone to sun bleaching.

Kiwi Gold: New Zealand. Another yellow sport of Heritage and similar in ripening season, productivity and growth habit. Good fruit quality, develops pink blush when over-ripe.

Purple Raspberries, summer-bearing

Purple raspberries are not adequately hardy to be commercially viable in most of northern New England.

Brandywine: A New York release. Ripens later than most red varieties. Canes very tall with prominent thorns, suckers from crown only, will not fill in. Susceptible to crown gall, but partially resistant to many other diseases. Fruits are large, reddish-purple, and quite tart. Best used in jams or jellies.

Royalty: From New York. The best purple raspberry. Extremely productive. Ripens late. Canes are tall and vigorous, with thorns. Immune to the large raspberry aphid, which decreases the probability of mosaic virus infection, but plants are susceptible to *Phytophthora* root rot and crown gall. Fruit are large, reddish-purple, irregular. Fruit tends to be soft, but sweet and flavorful when eaten fresh.

Success: From New Hampshire. Ripens mid to late season. Canes not as vigorous as other purple types and produces few suckers, but is very hardy. Difficult to propagate. Fruit smaller than other purple varieties, but yields quite well. Dark purple color and excellent flavor. Good fresh quality and for jams or jellies.

Black Raspberries

Black raspberries may winter kill to the snowline if temperatures drop to -10^{o}F in combination with desiccating winds. They are also quite susceptible to virus infections, *Verticillium* and rust. They are not considered commercially viable for northern New England.

Allen: Early-midseason. Relatively hardy. Plants are vigorous and high-yielding. Fruit ripens uniformly, short harvest period. Fruits are the largest and most attractive of the black types, but flavor is mild.

Blackhawk: From Iowa. Vigorous plants, relatively hardy and productive. Fruit is medium-large, glossy, with good flavor.

Early Sweet : From USDA (Maryland). Vigorous, productive plants. Firm fruit is medium- to large-sized and sweet. Early season. For trial.

Jewel : A New York release. Midseason. Possibly the hardiest black raspberry variety. Plants are vigorous, erect, and productive. Appears to have somewhat more disease resistance than other varieties. Fruit is firm, and glossy with good quality.

Blackberries, Thornless (trailing)

Thornless blackberries have vigorous canes which must be trellised. They are not hardy below -10°F and are not commercially viable for northern New England. They ripen later than most red raspberries.

Chester: From USDA (Maryland). Late season ripening, possibly hardier than other varieties. Resistant to cane blight. Large, high quality quality fruit with good shelf life.

Dirksen: Late season, relatively hardy. Plants are very vigorous. Resistant to anthracnose. Fruit are large, firm, slightly tart with good flavor.

Hull: Mid to late season ripening. Fruit are very large, firm, holds color under high temperatures. Sweeter than other varieties.

Triple Crown: From USDA (Maryland). Vigorous, semi erect type plant, somewhat sturdier than other varieties. Productive, midseason ripening. Large fruit with excellent flavor.

Blackberries, Thorny (erect)

Erect blackberries have tall, rugged canes with prominent thorns. The canes have very limited hardiness. They are not recommended for commercial production in northern New England.

Darrow: From New York. Hardiest blackberry variety. Canes are vigorous with large thorns. Good yields with long harvest season. Fruit are large and glossy, excellent quality.

Illini: From Illinois. A hardy, thorny blackberry with good quality fruit. Suggested for trial where Darrow can be grown successfully.

Raspberry Nutrient Management

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Work by Darrow as early as 1930 established a positive relationship between cane and plant vigor and yield. Cane size (diameter and length) and leaf weight are excellent measures of the productive capacity of a raspberry plant. Most research suggests that it is the physical nature of a soil (that it is well drained and friable) that most affects raspberry productivity. Cane growth, and hence yield, is most affected by root growth, and root growth is most affected by soil drainage. Additionally, soils rich in organic matter are correlated with good plant vigor and yield.

Raspberries grow well over a relatively wide soil pH range, but general recommendations suggest a pH from 5.5 to 6.5 as acceptable. As soil pH nears 7.0, availability of essential metal such as zinc and iron becomes limiting and leaf chlorosis is common. 6.0 is the generally recommended minimum target.

A proper pre-plant soil preparation regime is an essential first step to managing raspberry cane nutrients and vigor. Selecting that well-drained sandy loam, adjusting pH to appropriate levels, and incorporating cover crops are key parts of the process. Of course, a soil test is essential. Once the planting is established, take the soil for testing from within plant rows rather than aisles. Use the cover cropping process to correct soil nutrient deficiencies before planting.

Nitrogen is the one nutrient that will generally be applied on an annual basis. How much to apply is based on plant growth and yield, but generally up to 30 pounds of actual nitrogen per acre will be applied in the planting year and mature plantings will require up to 50 to 60 pounds per acre to insure adequate cane growth. Fall fruiting raspberries may need up to 75 pounds to maintain vigor. Over application of nitrogen does carry some risk. Excessively vigorous plants will not harden well in fall, increasing the risk of winter injury. In addition, plants will have fewer berries per cane if they are growing too vigorously. There are potential pest management implications as well – plants higher in nitrogen seem to support much higher populations of 2-spotted spider mites.

Nitrogen is applied in early spring – perhaps April into early May in Durham. Later application may lead to increased winter injury risk. For fall fruiting types, this risk of winter injury is not important, but late applications may delay harvest in the fall.

Phosphorous is rarely needed when raspberries are planted into land that has been used for vegetable production assuming soil pH is between 6 and 6.5 and soil organic matter levels are relatively high. Phosphorous applications of up to 50 lb P_2O_5 per acre may be recommended if soil levels are low and/or soil pH is above 7.0. Raspberries will rarely show a response to annual phosphorous applications. Excessive phosphorous levels may suppress uptake of essential nutrients including zinc.

Potassium (potash) is the other macro nutrient commonly applied to raspberries. There is conflicting data on whether potassium chloride (muriate of potash 0-0-60) poses a risk of root injury from the chloride ion for raspberry. In general, on sandy soils, the use of potassium sulfate (0-0-50) or sulfate of potash magnesia (0-0-22) is recommended. How much potassium to apply should be based on soil test, or better yet, tissue analysis. If levels are low, up to 90 lb K_2O per acre are applied. If levels are high, none would be recommended.

Minor elements that may be limiting in some soils include boron, iron, and zinc. The easiest way to manage these is by maintaining the appropriate soil pH. As the soil pH level rises, availability of these elements is greatly reduced – deficiency is likely if pH is much above 6.6. Applications of boron may be warranted in extreme cases – be sure to apply only based on tissue analysis. Zinc and iron deficiency should always be managed by maintaining the appropriate soil pH.

What should I buy for fertilizers? The use of a blended fertilizer such as 15-15-15 is rarely a good choice since for most plantings, excessive phosphorous will be applied. This is not only wasteful and expensive, it is not sound environmentally. Ammonium nitrate (32.5-0-0) is the most common nitrogen source used although calcium nitrate (15.5-0-0) and nitrate of soda (16-0-0) are widely used as well and offer immediate nitrogen availability for the crop. When K is needed, sulfate of potash (0-0-50) or sufate of potash-magnesia (0-0-22 plus 11 Mg) are both good choices. If phosphorous is needed, triple super phosphate (0-45-0) or bone meal (2-24-0) are both readily available.

Tissue analysis should be an at least every 3rd year addition to your regular soil testing program.

High Tunnel Bramble Production

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High tunnels, as shown by research conducted at Penn State with small fruit crops, have value for season extension, and for improvement in fruit quality due to protection of the berries from the elements. In Pennsylvania, early frost dates result in only a small portion of the potential crop of most primocane-bearing raspberry cultivars being harvested. In addition, low winter or fluctuating spring temperatures have, in the past in colder locations, resulted in no crop on thornless blackberries. This research was conducted to find out to what extent high tunnels would extend the length of season during which primocane-bearing raspberries could be harvested, and whether they could make thornless blackberry production possible in some areas where it currently is not feasible.

One 17'x36' tunnel of 'Heritage' and 'Autumn Britten' primocane-bearing raspberries, and 'Triple Crown' thornless blackberries was planted in 2000. In this tunnel, a spacing was used that was slightly reduced from what would be used in field plantings with 8' between rows and 18" between plants. Planting took place in mid-April, about 6 weeks before the last expected frost date for this area. Otherwise, establishment procedures were very similar to what would have been used in field production. The soil was tested and amended according to soil test recommendations before planting, and trickle irrigation was used. In 2001, a tunnel of 'Heritage', 'Josephine', and 'Deborah' primocane-bearing raspberries, and 'QDE-1' Wyeberries was established in a higher-density planting, with 4' between rows and 1' between plants. This planting was established with organic production in mind, as it became apparent from the previous year's planting that pesticide usage could be greatly decreased or entirely eliminated in high tunnel bramble production. Planting in this tunnel did not take place until mid-May, about 5 weeks later than in 2000.

Several interesting findings were apparent. 1) Production of raspberries and blackberries was much higher than would have been possible in field production. Marketable yields of nearly 1 lb per linear foot of row (or about 5000 lb/acre) were obtained with 'Autumn Britten' the same year plants were planted, which is similar to yields that had been obtained from a 3-year-old field planting at this same site. 'Heritage' yields were lower in the first year due to lateness of the crop, though a few additional measures taken to conserve heat through the first hard freeze could have increased yields considerably. 'Heritage' produced about 3/4 lb of marketable fruit per linear foot of row for a summer crop in its second year, and an additional 3 1/2 lb of marketable fruit per linear foot of row during the fall. This would translate to a yield of 23,000 lb of marketable fruit per acre, or 4 times that normally expected for this site in the field during 2001. Similar season-long yields were obtained in 2002, but most of the crop load was obtained from the summer crop rather than in the fall. Research is underway to better understand this balance and develop recommendations concerning cane management. 2) Plant growth was greatly increased, with many canes reaching 6 to 7 feet tall. Because much potential bearing length of the cane remained to produce a second crop after the fall harvest, summer cropping in addition to fall cropping was very feasible. All cultivars in both tunnels were cropped for both a summer crop and fall crop during 2002. 3) Not only was the season extended later into the fall, but because the plants broke dormancy earlier in the spring, harvest began about 3 to 4 weeks earlier than normal for the fall crop. Therefore, 'Heritage' did not finish out the entire fall season. For that reason, 'Josephine', and 'Deborah', 2 cultivars that would be too late for field production were tried, though their yields were not as high as for 'Heritage' or 'Autumn Britten'. 4) Thornless blackberries also produced very high yields, at about 3.6 lb/linear foot of row, or over 19,000 lb per acre. 4) Quality of berries was very high, with percent marketable ranging from 82% to 98% depending on row spacing, cultivar, and time of year. 5) Early planting (at least 6 weeks prior to the time that planting would normally take place in the field) is needed in order to achieve good yields in the year of planting. 6) Organic or pesticide-free production is relatively easy to achieve. Pests that were encountered in the high tunnel were two-spotted spider mites, which were controlled by a release of predatory mites when populations were still low, and Japanese beetles on the summer crop. 7) Yields in the two tunnels were similar. When the closer (4') row spacing was used, yield per linear foot of row decreased by half compared to rows that were 8' apart, probably due to shading of neighboring rows by the plants. This resulted in nearly identical per area (or per tunnel) yields between the two tunnels.

Organic Seed Crop Production:
A New Niche for New England Farmers

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Restoring Our Seed: The Context

In the last two generations the seedscape has changed dramatically. Farmers, who for thousands of years saved seeds and improved crops, abdicated those functions to professionals. Public university breeding programs, which introduced most of the best cultivars until late in the twentieth century, have mostly disappeared, replaced largely by proprietary corporate research. A series of consolidations has rocked the wholesale seed industry, reducing the players to a small handful. One company, Seminis, controls 60% of the North American vegetable seed market, yet, is itself, on shaky financial footing.

These changes are producing the following results:

1) Varieties are bred for wide adaptability to broad geographic regions. Varieties specifically adapted to New England's cool, short-season climate are neglected.

2) Seeds are bred with dependence on high input agro-chemicals. The needs of organic growers and home gardeners who eschew pesticides and herbicides are largely ignored.

3) Varieties are bred for long-distance shipability with little regard to the needs of growers with local markets where taste and freshness are highly valued.

Today's seed system is over-centralized, vulnerable and too vanilla. The new organic rule, requiring the use of certified organic seed where commercially available is a response to a need for a more diverse system. Although many small seed companies have arisen in counterpoint to industry consolidation, their expertise and production capabilities are limited. The organic rule is ahead of the industry. Small regional seed companies need technical support to meet this challenge.

Restoring Our Seed: The Program
Restoring Our Seed is a Northeast-SARE funded program Our goal is to develop the knowledge and skill for organic seed production and crop improvement, and to build a network of farmers, cooperative extension, seed companies and markets to produce more and higher quality organic seed for our region. We come together in workshops, on-farm field days, and collaborative breeding projects. Our work is posted on our website: growseed.org.

Why Grow Seed on Your Farm?
All farmers have in common that we are always short of cash, short of time, burdened with a never-finished list of tasks and details of daily life already too complicated. Why on earth would we consider growing seeds and adding another layer of complexity to our lives?

Economic Reasons:

1) To save money. Seed prices are rising rapidly.

2) To acquire desired varieties regardless of their commercial availability. If you are your own source, you don't have to worry about others' crop failures, or unexpected out-of-stocks.

3) To meet or exceed standards of the new organic rule. You'll have certified organic seed even when others can't find it.

4) To adapt and improve varieties to your conditions and climate. According to Bert Grosgahl of Even' Star Organic Farm in Maryland, it is not difficult to build in outstanding degrees of local adaptability, disease tolerance and weather-hardiness into favored varieties without sacrificing flavor.

   "If you are already running a market-driven farm, you have the background to manage your own crop genetics. And if you're a surviving farmer in this competitive and corporate era, you've got more than enough brain cells to manage your crop genetics very well…Seed saving and genetic management can be readily integrated into the seasonal operations of most market farms."

   Grosgahl has attained tolerance to *fusarium* and *verticillium* wilts in 25 lines of tomatoes and 10 of peppers, to *rhizoctonia* in ten lines of brassica, drought-hardiness in 5 brassicas, cold-hardiness in 10 brassica lines including his special strain of cold-hardy arugula and resistance to splitting in cherry and teardrop tomatoes following heavy rains.

5) To develop a new source of on-farm income. High Mowing, Turtle Tree and Fedco are among seed companies in our region looking for growers. Seeds of Change also buys extensively from farmers**.** Growers have had success marketing seeds at farmers market or starting their own mail order business.

6) To get two harvests from the same crop, a vegetable or fruit harvest plus a seed harvest. Many crops, such as lettuce, melons and pumpkins, can be double-dipped. Others, such as peas or beans where the seed is the edible part, cannot.

Ecological Benefits:
Plowing, tilling and cultivating creates ecological disturbance. A freshly-plowed garden is a pioneer ecosystem. Pioneer systems are typically unstable. They are colonized by pioneer species including most of our vegetable crops which are good at occupying a freshly-disturbed system but poor at competing. In a typical monoculture of lettuce, you

have only lettuce plus the enemies of lettuce. With no checks on the enemies, the farmer is forced to intervene extensively to keep them at bay. A more complex agro-ecosystem will reduce the necessity of farmer intervention. Seed crops increase farm biodiversity by:

1) Allowing plants to go through their full flowering cycle. This creates habitats for beneficial insects, pollinators and predators of insect-pests. Seed crops provide shelter, food and stability for beneficials within the habitat upheavals of the pioneer vegetable farm ecosystem.

2) Creating more ecological niches resulting in increased species diversity.

3) Increasing complex species interaction for enhanced biological control of insect pests.

4) Changing the nature of the organic matter being returned to the soil. The mature tissues of seed-bearing crops contain more lignin and fix more carbon for soil food than nitrogen-rich vegetative crops or green manures alone.

5) Increasing the pollination rate and yields of vegetable crops.

Techniques to Increase Benefits:

1) Doublecropping: Two uses for the same crop. Example: beets are thinned for beet greens and bunching beets. Remaining plants (selected for maximum fitness) are grown for seed the second year.

2) Intercropping: Two crops in the same space grid. Example: cilantro as an understory of sweet corn.

3) Hedgerows: Planting an insectary hedgerow such as a fennel seed crop adjacent or as a border to other crops.

4) Seed Guilds: Mixing different plant families with compatible growth habits that won't cross in the same patch to be grown for seed.

How Growing Seed Differs from Growing Vegetables

1) Some seed crops require a longer growing season. Examples: peas, beans, lettuce, cucumbers.

2) Many seed crops have different spacing and cultural requirements than when grown for produce. Examples: radish and mustard require much more space because they grow huge when allowed to go to seed. Lettuce must be started indoors because it is so much longer to mature as a seed crop. Beets and carrots which are annual food crops are biennial seed crops.

3) Seed crops have different harvesting, cleaning and conditioning requirements and require additional equipment such as fans, tarps, fanning mills or cleaning machines. They require threshing, drying and storage areas.

4) Seed crops of cross-pollinated crops require isolation from other crops of the same species. Examples: zucchini and pie pumpkins must be isolated from each other because each is *Cucurbita pepo* and will cross. Beets and Swiss chard are both *Beta vulgaris* and will cross.

5) Controlling disease is even more important in seed crops. Some diseases are seed-borne.

6) Seeds have a longer harvest window. For example: tomato seed can be harvested over an extended period of weeks.

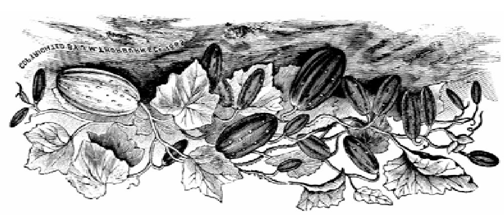
7) Marketing is different. A contract with a seed company enables you to market the entire crop at once and avoid the typical vegetable marketing hustle. On the other hand, there are far fewer potential markets and gluts are quite possible. One of Fedco's seed growers greatly prefers seed production to vegetable production because she home schools her four daughters and seed production allows her to stay on the farm. Even though she refuses to estimate her hourly return for seeds (it is so low) she can't beat the working conditions.

8) Seed crops can fail unexpectedly at the end. They may fail germination test for reasons not readily apparent. They can mold in improper storage conditions or be molested by rodents.

Restoring Our Seed: Participatory Breeding
In addition to our organic seed production program, we are teaching how to breed varieties that will flourish on organic farms.. Season by season we are selecting for exactly what New England farmers want - superior flavor, early maturity, resistance to local pests and disease, and reliability in our cool climate.

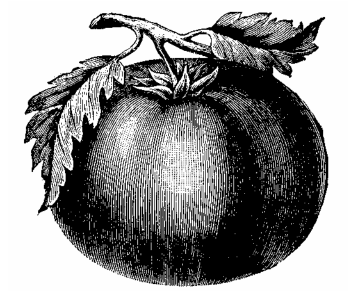
To date our breeding projects include:

<u>A Delicious, Disease Resistant Pickle</u>



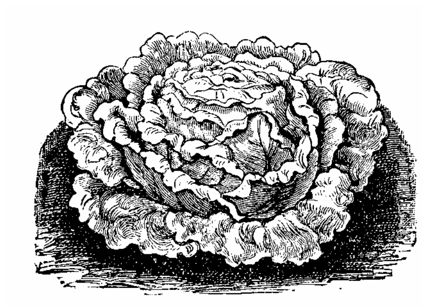
With the support of Dr. Mark Hutton, Maine Cooperative Extension, ROS growers are developing a delicious, disease-resistant pickling cucumber. Last year we crossed a delicious pickle, Conquest, that is no longer commercially available with Clinton, a disease-resistant pickle. Rob Johnston provided the Conquest seed and Mark Henning of Cornell University supplied the Clinton seed, and conducted the first generation cross at Cornell. Seeds from the second generation are available to interested growers

Tomato



We are continuing our improvement of Purden's Purple, an heirloom tomato, for resistance to altenaria (early blight). In the coming years we hope to increase the durable horizontal resistance of this variety to early blight.

Cold-Hardy Lettuce



ROS will supply several lettuce varieties, such as Winter Density and Red Sails, known for cold-hardiness, to interested growers. Growers will select for cold-soil tolerance by starting seedlings in a low-heated greenhouse and transplanting early. Lettuce will be selected to increase robustness and for resistance to bottom rot. Seed will be saved from the best survivors.

Later in the season growers will plant these seeds in an unheated hoop or greenhouse, rogue again and save seed from the varieties most tolerant to cold. Lead Growers: Jeremy Barker-Plotkin,
(Jay Leshinsky, Middlebury College Organic Garden -pending approval)

Dancing Salad Green

ROS and Frank Morton will mentor a project to cross three *Brassica rapas* to develop a niche-market, tasty, colorful salad green. ROS will supply seed for:

4) Mizuna (serrated, cold-hardy) x
5) Tatsoi (spoon-shaped leaves) x
6) Scarlet Turnip (red leaves).

Frank and Karen Morton, www.wildgardenseeds.com, will develop an ecological breeding module with photos and selection guidelines. Our goal is to help growers see the plant as a breeder might.
Lead Growers: Jeremy Barker-Plotkin , Eli Rogosa, (Jay Leshinsky, Middlebury College Organic Garden -pending approval)

Super Spud

Dr. Raoul Robinson and Jim Gerritsen, woodprairie.com, are working with ROS to cross about ten of the best modern potatoes and select for early maturity, high yield, disease and pest resistance. Download Dr. Robinson Amateur Potato Breeding manual on: www.sharebooks.ca.

Other Breeding Interests:

Kim Stoner, Conn. Extension and entomologist, expressed interested in selecting arugula or mustards for flea beetle resistance. There was a ripple of yes! at our recent conference at this suggestion. This would be a long-term project.

Dr. John Sokoloski from Yale suggested breeding for nutrition; ie: higher anti-oxidants - lycopene. He suggested crossing a black tomato (Black Krim or Cherokee Purple) with a thicker-skinned tomato, perhaps a paste tomato.

What have you dreamed of breeding?
To be involved in the breeding program contact Eli Kaufman at humus1@netvision.net.il

Levels of Scale

Each succeeding level requires a greater amount of responsibility and commitment while offering a higher potential benefit.

1) Save seed for own use. Failure affects only you. Some amount of crossing may be tolerable.

2) Select seed for crop improvement. Requires greater time commitment and more attention to detail than #1. May greatly increase on-farm economic benefits over #1.

3) Contracted seed production. Seed quality affects many other stakeholders including the seed company and its customers. Crossing and off-types are not tolerated. Commits more land than #1 or #2. Possibility of total loss if seed not up to germination standard. Increases diversified on-farm income. Seed company takes responsibility for germ tests, packaging, labeling, and retailing.

4) Retail. Become your own seed company. Responsible for all facets of seed quality including adherence to state and federal laws, germ testing, packaging, labeling, marketing (through farmers markets, catalog, retail store or whatever). Huge value-added potential. For example, a cucumber variety that might wholesale for $30 per lb. could bring $307.20 when divided into 256 1.75g packets at $1.20 each. However, operating own seed company involves high overhead. For example, Fedco paid more than $30,000 to print and mail 40,000 catalogs last year not counting labor costs for the production time.

5) Intermediate between 3) and 4) could be a seed growers' cooperative. It has been talked about but not yet tried.

Finding the Appropriate Scale

1) Do you want to commit to growing seed? Why?

2) What is the level of commitment appropriate to your purpose?

3) If you are growing to sell, imagine a triangle with three legs: A scale, B variety, C market. Each is an interdependent variable so we have a complex system.

4) How much land do you wish to commit? How much time? What equipment will you need? Will isolations required for cross-pollinating crops interfere with your vegetable operation?

5) What is the market for the variety you wish to grow? A niche variety such as Candy Roaster squash or Boothby Blonde cucumber will have a limited market requiring only a few pounds of seed. On the other hand, competition from other growers for these specialty items may be nil. These varieties are appropriate for small scale. Specialty heirloom tomatoes and melons may require so little land that they can be grown by backyard gardeners. On the other hand, mainstream varieties such as Marketmore 76 cucumber could be suitable for large scale production in the hundreds of pounds and there is much more demand for famous heirloom tomato Brandywine than for the obscure Schmeig's Striped Hollow. Another grower could flood the market for any of these varieties and change your future plans.

Real-life Results
Lettuce breeder Frank Morton is often says that making money is the hardest part of seed growing. Yet it can be done. High Mowing Farm's Tom Stearns reports making better than $37 per hour after expenses on a 2,000 square foot crop of mizuna seed (67# total) valued at $20 per lb. Of course Tom is in the business. He has all the equipment, expertise and desire to make it work. One of his growers, growing a similar mustard crop the same year reported making a dismal $2.07 per hour. This grower, relatively inexperienced and with lower fertility achieved less than one-seventh of the yield per plant of Stearns. Several Fedco growers have achieved good results, one making 9.74 per hour after overhead on tomatoes (a fairly typical result), one making 9.28 an hour on three pepper varieties, one realizing $12.63 per hour on a 38# crop of Long Pie Pumpkin. Two years later the same pumpkin grower averaged 8.82 per hour for a market basket of six crops. But for a time-consuming failure with a difficult onion crop, she would have achieved $14.16. Many of these crops check in with high gross per acre: Stearn's mizuna at $26,800 and several tomato varieties exceeding $30,000. Trouble is, where you gonna sell an acre of tomato seed production? And therein lies one of the rubs.

The Intangibles
Money is important but the truth is most of our seed growers aren't in it only for the money. Growing seed brings other satisfactions, including allowing plants to complete their life cycles, reconnecting to a more self-sufficient farm heritage, finding the security that comes with controlling the source of our food. Growing seed is an opportunity to give people a way to grow food instead of just giving them food. As well-known plant breeder Carol Deppe puts it,

> "Why save seeds? Saving seeds is fun… Gaze at the seed, run your fingers through it, play with it and you can feel the connections…Unquenchable joy arises… It is the joy

that comes from being who you are supposed to be and doing what you are meant to do."

Bio

CR Lawn founded Fedco Seeds in 1978 and has worked with the cooperative for the past 25 years. He is a speaker, catalog writer and heirloom vegetable variety specialist.

Eli Rogosa Kaufman is an organic farmer, idrc.ca Research Fellow in Regenerative Farming and works with Mideast farmers to improve native landraces. She founded www.jerusalemcityfarmers.org.

Managing Flea Beetles on Brassica Greens

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Flea beetles are small oval-shaped beetles with large hind legs that enable them to jump large distances. Many species of flea beetles exist, and each species is adapted to be able to locate, feed and reproduce on a certain plant group. Crucifer and striped flea beetles feed on Brassica crops as well as weeds that are in the same family, such as yellow rocket or wild mustard. Other species of flea beetles attack other crop families: solanaceous crops such as eggplant, potato, and tomato, or sweet corn, for example. These beetles may look very similar to those that attack Brassicas, but if they are feeding on a different crop group, they are almost certainly a different species of flea beetle. Thus, management strategies for flea beetles in Brassica greens needs to focus on cultural practices and insecticides that are used specifically in Brassica crops.

The crucifer flea beetle (*Phyllotreta cruciferae)* is uniformly black and slightly shiny, about 2 mm in length, and is the most abundant species on Brassicas in New England. The striped flea beetle (*Phyllotreta striolata)* can be distinguished from the crucifer flea beetle by two yellow stripes, one on each side of its back. Neither is native to North America. Crucifer flea beetle has achieved pest status fairly recently; it was first reported in the Northeast in the 1950's.

Feeding damage and crop preference. Flea beetle adults feed on the surface of leaves and stems, resulting in numerous small holes, or 'shot-holes'. Intensive feeding damage can kill plants, especially young seedlings, and moderate damage can reduce plant size, delay maturity, reduce yield, or render crops unmarketable. In addition, flea beetle larvae feed on roots. Their damage is less obvious and has not been well studied, but may also cause reductions in the size and health of plants.

Flea beetles show differences in preference and feeding behavior among the Brassica species. Most of the Brassica vegetable crops that are of European origin (cabbage, broccoli, cauliflower, Brussels sprouts, collards, kale, and kohlrabi) are variations of the same species, *Brassica olerace*a. The cotyledons of these crops tend to be very attractive to flea beetles, but as plants develop the leaves become more waxy. The waxy surface is more difficult for beetles to grasp and feed; as a result, beetles feed mostly at the leaf margins in older crops. While waxiness varies among these crops, in general, once seedlings are past the two or three leaf stage, flea beetles tend to be less of a pest problem.

Many Brassica greens – and also Brassica root crops -- belong to different *Brassica*s species that are more preferred by flea beetles. These include *Brassica rapa* (Pac choi, Choi Sum, Chinese cabbage, tatsoi, mizuna, komatsuna, turnip), *Brassica juncea* (mustards), and *Brassica napus* (red Russian kale, rutabega). There are also Brassica greens from other genera including *Raphanus sativus* (radish, daikon) and arugula (*Eruca vesicaria*). Most farmers who produce Brassica greens are well aware of the preference that flea beetles have for these species compared to the *Brassica oleracea*. A key difference is that these species have non-waxy leaves, which are easier to grasp and feed. There may be other differences in plant chemistry that play a role. There is also evidence that larvae survive better on these species. Feeding occurs across the whole surface of the leaf and feeding continues from the seedling stage until harvest. Holes that are made to small leaves expand as the leaf grows. Control is needed throughout crop growth. While some markets are more demanding than others, many markets will not accept greens with even slightly shot-holed appearance.

Flea beetle life cycle. In the autumn, adult flea beetles move into shrubby or wooded areas near fields where they have been feeding. At UMass we have sampled overwintering beetles in different types of habitats in or next to fields. We found the highest numbers in shrubby borders, somewhat fewer in the woods, and virtually none in more open grassy areas near the edge of the field. This is consistent with what has been found by researchers in other regions.

Adults become active and leave overwintering sites to feed and mate in early spring. In 2003 we collected beetles from the field every week from late April through September and dissected them to determine when female beetles contained eggs. The first eggs were found in female beetles in mid May.

Eggs are laid in the soil near host plants, and larvae feed on root hairs and roots. The rate of larval development is temperature-driven, so cooler soils will result in slower growth and delayed emergence of the summer adult generation. It requires 456 Degree days (with a base temperature of 51.8 °F, or 11 °C) for development from egg to adult (Kinoshita 1979). Depending on temperature, the new generation of adults will begin to emerge in mid to late July. Based on what we found in 2003, we believe that at least some of these summer beetles produce offspring. Eggs were found in dissected beetles until the end of August. Larvae from these eggs would emerge as adults during the fall.

Newly emerged beetles appear to have a strong propensity to feed. In cage studies of field-collected beetles, adults collected in early August fed at a higher rate (ie, the same number of beetles produced more holes per plant in 24 hours) than those collected in spring. In late August and early September, feeding by field-collected beetles declined greatly. At that time, some beetles are likely to be leaving the field to find overwintering sites.

What does this mean for growers? We hope that this information suggests how certain cropping systems create a very favorable environment for flea beetles – and what changes might help reduce their numbers. Succession-planted Brassica crops, side by side in the same field, provide a steady supply of food for both adults and larvae from early spring to fall. Planting Brassica greens that are preferred host plants also favors higher populations. On small farms with few rotation options, spring plantings may be close to the fields that were used for Brassicas the previous fall, which makes it easy for flea beetles to colonize the spring crops in large numbers. Greens are often especially important for organic growers, and effective organic insecticides have not been available. The combined result is that we are seeing an increase in pest pressure for longer periods of the growing season. Growers have reported finding more beetles not only in spring crops, but also in August-planted Brassicas. For example, fall broccoli suffers heavy feeding damage in mid August, most likely from newly emerged summer beetles.

Management strategies. Below are several cultural practices that can be used to reduce flea beetle damage to Brassica crops. They may or may not be suitable for a particular farm.

Crop rotation. To reduce and delay flea beetle invasion of spring crops, move them as far away from the fields that were used for fall Brassica crops as possible. Barriers such as woods, roads, waterways, etc. help slow movement from overwintering sites to the new spring field. We do not know enough about beetle flight patterns to answer the question 'how far is far enough?" We do know that any rotation is better than none, and the farther the better.

Delayed planting. If no Brassica crops are planted until mid to late July, this will stop the reproductive cycle because overwintered beetles will have no where to feed or reproduce (except on Brassica weeds). This strategy can be very effective in bringing the numbers down. Some mesclun growers use only non-Brassica greens in their mix until late summer. Depending on your markets, this strategy may require serious adjustments to the farm's production and marketing plan – and may not be feasible. It is hard to imagine a successful farmstand or CSA farm with no Brassicas until fall.

Separate early and late crops. Let's assume that emergence of the summer generation of beetles from a spring crop begins in mid July. If there are young Brassicas close by, they will be heavily damaged. However, if fall Brassicas are seeded into an isolated, rotated field, beetle numbers will be low and the crop will suffer much less damage.

Provide crops with good growing conditions. Research studies have shown that well-fertilized plants growing in good soil with adequate water are attacked less than plants that are wilted, poorly fed, or growing in compacted soil. While this may not overcome a large flea beetle population, it can make a difference in plant survival, growth and quality.

Using row covers. One of the best ways to protect Brassica crops from flea beetles is to place a floating row cover over the bed or row. At UMass we have conducted trials of various insecticides for the past three years, and we usually include row cover as one treatment. The cleanest, highest quality greens are always those under row cover. For growers with relatively small (<1/2 acre) plantings row covers can be practical and cost-effective; however, they are a management-intensive system.

It is critical to seal the edges immediately after seeding, because Brassica seeds germinate quickly and beetles rapidly invade the emerging cotyledons. Flea beetles can fit through extremely tiny cracks when they want to. Edges of the cover must be sealed on all sides with a ridge of soil, periodic shovelfuls of soil, black plastic bags filled with soil, or some other method. One key entry point for beetles that is often neglected is the end of the row. Often there are a few uncovered plants at the end of the row that draw the beetles in, and an opening of the cover that allows them to get underneath. One advantage of wider row covers is that they protect a larger area relative to the length of the edges. However, if there are raised beds, the furrow may have a large gap that allows entry. In 2003 we worked a farmer to test eight-foot, water-filled plastic tubes for the ends of the bed. These tubes conformed to the contour and sealed the ends very effectively. Black plastic bags worked almost as well, if the bags were placed in the bottom of the furrow.

The weight of the row cover fabric should be considered. Heavier covers are more durable (an important factor, given the cost of row cover), have lower light transmission, and provide more heating and more cold protection. Lower light transmission increases tenderness and length, which can be desirable. However, if heavier covers are used in midsummer, yield may be reduced. Non-heating, reinforced covers may be desirable for midsummer plantings.

Weed control is another major issue with row covers. Preparing a stale seedbed before seeding, using flaming, cultivation or herbicide, will help delay weed emergence. We have also observed a compost mulch being used with success for intensively planted beds of greens. For conventional growers, preplant incorporated herbicide is an option. Even when weed control techniques are used prior to planting, covers may need to be removed for cultivation or hand hoeing. To minimize beetle entry, replace covers the same day.

Table 1. Results of insecticide trials for flea beetle control in komatsuna, 2002 and 2003						
Treatment	**Trade Name**	**Rate (formulated)**	**2002**		**2003**	
			mean damage* (holes/leaf)	**mean weight* (g/plant)**	**mean damage* (holes/leaf)**	**mean weight* (g/plant)**
control			25.23 b**	64.16 c**	137.40 bc**	41.53 bc**
row cover	Agril 17 (2002); Covertan P30 (2003)		0.88 d	108.06 ab	2.38 e	58.97 abc
pyrethrin	Pyganic EC 5.0	16 oz/A	--	--	161.90 ab	72.39 a
carbaryl	Sevin XLR Plus	0.75 qt/A	6.05 cd	128.44 a	33.45 de	74.69 a
spinosad-Spintor	Spintor 2SC	5 oz/A	10.19 c	85.87 bc	91.40 cd	69.91 ab
spinosad-Entrust	Entrust	1.5 oz/A	--	--	71.15 d	62.87 ab
spinosad-seed trt	Tracer	2.5 g ai / 100 g seed	--	--	88.75 cd	31.34 c
kaolin	Surround WP	1/2 lb/gal water	25.38 b	64.11 c	--	--
thiamethoxam- seed	Cruiser 5FS-C	2.5 g ai / 100 g seed	--	--	215.65 a	50.29 abc
thiamethoxam- furrow	Platinum	0.31 oz/1000 row feet	36.77 a	109.22 ab	192.45 ab	53.11 abc
Capsaicin	Hot Pepper Wax	8 oz/gal water	9.93 c	77.8 c	--	--

* Harvest samples taken five weeks after seeding.
**Means within the same column followed by the same letter are not significantly different (Duncan's, $p<0.05$)

Insecticides. There are a number of synthetic pyrethroids and carbamates, which are labeled for flea beetle in Brassicas and which can give effective control of flea beetles for conventional growers. Organic growers have lacked an effective material. Rotenone, which was somewhat effective, is no longer allowed. For the past three years we have conducted insecticide trials at the UMass Research farm with the goal of identifying low-risk and organic insecticides that will suppress or control flea beetles.

We conducted these trials using Komatsuna, *B. rapa* species that is attractive to flea beetles, with an open growth habit and flat leaves. Treatments were tested in replicated plots that were 5 rows wide X 7.5 feet long (2002) or 6 rows X 9 feet (2003), and separated by 15 feet on all sides. The seeding date was June 13 in 2002 and May 30 in 2003; in both years, flea beetle populations were high enough to reduce plant growth rates in unprotected treatments. Foliar treatments were applied weekly. Furrow treatments (thiamethoxam) were applied once at seeding. The final harvest sample was taken at 5 weeks.

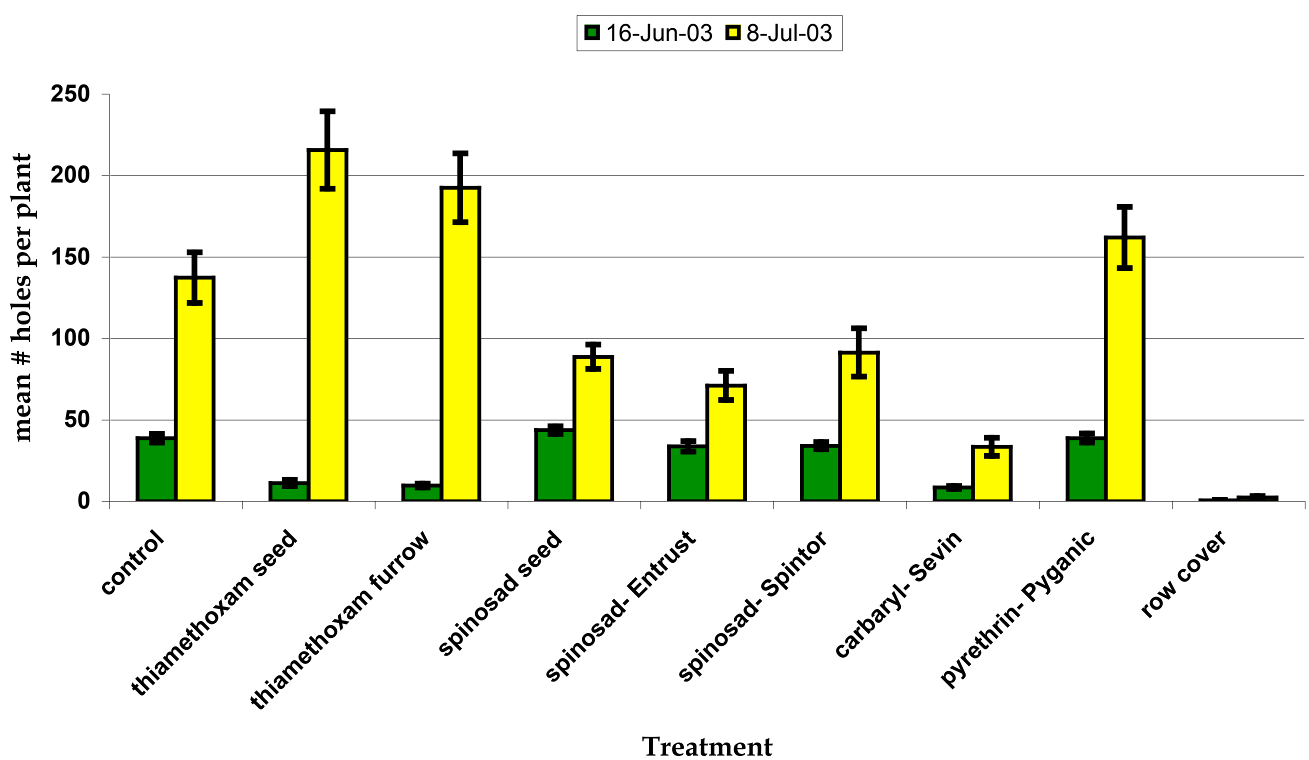
Results (see Table 1). In leaf damage at harvest, neither kaolin nor pyrethrin treatments were significantly better than the untreated control. Spinosad, both the Spintor and the Entrust formulations, significantly reduced leaf damage in both years, though it did not result in signficantly higher plant weights. Carbaryl and row cover treatments had the lowest damage, and plant weights were signficantly higher than the untreated controls for carbaryl in both years and for row cover in 2002. Capsaicin, in the Hot Pepper Wax formulation, reduced leaf damage as much as carbaryl and spinosad. Because this product is currently not allowed by the National Organic Program (NOP) we did not test this again in 2003. However, the level of protection provided by spinosad is an encouraging result for organic growers because Entrust is allowed by the NOP.

Thiamethoxam (Platinum) is currently not labeled for brassicas; however, the manufacturer is seeking registration for this crop. This sytemic neo-nicotinoid insecticide is absorbed through the roots into leaf tissue. This treatment, either as a furrow drench or a seed treatment, showed higher plant weight, and reduced flea beetle damage for about 3 weeks after seeding (see Figure 1; the June 16 sample was taken approximately two weeks after seeding). At harvest (July 8), leaves were heavily damaged, indicating that the insecticide was no longer present in leaf tissue.

Reference:

Kinoshita G.B., H.J. Svec, C.R. Harris and F.L. McEwan. 1979. Biology of the crucifer flea beetle, *Phyllotreta cruciferae* (Coleoptera: Chrysomelidae), in southwestern Ontario. The Canadian Entomologist 111:1395-1407

Figure 1. Flea beetle damage to Komatsuna (average number of holes per leaf) at the two-leaf stage and at harvest



Diseases – Angular Leaf Spot to Wilt and How to Manage Them

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Accurate diagnosis is step one in disease management since there is no fungicide or other management practice effective for all diseases. From Angular leaf spot to wilt, there are numerous diseases that can affect pumpkins in the Northeastern USA. Fortunately there are resources available to assist with diagnosis. The *Pumpkin Production Guide* from NRAES has a disease identification key plus several pictures (www.nraes.org/publications/nraes123.html). There is also information and photographs at vegetablemdonline.ppath.cornell.edu. These resources also have management guidelines.

Angular leaf spot occasionally occurs in the Northeast. Leaf spots are angular because the pathogen cannot move through major veins. Spots are initially water-soaked, then turn brown, become dry, and may crack. Spots on fruit are small and round. Symptoms can also develop on petioles and stems. A milky substance that becomes crusty can exude from affected tissue under high humidity.

Seed and infested crop debris can be the source of bacteria that cause this disease. Therefore use pathogen-free seed and rotate out of cucurbit crops for at least 2 years. Also do not work in infested fields when leaves are wet to avoid moving bacteria on workers or equipment. Copper fungicides can be effective used early in disease development when there are few symptoms.

Downy mildew is a potentially devastating disease that occurs sporadically in the Northeast. It was severe in some areas in 2003. Only leaves are affected. Leaf spots are angular being delineated by leaf veins. Initially they are pale green, then yellow before the tissue dies. Extensive defoliation can occur when conditions are favorable. Leaf petioles often remain green and upright after the leaf blade has died and drooped. In contrast with powdery mildew, a more common disease, spores of the downy mildew fungus are darker (purplish gray) and develop only on the underside of leaves.

This fungal pathogen does not survive winter here, thus it only occurs when conditions favor spore production, release, and movement from where the disease is occurring plus favorable conditions for disease development where the spores land. These factors are being used to forecast where downy mildew will occur in the eastern USA. Forecasts are posted at a North Carolina State University web site (www.ces.ncsu.edu/depts/pp/cucurbit/). Fortunately, downy mildew rarely starts developing early enough in the growing season in the Northeast to be a major disease. But its destructive potential warrants checking forecasts and scouting for symptoms.

Broad-spectrum contact protectant fungicides provide some control. Apply systemic fungicides beginning when downy mildew is forecast to occur in the area or symptoms have just started to develop. Fungicide resistance is a concern with this pathogen, therefore alternate among systemic fungicides in different chemical classes. Systemic fungicides currently registered include strobilurin or QoI fungicides (eg Amistar, Cabrio, Flint), mefenoxam (eg Ridomil Gold Bravo), and phosphoric acid (eg Aliette). Amistar is a new formulation of azoxystrobin replacing Quadris. Cabrio has controlled downy mildew better than Quadris in some efficacy experiments.

Fusarium fruit rot has recently re-emerged as a major problem, especially in fields where pumpkins are grown with minimal rotation. A major outbreak occurring in CT and NY during the 1940's led to a reduction in commercial production of all cucurbits for several years. It was not reported again as an important problem until 1996. Significant losses were observed in several fields in 2002 and 2003 in the Northeast as well as elsewhere in the USA.

Symptoms develop on the side of fruit contacting soil, beginning as round water-soaked spots. These spots become whitish when the fungal pathogen produces spores. Brown rotting tissue extends well into the flesh. Two races of the pathogen have been described. Race 2 only causes fruit rot while Race 1 also infects root and stem tissue causing a crown rot.

Seed and infested crop debris can be the source of the fungus causing this disease. Therefore use pathogen-free seed and rotate out of cucurbit crops and corn for at least 3 years. No fungicides have been found to be effective. Incidence of fruit with Fusarium fruit rot, and also incidence of black rot, was lower where pumpkins were planted into rye straw mulch than where grown on bare ground during a study conducted in Ohio. A research project is starting in the Northeast to evaluate straw and living mulches.

Plectosporium blight (previously named Microdochium blight) is another potentially devastating disease. It is a new disease having been first observed in the USA (TN) only in 1993. It was first seen in the Northeast in 1999. Severe losses occurred in 2003 probably because rainy weather provided favorable conditions.

Symptoms occur on leaf veins, stems, and fruit. Lesions are white and have a very distinctive diamond to spindle shape that is characteristic for this disease. They are small initially, but can expand and coalesce, causing the entire surface of stems, leaf veins or fruit handles to turn white. Leaf tissue between veins is not affected, thus early symptoms are not as apparent as with other foliar diseases. Leaves eventually die and collapse, often in a 10- to 25-ft diameter circle around the site of initial infection. Dead vines can be so brittle they shatter when stepped on. Spots are more circular on fruit, and they remain small and don't coalesce.

The pathogen can survive in soil, therefore rotation is recommended for management. Chlorothalonil (Bravo, Equus, etc) applied regularly beginning at flowering or fruit set has provided effective control. Strobilurin fungicides are also effective, but their use should be limited to when they are needed most for overall disease control because of the high risk of selecting resistant strains of this or another pathogen that is also present. Restricted use will maximize the useful life of this important group of fungicides. Thus strobilurins are only recommended specifically for Plectosporium blight where this disease is a major concern. Strobilurins applications targeted for other diseases (e.g. powdery mildew, downy mildew, black rot) will also control Plectosporium blight.

Phytophthora blight continues to be a challenge to manage. Unfortunately it has been increasing in importance as it spreads into new areas. Symptoms include crown rot, tip blight, leaf spots, and fruit rot, the most common symptom occurring in pumpkin. Management focuses on preventing the pathogen from being moved into a new field and managing soil moisture to avoid saturated conditions that favor disease onset. Prevention is very important because Phytophthora blight is difficult to control once it starts, and after it has occurred on a farm it is challenging to continue growing susceptible crops without Phytophthora blight occurring, even in fields with no previous history. In addition, it is very difficult to suppress this disease once it starts to develop in a field.

It is important to use an integrated program with as many of the following practices as possible.

1. Avoid the pathogen if not already on a farm.
2. Long rotations (over 2 years) away from peppers, tomatoes, eggplants, lima beans, green beans and other cucurbits. This pathogen has recently been detected in roots of some weeds, including purslane, which means these plants will need to be controlled during rotation for this practice to be effective.
3. Select well-drained fields.
4. Plant cover crop in low areas.
5. Physically separate susceptible crops.
6. When growing small-fruited pumpkins, select varieties with hard rinds (eg Lil' Ironsides).
7. Subsoil between rows after planting to improve drainage. Also subsoil along driveways. Plant grass in driveways.
8. Don't move soil between fields on equipment or boots.
9. Irrigate as needed; not excessively.
10. Don't use pond or stream water draining from infested field for irrigation.
11. Fungicides have provided minimal control in efficacy trials and thus should not be relied on for managing Phytophthora blight. Currently available products include phosphoric acid (Aliette, Phostrol), dimethomorph (Acrobat), and zoxamide (Gavel). Chlorothalonil and copper fungicides, which are registered for other diseases, can also provide some control.
12. Scout routinely. Include any areas where water does not drain well or soil is compacted, such as driveways.
13. Disk affected areas plus border area if found early. Begin with border area.
14. Remove good fruit from affected field ASAP, especially if rain is forecast. Hold a few days then re-examine for symptoms before selling.
15. Don't display fruit in a field where blight occurred previously.

Powdery mildew is the most common foliar disease, occurring every year throughout the Northeast. White powdery fungal growth develops on both surfaces of leaves and on stems. Resistant varieties are available, but application of fungicides continues to be the main management practice.

<u>Powdery mildew needs to be controlled on both leaf surfaces</u> to avoid premature death of leaves. It is especially important to control powdery mildew on the underside of leaves where conditions are more favorable for disease development than on upper surfaces. <u>The best approach is to use systemic fungicides</u>. Advances are being made in sprayer technology to deliver more spray material to the underside of leaves. <u>Fungicide resistance is a major concern</u> with systemic fungicides. They generally have a high risk of resistance developing due to their specific mode of action. Powdery mildew fungi have a high potential for resistance development. In the USA, the cucurbit powdery mildew fungus has developed resistance to all chemical classes registered for controlling it: benzimidazole fungicides (Benlate, Topsin M), demethylation inhibiting or DMI fungicides (Bayleton, Nova, Procure), and strobilurin fungicides (Amistar, Quadris, Flint, Cabrio). Thus, <u>managing fungicide resistance is an essential component of effective powdery mildew control</u>.

General recommendations for managing powdery mildew and fungicide resistance are:

1. Reduce the need for systemic fungicides by selecting resistant varieties and not planting pumpkins next to spring cucurbit crops treated with systemic fungicides.

2. Use systemic fungicides only when needed and not curatively; this can be accomplished by scouting to ensure applications are started very early in powdery mildew development, and using protectant fungicides alone late in the growing season. An action threshold has been developed to time the first application of systemic fungicides for powdery mildew. The scouting protocol entails weekly examining both leaf surfaces of 5 old, crown leaves in at least 10 locations through out a field. Start applying systemic fungicides when powdery mildew is found on at least 1 of the 50 leaves. It is critically important to examine the underside of leaves, especially where a protectant fungicide has been used for other diseases. Towards the end of the season it may be possible to obtain adequate control without sacrificing yield by using just protectant fungicides.

3. Alternate among systemic fungicides with different modes of action and mixing these with protectant fungicides. Specific recommendations often change as resistance develops to a new group of fungicides and new materials are developed. A protectant fungicide is needed because it has multi-site activity and thus low resistance risk. It will control pathogen strains resistant to systemic fungicides.

4. Maximize control obtained with protectant fungicides by selecting a product with good efficacy and ensuring good spray coverage.

5. Assess efficacy to determine if resistance may have developed. Any disease control problems should be reported promptly to local extension specialists so that the possible cause can be investigated.

Many protectant fungicides are available for powdery mildew. They vary considerably in efficacy (Table 1) and also price. This group includes products approved by OMRI for organic production: biofungicides (Serenade), potassium bicarbonate (Kaligreen), oil (JMS Stylet-oil), sulfur, and copper. Sulfur and oil are more effective than chlorothalonil because they provide better control on the lower surface of leaves. Sulfur is the least expensive fungicide available. Micronized formulations (eg Microthiol Disperss, Micro Sulf) are recommended over wettable powders. Powdery mildew is the only disease controlled by sulfur, therefore it is critical when using sulfur to inspect a crop regularly for symptoms of other diseases. Chlorothalonil and copper are effective for more additional diseases than the other protectants.

Resistance has developed quickly to strobilurins. This group of fungicides has been available for commercial use in the USA beginning in 1998 when Quadris received Section 18 registration in some states for cucurbit powdery mildew because systemic fungicides available then, Benlate and Bayleton, were no longer adequately effective due to resistance. Federal registration was granted in March 1999. Resistance to strobilurins was first detected in field and greenhouse crops of melon and cucumber in Japan, Taiwan, southern Spain, and southern France in 1999, after just 1 to 2 years of commercial use.

Reduced efficacy with strobilurins was first noted in the USA in 2002. Most reports were from research fields where one treatment was a strobilurin used alone on a 7-day schedule (use pattern not labeled). Detecting resistance based on reduced control can be harder to do in commercial production fields than in research fields where plants treated with other fungicides and non-treated plants provide comparisons for determining that efficacy is reduced and ruling out poor application timing as the cause. Additionally, other fungicides used with strobilurins in a program designed for managing resistance, as is done in commercial fields, might provide enough control of powdery mildew to mask the presence of strobilurin resistant strains, especially if they are at a low frequency. Resistance to strobilurins was confirmed by conducting laboratory assays on isolates of the powdery mildew fungus collected from fields with poor control in GA, NC, VA, and NY.

Development of resistance to strobilurins greatly challenges powdery mildew management. Cross resistance occurs among strobilurins, thus a resistant isolate is insensitive to all products in this group. Resistance was shown to be qualitative, which means isolates of the pathogen were either highly sensitive to strobilurins or highly resistant. Control cannot be regained with qualitative resistance by applying the fungicide more frequently and/or at a higher rate or by switching to a more active fungicide in the same chemical class, in contrast with quantitative resistance. Resistance to demethylation inhibiting fungicides (DMIs) is quantitative. Degree of resistance to DMIs in the cucurbit powdery mildew pathogen in the USA presently is such that the old DMI fungicide Bayleton is no longer effective while newer fungicides such as Nova are effective when applied at high rates. There continues to be concern that using DMI fungicides will eventually select for pathogen strains with greater resistance to this group of fungicides such that Nova is no longer effective. Strobilurins are needed to continue playing an important role in managing this resistance, therefore it is prudent to use them wisely in order to prolong their useful life. However, a further challenge to managing powdery mildew and resistance is that most of the 2002 strobilurin-resistant isolates tested also exhibited reduced sensitivity to DMI fungicides. Isolates collected in 2003 are being tested now.

To develop recommendations for managing powdery mildew with strobilurins, information is needed on occurrence of strobilurin resistant pathogen strains before these fungicides are applied and information is needed on impact of applying strobilurins on frequency of resistant strains. Obtaining this information was the goal of a project conducted on Long Island, NY, during the 2003 growing season. Fungicide resistance was monitored using a seedling bioassay. Squash seedlings were treated with fungicide, then placed with non-treated seedlings in a production field for a day. Afterwards seedlings were kept in a greenhouse until symptoms appeared. For the first assay, seedlings were placed during late July in spring plantings of squash that had not been sprayed with systemic fungicides. Powdery mildew starts to develop in spring squash before main season plantings of pumpkin, melon, etc. Resistance to strobilurins was detected at a low level in one of five fields. A second assay was conducted at the end of August in pumpkin fields where systemic fungicides had been used. DMI and protectant fungicides had been used in all 7 fields; strobilurins in 6 fields. Resistance to strobilurins was detected in all fields. Several strobilurin-treated seedlings had as much powdery mildew as non-treated plants indicating a very high frequency of resistance. Seedlings treated with a DMI fungicide had less powdery mildew, indicating a lower percentage of isolates with reduced sensitivity to this fungicide group. Powdery mildew did not appear to be suppressed very well on the underside of leaves in these fields. Resistant strains were also detected during a third assay conducted in organic and conventionally-managed fields that had not been sprayed with systemic fungicides. Widespread distribution on Long Island of strobilurin-resistant powdery mildew strains is alarming. Poor control possibly due to resistance has been reported elsewhere in the USA in 2003. Fortunately, there were also areas where strobilurin fungicides appeared to be effective, especially where disease pressure was not very high and good fungicide programs were used. Thus strobilurin fungicides may continue to be important tools for managing cucurbit powdery mildew in some areas.

Several fungicide programs were evaluated in 2003 on Long Island where strobilurin-resistant strains occurred. On September 8 after 5 weekly applications (August 7 – September 6), the strobilurin fungicide Flint (2 oz/A) applied in alternation with sulfur (4 lb/A Microthiol Disperss) was providing poor control (37% on upper leaf surfaces and 0% on lower surfaces). Control was improved by applying sulfur every week and applying on alternate weeks a DMI fungicide: using Nova (5 oz/A) provided 84% and 48% control on upper and lower leaf surfaces, respectively;

Procure (6 oz/A) provided a similar level of control (89% and 34%). Applying a DMI fungicide every week in this program with Flint and sulfur by alternating between Nova and Procure did not improve control significantly (86% and 52%). Control was not improved by applying Flint and Procure more than once in a fungicide program with weekly applications of sulfur, most likely due to high frequency of resistant strains; Flint plus sulfur applied week 1 followed by Procure plus sulfur week 2 then sulfur alone weeks 3 – 5 provided 68% and 24% control. Sulfur applied alone weeks 3 – 5 did contribute to control; where only the week 1 and 2 applications of Flint, Procure and sulfur were made, powdery mildew on September 8, 25 days after the last application, was as severe as where no fungicides were applied. There was also no significant differences in amount of defoliation on September 22: 66% where the two applications were made and 76% where there were none, versus 21% where there was an additional 3 applications of sulfur. Flint used with sulfur as the protectant fungicide was more effective than Quadris used with Bravo (Procure included in both programs), which provided 45% and 19% control. In comparison, 95% and 91% control was obtained with an experimental fungicide.

When selecting powdery mildew resistant (PMR) varieties, it is important to know the degree of resistance and the potential for other diseases to occur when less fungicide is used for powdery mildew. Some fungicides have broad-spectrum activity and thus will control additional diseases. Resistant varieties should be scouted weekly for powdery mildew, as well as other diseases, regardless of the variety. Resistance is not immunity, and new races can arise at any time. Resistant varieties differ in the degree of resistance depending on the number of resistance genes they have. There are at least two genes for resistance plus several modifier genes. Varieties with genes for resistance from both parents (eg PMR Aladdin) will be less severely affected by powdery mildew than those with a single resistant parent (eg Merlin and Magic Lantern). A reduced fungicide program is recommended with PMR varieties to improve control of powdery mildew and lower selection pressure for new races of the pathogen able to overcome genetic resistance. Fewer applications will be needed compared to a susceptible variety because disease onset generally is delayed and a 14-day spray interval can be as effective as a 7-day interval. Additionally, biocompatible fungicides (eg potassium bicarbonate, biofungicides) can be as effective for controlling powdery mildew as conventional fungicides when combined with genetic resistance. Some PMR varieties are more susceptible to bacterial wilt.

Wilt caused by bacteria (bacterial wilt) has recently become a greater problem on pumpkin, which was previously considered a minor host compared to cucumber and melon. This may be partly due to presence of new strains of the pathogen and greater susceptibility of some new varieties.

Initial symptoms of wilt are pale, wilted sections of leaves that are often associated with feeding injury. Leaf tissue between veins becomes yellow while main veins often remain green even after the rest of the leaf tissue dies. Plants may have shortened internodes causing branches to have a "tufted" appearance. Symptoms of bacterial wilt progress from localized leaf symptoms to collapse of individual vines and eventually to plant death. When plants are affected young they often die quickly. Older plants may continue to grow, but fruit will be small and/or soft.

A common diagnostic test for bacterial wilt involves cutting a wilted vine close to the crown of the plant, rejoining the cut surfaces for a moment, then slowly drawing apart the cut ends. Only with this disease will there be strands of a sticky clear substance between the cut surfaces. The strands are masses of bacteria streaming from xylem tissues. The procedure may need to be repeated several times to obtain these strands.

Bacteria that cause wilt survive overwinter in cucumber beetles. There is no evidence for transmission in seed or survival in soil. Bacteria do not survive long in dried plant debris.

The bacterium causing this disease cannot be controlled directly with pesticides, therefore, management practices have targeted the insects that harbor and vector the pathogen, which are the striped and spotted cucumber beetles. Control is complicated because the presence of beetles alone is not indicative of an impending wilt epidemic. In the absence of the pathogen, a much higher beetle density can be tolerated by the crop. However, if growers wait until disease symptoms occur to treat the beetle vectors, subsequent control of wilt is erratic. Neonicitinoid insecticides (eg Admire) are a valuable tool for managing bacterial wilt because they are systemic and can be applied in furrow when direct seeding or to seedlings before transplanting, thus control is provided to young plants which are very attractive to beetles and susceptible to wilt.

Perimeter trap cropping is an alternative management strategy recently demonstrated to be effective under conditions in the Northeast by Jude Boucher in CT. It entails planting 'Blue Hubbard' squash, or another cucurbit crop that is highly attractive to cucumber beetles, around the edge of a cucurbit crop and targeting insecticide applications to this trap crop.

Two PMR pumpkin varieties, 'Merlin' and 'Magic Lantern', are more susceptible to wilt than other pumpkin cultivars. Therefore wilt needs to be controlled more aggressively when these varieties are grown. 'Merlin' is the most susceptible. This is not due to greater attractiveness to beetles based on beetle density or feeding damage. These varieties were developed in an area where bacterial wilt does not occur. Fortunately wilt susceptibility does not appear to be linked to PMR genes. An experimental pumpkin line closely related to 'Magic Lantern' that has resistance from both parents was not more susceptible to wilt than 'Magic Lantern' as would be the case if these two traits were linked

Table 1. Percent control of powdery mildew achieved on upper and lower surfaces of pumpkin leaves with fungicides and health-promoting fertilizers applied weekly in experiments conducted in Riverhead, NY, in 1997 to 2002.

	Upper leaf surface						**Lower leaf surface**					
Fungicide and rate/A	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Serenade 6 lb					36 b	23 ab					8 abc	10 bc
Milsana 1%			45 b	85 b	59 c				21 ab	26 b	10 a-d	
Armicarb 100 4 lb				23 a	62 c					23 b	16 bcd	
Kaligreen 2.2-5 lb	65 ab				62 c	47 cd	45 bc				5 ab	6 bc
Prudent Plus 1.4-2.5 qt					40 b	47 cd					17 bcd	0 ab
Nutrol 20 lb	60 ab	66 cd			68 c	50 cd	29 b	24 b			21 d	16 c
Prudent Plus 2 qt + Nutrol 10 lb						61 de						18 c
Kocide 2000 2-2.25 lb	98 f-h	72 de	64 b		84 d	60 de	60 c-e	20 b	26 ab		19 cd	0 a
JMS Stylet-oil 1.5%					93 e	59 de					55 f	4 abc
Microthiol Disperss 4 lb	99 g-j	96 i	69 b		93 e	76 e	72 d-f	63 efg	31 ab		53 f	10 bc
Bravo Ultrex 2.7 lb				97 cd	98 e	78 e				14 ab	37 e	10 bc
Quadris 15.4 oz alternated with Nova 5 oz + Armicarb				100 efg						100 g		
Quadris 15.4 oz alternated with Nova 5 oz + Bravo		93 i	100 d	100 e	95 e	45 bcd		58 ef	84 de	98 fg	72 g	18 c

Numbers in a column with a letter in common are not significantly different according to statistical analysis using Fisher's Protected LSD. Numbers with an 'a' are not significantly different from nontreated, thus control is really 0% ('a' or 'b' for lower leaf surface in 2002).

Weed Management in Pumpkins

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Introduction

The 2004-2005 version of the New England Vegetable Management Guide is available and all vegetable growers should have a copy of this publication. All of the new label changes have been included in this publication. The most significant label changes are for two newer herbicides, Strategy and Sandea. Information on these is provided below. Although this is a pumpkin talk, I have left certain details that pertain to other cucurbit crops in the narrative below. All other information that will be presented in this talk can be found in the Vegetable Management Guide. I expect that copies will be available for sale at the Conference and copies are available from all 6 New England Extension services. Members of the New England Vegetable & berry Growers will receive this publication as part of their membership dues.

Significant Recent Label Changes

Strategy (ethalfluralin + clomazone): This label came out during 2002 and the product was extensively throughout New England during 2002 and 2003. Strategy is a premix of Curbit (ethalfluralin) and Command (clomazone). It is intended for preemergence control of annual grasses and many broadleaf weeds in cucumber, melon, pumpkin, summer squash, winter squash, and watermelon. Broadleaf weeds controlled include, common lambsquarters, pigweed, common purslane, velvetleaf, common ragweed, and Pennsylvania smartweed. This product may be applied to the soil surface after direct seeding on bare ground. It may also be banded between plastic for both direct-seeded and transplanted crops. The formulation of Command contained in this product is the ME (microencapsulated) formulation which does not need to be incorporated. There are many precautions on the label including some replant precautions. For squash and pumpkin, this product will be the treatment of choice since it controls so many weed species. In cucumber and melon, however, Curbit tank-mixed with Alanap (naptalam) may still be a good option since most of the same weeds are controlled but the carryover concerns with clomazone are not present.

Sandea 75WSG (halosulfuron): The new label covers cucurbits, tomatoes, fruiting vegetables, asparagus, dry beans, and snap & lima beans. Sandea provides preemergence and postemergence control of many weeds. Most weeds are controlled by either a preemergence or postemergence application; however, common lambsquarters is controlled best by a preemergence application while yellow nutsedge is controlled best by a postemergence application. Postemergence applications require the use a non-ionic surfactant at a rate of 1 quart per 100 gallons spray mix. Heavy rains following preemergence applications can lead to severe crop injury. There is the potential for crop stunting and a slight maturity delay with the use of Sandea over the top of the crop. Growers should limit their use of Sandea initially to gain experience. Use the correct amount of product per acre. The most common use rate will be _ ounce per acre. If the directions are not followed, the potential for severe crop injury does exist. A brief summary of use directions follows follows and can be found in the New England Vegetable Management

Guide. Consult the label for complete directions. Consider using Sandea only if current management strategies are not working or as a supplement to existing management strategies to control certain problem weeds. This herbicide may carryover to the following year and can cause severe injury in crucifers, greens, spinach, beets, carrots, onions, and other crops. See the label for details.

Pumpkins and Winter Squash: Apply postemergence when the seeded crop has 2 to 5 true leaves. Crop injury and some delay may result. Can also be used preemergence after seeding; however excess rainfall or irrigation may cause unacceptable crop stunting. Can also be used between plastic mulch with direct-seeded or transplanted winter squash and pumpkins. Perhaps the best fit for this product in winter squash and pumpkins is for postemergence control after preemergence use of another product (Curbit, Strategy, Prefar, or Command). Sandea will provide postemergence control of yellow nutsedge, redroot pigweed, velvetleaf, common ragweed, and many other broadleaf weeds

Cucumbers: Apply preemergence after seeding and before crop emerges. Can also be applied when a seeded crop has 2-5 true leaves but the potential for crop stunting and yield delay should limit postemergence use to areas where weed pressure is high and yield reductions due to weeds would be unacceptable. Can also be used between plastic mulch with direct-seeded or transplanted cucumbers. In cucumbers, with a shorter life cycle that most other cucurbits, it might make sense to use this product preemergence alone or in addition to Strategy, or Curbit, or Alanap

Summer Squash, Muskmelons, Watermelons: Apply between rows of plastic mulch avoiding contact with the plastic and crop. May also be used in row middles without plastic; any crop contact or use in the crop row will cause injury.

Please read the label entirely regarding application directions and precautions. Accurate measurement and application is essential to minimize crop stunting and delay. A plastic measuring cup should be included with the herbicide container. Results during 2002 in Massachusetts and throughout New England in 2003 on winter squash, cucumbers, and pumpkins were generally favorable although some severe injury did exist. Crop stunting was common but plants, in most cases, recovered with only a slight or no yield delay.

No-till Pumpkin Production

Many growers have tried growing pumpkins with no tillage. This generally requires the use of the cover crops that must be killed, use of a preemergence herbicide, and potential use of a postemergence herbicide. Both the Strategy and Sandea registrations have made no-tillage more successful in recent years since cultivation is not an option. Overall, current herbicide options are the same as for bare ground systems.

Adding Horticulture to an Already Diversified Farm

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Lilac Ridge Farm is a family-run, multi-generation, diversified farm. When I joined the Thurber family as an employee first in 1995, Beverley and Stuart Thurber, my now mother and father in-law were operating a 60 cow dairy, 1600 tap sugar bush, 5 acre Christmas tree lot, timber harvest and firewood business. In the spring of 1996 Ross, my now husband and I planted a _ acre market garden to provide the produce and flowers for our wedding that September. The market garden was a success, and has now blossomed into a 5 acre market garden with 1 acre in cupflowers, and new to this year, pick your own pumpkins. We also have a planned commercial blueberry planting for spring of 2004.

This presentation will go over some of the joys and pitfalls of adding horticulture to an already diversified farm. Also, as my own addition, will be some discussion of the joys and chaos when you add young children to an already diversified farm that includes horticulture.

The way it works on our farm is that each member of the farm partnership contributes significantly to his/her part of the farm operation, with of course a lot of overlap. For example, though my mother in-law, Beverley is principally in charge of the books and the Christmas tree operation, she does most any job: baling hay, milking, fencing, washing produce. This is the same for all of us. Whatever the seasonal job emphasis, i.e.: haying, sugaring, squash harvest, we all strive to foster the success of that particular job.

Below is a general list of our farm jobs, when we do them, and who on the farm does them

Bookkeeping: all year for all parts of the farm operation
Beverley (my mother in law)

Horticulture: Seasonal: March-late November 5 acre diversified vegetable and cut flower operation. Greenhouse 21'x48' poly tunnel for spring starts primarily. Organic, not certified. Markets: 2 farmer's markets, wholesale to 3 restaurants, food coop, wholesale flower sales and weddings
Amanda (me) with 1 full time (5days 7:30AM-4:00PM) March-October employee,
1 full time June-August employee
1 part time (2-3 days) May-August employee
Ross (my husband): plowing
Beverley: washing produce during thin labor times and co-running the farmer's market stands

Dairy: all year 60 cow milking herd Holstein and Brown Swiss. Tie stall pipeline milking barn. Cows milked 5:00AM and 4:00PM Feeding: Summer, Fall: Intensive management grazing, Winter, Early spring mixed ration feeding in our free stall

Ross(my husband) and Stuart (my father in law) with 1 evening milker 5days/ week , every other Sunday in summer and fall.

Auxiliary chores: all year. calves, heifers
Ross and Stuart

Forage Production: Seasonal: June-November 17 acres silage corn, 110 acres hay: 700 round bales and 9000 square bales, 60 acres pasture
Ross and Stuart with occasional part time help

Sugar making: Seasonal: February-April. setup: hanging pipeline, tapping, gathering, boiling
Everyone (Ross, Amanda, Stuart, Beverley) and other family and neighbors

Timber harvest: 420 acres woodland, 25,000 board feet harvested per winter starting usually in January
Ross, Stuart, Shabir (my brother in law) Amanda

Firewood: 26 cords for 3 households and 25 cords for sugar wood
Everyone (mostly Ross)

Christmas trees: Seasonal: marketing December, planting April, trimming July, sold directly from farm.
Beverley and Stuart (Ross and Amanda harvest)

Head spinning yet? Mine is.
So, how do we make it work without going crazy?

1. Passion. For our work, and our farm and our land.
2. The farm evolved, and will continue to do so. We have an ethic we work around which is to start small, with a low but reasonable amount of capital start up cost and a lot of hard work. For example, I originally ran the market garden business as a sole proprietorship, and used my own money resources to finance the startup capital expenses (4000 total). After 2 years, we made the market garden part of the whole farm
3. Our operation fits our land base. The farm is 600 acres, 180 open land for crop and forage production.
4. In order to work well as a group, we all need something to be "in charge of".
5. The joy of machine multitasking and overlap (for a list of our tractors see p.). We think it is great to use equipment for a diversity of purposes. For example, our Ford 4100 is used for cultivation, wood splitting, raking hay, disking, you name it.
6. The financial earnings of a horticultural business are readily apparent and often cash (from farmer's market). Because the dairy has always been the principle money earner on the farm, it was surprising when the market garden started keeping the farm financially up when dairy prices dropped to the low levels that they were this summer.

The challenges:

1. Time off (especially with the dairy). We never can go away as a group, but each individual family takes time away.

2. When one seasonal job flows into another or if weather doesn't hold out for adequate job cleanup, storage and maintenance areas can get messy.
3. When we are busy, we are really busy. A "farmathon" we call it. This takes a lot of physical and mental stamina.
4. Household jobs get deferred.
5. The biggest challenge this year for me was managing the gardens and our children. We have two young children; Isabella age 4 and Henry age 10 months. Young children take patience and time, something that "in the thick of it" is difficult to muster.
6. Finances. When one enterprise is earning good profit, it often plays out that another one is not. This situation happened this year. No, our farm was not losing money at the rate of other dairy farms, but for all of the work we were doing, we weren't getting ahead either. Double the work does not add up to double the profit in many cases.

In the slides you see many situations where we are working with our children. This is another area of farm diversity. Balancing the management of a farm and of family life is not easy. We continue to try to figure it out.

Here are some of the guidelines we use

1. Another farmer friend of mine said, "Your kids are your most important crop." This is something that we repeat when the demands of our work are all around us.
2. Hire help, no matter how small your operation. Of course for a while I thought that I was the only person who could do a job the "right" way. I soon learned that I was incorrect, and that I have a lot to learn from people who work for me.
3. Never get "inconvenienced". As soon as you start thinking, "this is terribly inconvenient to be carrying a 21 pound baby on my back while I'm moving this mulch hay," you lose moral. Just have fun. Your body can get used to anything. If the kids are willing to go along, do it! Our son loves being outside no matter what the weather, because he's been with me in the field all season.
4. Create a child friendly field/barn environment. Foster independence by creating jobs for them to do as soon as they want to.
5. Create alternatives to time in the field with Mom and Dad. When Isabella our 4 year old was 1, she went to day care 2 mornings a week. This was much needed space for me, and great socialization for her. We take seriously making some off farm plans for our children. We think it is healthy.
6. Since we are in a family farming situation, there is usually a grandparent or aunt of uncle willing to play for awhile with one of our children. This is so great and helpful. But of course, not everyone has it as easy.
7. It seems to me that we are at one of the easier stages of parenting and farming because we are still pretty much in charge of the family agenda.

Our farm financial philosophy and reality

A diversified farm like ours has a diversity of farm accounting to deal with. On the income end we have on farm sales, farmer's market sales, accounts receivable from wholesale vegetables and flowers, wholesale maple syrup sales, wedding accounts which require charging sales tax, direct deposit for our milk check, log sales, Christmas tree sales. During the market garden season, Beverley must make deposits weekly. Expenses are more intense at some times of the year than other times of year. The good thing about being a diversified farm is that we rarely have to take out operating loans for spring fertilizer and seed costs because our cash trickle is continuous.

One difference between our diversified farm without horticulture and with is probably the payroll. We employ more people. Though our market garden is labor intensive, it is not capital intensive in the equipment area. Adding horticulture allowed us to add income using mostly existing equipment.

Have no expectations.
We are constantly surprised by our success. We do not create enterprise budgets, or figure how many bunches of beets we are going to sell at a farmer's market before we sell them. Just as we can't predict a sugaring season, we can't predict a market garden season exactly. To our family, that is the fun. We are not micro managers by nature. We understand the things on the farm that we can control, and the things that we cannot.
So we control the things we can, by creating efficient systems for doing them and leave up to God the things that we cannot control. We are a happy family and happy farmers.

Our First Five Years in Farming

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Farming is my third career choice having been a teacher and a small business owner for numerous years. I was raised in the Midwest on a small piece of land where we grew all our own food. It was there that I learned and loved growing food. Over 10 years ago I decided that I wanted to farm and began reading, attending conferences and workshops and visiting farms to see if my dream could be a viable way to make a living. While looking for land, I gained some experience apprenticing and working with other farmers. Five years ago, with the help of two land trusts and numerous other people, we purchased two adjacent parcels of land totaling 18 acres that once had been part of a larger farm and established Ol'Turtle Farm. We are mainly a CSA farm marketing our excess to local markets and farm stands and donating to two shelters.

The cropland was approximately 12 acres. The infrastructure included an 1800 farmhouse with very little updating, two barns, one in very poor condition and the other structurally sound but needing a new roof and siding.

Year #1 (1999)

We took possession of the property in September 1998, and immediately began work on the main barn and put up a 19'X 96' greenhouse. The cropland was in hay and the farmer currently using the land took the hay off in late October. I divided the field space into two 5-acre parcels with a small 2-acre triangle on one side. In late October I had the north field rough plowed in preparation for the following season.

At that time my equipment consisted of a cub lowboy with cultivators. My farm plan involved working with permanent beds so the first purchases were a 4' Imants spader, an International 274 hi mount cultivating tractor that was capable of carrying the spader, a Buddingh basketweeder and an old planet Jr push seeder. I also bought a DR Brush mower to handle the headways and to help push back the brush that was moving into the fields.

Originally I had planned to start with a small market garden selling at farmers' markets and to local stores but the group of people who helped with acquiring the land were so enthusiastic about the CSA that I was gently nudged into starting with a 60 share CSA. Excess produce was sold to a local grocery, health food store and neighboring farm stand. Considerable produce was donated to two shelters. The labor force consisted of myself, one apprentice and several volunteers from the membership and surrounding community. In the spring of 1999, a "for hire" farmer, composted and disced the north field in preparation for planting. We then spaded into permanent beds the first 5 acres. We planted approximately 4 acres of vegetables. Management of the rest of the fields was done by the "for hire" farmer. I contracted him to plow, seed into cover crop and mow the remaining cropland. I did not have the equipment or the time necessary to handle it. We started all our transplants in the greenhouse and planted them by hand. Most of the crops were transplants though we did direct seed carrots, beets, greens, peas and beans.

1999 was a very dry year and though we had been granted permission from the Conservation Commission to pump from the brook behind the farm we did not have money for irrigation equipment and as it was the brook went dry that year. We did irrigate, however, two times that season with the help of a neighboring farmer's pipe and the water department hooking us up to a fire hydrant. We had to pay for our water.

Distribution for the CSA was set up in a small area of the Big Barn, which was nearly completed. We had stabilized the main structure, replaced the roof, replaced siding on two sides, built new doors and brought in electricity.

Year #2 (2000)

The south field had been seeded in oats and peas the previous Fall by the "for hire" farmer and was ready early spring to be disced and composted by him. We then proceeded to spade that field into beds in preparation for the season's crops. The north field was in rye and vetch planted by hand the previous fall.

Part of the winter months had been spent researching equipment. Since the north field was now in permanent beds, we needed a way to manage the cover crops on that field. I purchased a 4' flail mower so that we could mow each bed individually. This would allow me also to mow old crop beds as they finished and put them into cover. I also bought a Kifco irrigation reel and layflat hose. Our only available reliable water source was town water. After much research I had a 4" line brought onto farm property. The Kifco reel is small enough that I could manage it myself when necessary. The last piece of equipment was a flat bed trailer that was adjusted to fit our bed size. This became a amazing time and labor saver for moving things around the farm but also in harvesting as we could take it down the beds to pick up barrels of melon, baskets of onions, barrels of winter squash and baskets of potatoes.

The CSA consisted of 100 shares and the excess was sold to local outlets and given to two shelters. This season I had one apprentice and a part-time farm hand that worked 3 days a week. We also had volunteers from the membership and the local community.

The remaining field area consisted of a 2-acre triangle, which had been in oats, peas and vetch. When the vetch was in flower, we mowed it. The "for hire" farmer disced that section. Part of it was planned for a u-pic raspberry section. We cut out the beds for the raspberries with the spader and had the remaining area between beds seeded into a permanent grass. The beds were planted in oats and peas.

The CSA distribution was once again in the Big Barn. We began work on the Far Barn, stabilizing it, replacing the roof and putting in a cement floor.

Year #3 (2001)

Year three heralds the beginning of managing the whole farm. All the crop areas had been put into permanent beds so only our equipment would fit the system. This meant that one major equipment purchase had to be a manure spreader. We worked with Millcreek to adapt a spreader that would fit our beds and that would drop, rather than throw, compost onto just the bed area. This saved us a lot of compost that was not needed in the pathways. I also purchased gauge wheels for the flail mower to run in the pathways as the roll bar that was originally on the mower compacted the beds. Our third equipment purchase was an old potato digger. Just could not dig anymore potatoes by hand.

Our rotation this year brought us back to the North field. It had been planted in oats and peas the preceding August. Cover crops were being planted by hand with a bucket of seed and then basketweeded in and rolled with a pipe dragged on the back of the tractor.

The CSA consisted of 125 shares and we sold to two groceries, a farm stand and gave food to two shelters. The work force consisted of a full time experienced apprentice and a part time experienced farm hand who worked 3 days a week. We also had our volunteers. This season we also added a few laying hens to the farmyard.

In the fall of 2001, we began re-siding the Far Barn and during the winter we enclosed an area in the barn for distribution and insulated a room to provide a cold storage space.

Year # 4 (2002)

This year marked a major change in our rotation. Instead of moving back to the South Field we divided the field space into 30 bed sections. This was based on the capacity of our irrigation equipment. In the fall of 2001 as we began seeding beds to cover crops, sections were determined and the areas to be fallow were seeded in rye and vetch. The areas to be cropped in 2002 were seeded in oats and peas. We ended up with a section of crop between two sections of cover crop creating more diversity and closer proximity for beneficial habitat.

Equipment purchases for 2002 included a Kennco waterwheel transplanter which fit our bed width and could be changed from a single row to a double row quite easily. As up until now we had done all the transplanting by hand, this was a major labor saver. I also bought a 4' Shaper Bros. drop spreader to spread our cover crop and to drop gypsum. Again this was a major time saver as all the cover crop had been put down by hand.

Added to the mix this season were a few more layers and 3 lambs. The chickens were in a mobile coup. They and the lambs were moved around the fallow cover crop areas confined in an electric fence. They provided some cover crop management and dropped some fertility for us as well. At the end of the season the chickens stayed but the lambs moved on to greener pastures.

The CSA was 135 shares this season and we continued to sell the excess. The Far Barn was not finished but the distribution area was done enough to use so the CSA was moved to that area. The siding and doors were finished on the barn late fall and a porch roof was added to provide a covered wash station and room for the u-pic information station. It also added space to the distribution area where people could congregate without congesting the pick up area. Our labor force this season consisted on a full time assistant farm manager and an assistant grower who worked 4 _ days. Volunteers are always a part of the mix.

Year #5 (2003)

The concentration this year has been on fine tuning the systems—better planning, better successions, better methods to managing remay, better cultivation set-ups, more efficient methods.

I did not buy any new equipment but we did put down a drip irrigation system on the raspberry beds. Reaching them with the reel is difficult and irrigating the grass areas is not needed. We retired our 12 old hens and got 30 adolescent layers, 15 chicks and 25 meat birds. The laying hens are a "keeper" as we can sell far more eggs than we can manage hens. The meat birds were a trial, which I do not think we will do again in the near future.

The CSA was 146 shares this season again selling the excess to local outlets and giving to two shelters. We did develop a Farm Market to go with the CSA. The Market sells other local products including bread, milk, cheese, ice cream, butter, various fruit and our eggs. This has been very well received by our members.

This season's work force includes a full time assistant manager who is a returning apprentice and a returning assistant grower working 4 _ days. The assistant grower has also taken on the responsibilities of harvest manager and farm market manager. It is my hope to develop this consistent work crew. Volunteers were also an important part of our labor force. Some volunteers come from our membership while others are just interested persons.

We are continuing with this strip farming of 30 bed sections of crop next to 30 beds of cover crop. We have been experimenting with different cover crops and combinations of cover crops to add diversity and hopefully reduce management.

As we end year five, we look forward to the challenges and changes coming for year six.

Retailing Color Through Baskets and Tubs

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Marstaller Greenhouses 549 Mountfort Road North Yarmouth, ME 04097
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The following is what we do at our retail location:
The Flower Center 327 Main Street Cumberland, ME 04021 Tel. (207) 829-3444

Containers we offer
- Hanging baskets - 12” and 14” - $ 25.00, $ 40.00
- Containers - 10”, 12”, 14” pots - $ 20.00, 25.00, 30.00
- 3.5” Market Baskets - $ 7.98
- Patio Tomato (w/ cage) - $ 9.98
- Vines (w/ bamboo hoops) - $ 17.50
- Flower Bags - $ 9.98

Combinations hanging baskets
- Single variety for 60%
- Combination of colors and textures for the other 40%
- Red/white/blue/yellow is used for about 75% of our containers
- Single colored containers for about 10%
- Pastels and two-color for the final 15%

Construction schedule
We used to pot up in March for May sales
- good - it is all done - good - presentation is full (too full?)
- bad - projections aren’t perfect - bad - lost way too much bench and floor space

So, now we pot up most containers at the shop.

Customer Care
All baskets and containers are subjected to water crystals and time release fertilizer treatment.
Pricing - $ 5.00 (covers soil, fertilizer, water crystals and labor for normal container) plus the cost of the plants
Display - Neat, orderly and, at least a large sample, viewable to the drive-by customer
- We try to have at least 10 of each container type displayed
- Overflowing displays work best for us but they require more maintenance
- Improve some aspect of our curb appeal each year

Evaluate
At season’s end, we run our numbers and check where we had the best margins, and where the public was most receptive. We record next year’s expectations each July.

New Vegetative Annuals

Dr. Lois Berg Stack, Extension Specialist, Ornamental Horticulture
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Vegetative annuals exploded onto the market a decade ago, and the number of cultivars on the market grows every year. So many programs, so many introductions, so little bench space! It's tempting to grow some of everything. However, there is considerable redundancy among programs, and too much product diversity leads to management problems.

In some ways, national marketing programs have eclipsed local programs. That works in mass marketing. But ultimately, if your business is an independent local greenhouse/garden center, your customers look to you for *more*. They trust your professionalism, appreciate your fairness, value your service, and rely on your knowledge. That means it's up to you to decide which new vegetative annuals to grow, how to market them, and how to educate consumers about them.

If you focus only on what's new, then that's what you'll offer -- lots of new plants. But if you use your professionalism and knowledge to select new cultivars in the context of the garden trends you want to market to, you'll be able to differentiate yourself in a way that lets your customers know they *can* in fact look to you for *more*.

With that in mind, here are several exciting new cultivars that are truly worth your consideration. They're presented in the context of six gardening trends. If you market to these trends, then you might consider growing and marketing the cultivars mentioned.

1. <u>Some plants are simply outstanding. Always go with the winner!</u>
   Ok, ok, perhaps this isn't a trend. But some plants are terrific, and build up their own following. Those plants are worth considering. *Argyranthemum frutescens* 'Butterfly' was introduced in 1994, and it remains one of the top selling Proven Winners®. It has gained a large and loyal following for a good reason: it performs well all season long.

   Another plant in this category is *Scaevola aemula* 'New Wonder' (Proven Winners®, introduced in 1996). Finally, a white cultivar, *Scaevola aemula* 'Whirlwind White' (Proven Winners®, 2004) performs nearly as well. It's been a long time coming!

   A third plant in this category is the *Phlox* 'Intensia' series. I obtained three cultivars from the Proven Winners® propagator for this year's trials, and all three are available for 2004: 'Lavender Glow', 'Lilac Rose' and 'Neon Pink'. I was not particularly impressed at first, but as the season progressed, these plants, especially 'Lavender Glow', became the highlights of the trials. These are outstanding garden performers, spreading into 15" x 28" mounds, covered with flowers until frost. Remember that those mixed containers need to perform throughout the season. In June, your big-container customers may not even notice that you tucked in a few of these, but they'll thank you in September.

2. Something old, something new …
   Old-fashioned plants are popular again. Everywhere I looked this summer, I saw love-lies-bleeding, snow-on-the-mountain and heliotrope. Some recent vegetative annuals are improved forms of old favorites. *Bidens ferulifolia* 'Solaire Compact Yellow' (Proven Winners®, 2004), really captured my attention in the 2003 trials. It's much more compact than older types, creating a spreading mound of foliage topped by short-stemmed yellow flowers all season -- much different from the open, floppy plants of the past. Although a majority of flowers on 'Solaire Compact Yellow' were toward the edges of the plants by the end of the season, the plants stayed tight and attractive in the middle.

   A second old-fashioned favorite is ageratum, and the 'Artist' series is the best on the market. 'Artist Blue' and 'Artist Purple' (Proven Winners®, 2003) are well-branched, compact, dark green plants covered with flowers all season, well past the first light frosts of fall. Best of all, the flowers look good all season without any deadheading, making the plants much lower maintenance than the older types.

   A third old-fashioned plant that has made big news in the past few years is coleus, or *Solenostemon* as the taxonomists now call it. Cultivars abound. Some of these "new coleus plants", like 'Mars' and 'Saturn', are old types that you may remember from years ago. They were not viable crops before the vegetative annual industry developed, because they required growers to hold over stock plants to take winter cuttings. Now, terrific coleus are available once again -- more than 100 named types are on the market. Look closely, as some are quite similar to each other ('Mars' and 'Purple Duckfoot' look the same to me …). Your customers might ask for some types by name, as they've received considerable press lately -- Proven Selections® include 'Amora', 'Dark Star' and 'Life Lime'; Simply Beautiful® cultivars include 'Stoplight', 'Sherbet' and 'Chocomint'; 'Stained Glassworks' is a beautiful introduction from Flower Fields®. Many coleus cultivars are available both as part of registered vegetative annual programs, and from general propagators.

3. What's in a name? … or, Marketing garden whimsy
   Garden whimsy is Big -- gates, arches, gazing balls, tropical plants, garden fairies, greenmen, and on and on. It's a trend that encourages people to express humor through their gardens. This year's whimsical plant seemed to be *Perilla* 'Magilla' (Simply Beautiful®, 2003), It's hard to say "Magilla Perilla" without conjuring up the picture of a cartoon character. It makes people smile -- and that's part of what gardening is about. The plant itself is a good performer, similar to a coleus, but it's the name that makes it a marketing success. Another recent whimsical plant is *Cuphea llavea* 'Tiny Mice'. I loved sharing this plant with kids in our trials in 2002; it's available as a Proven Selection® (introduced 2003).

4. Two uses are better than one
   Everyone likes a bonus. In our multi-tasking society, multi-purpose plants offer something extra … parsley-the-herb is also parsley-the-edging-plant, and impatiens-the-garden-plant becomes impatiens-the-houseplant.

   In the world of vegetative annuals, a previously underused genus, *Angelonia,* has become a star. It's a beautiful summer annual with upright stems and excellent branching, useful in the midground and background of small gardens and also useful as the height and depth in large containers. But it's more than that! We took *Angelonia* 'Angelface White' and 'Angelface Blue Bicolor' (Proven Winners®, introduced 2003) to a commercial florist design seminar in September 2002, to rave reviews. 'Angelface Blue' was good too, but at just 15" tall, it didn't fill that cut flower niche the way the other two did at 24". Flower Fields® offers seven colors in its AngelMist series; 'Deep Plum Improved' and 'Light Pink' are exceptional colors.

5. <u>Movement and grace are part of gardens, too!</u>
   Often, we focus on color to the exclusion of other elements and principles of design. More recently, we've added texture to our palette. Now … it's time for movement! We have access to terrific grasses that add a whole new dimension to gardens and containers. Try *Pennisetum setaceum* 'Rubrum' -- you can propagate it yourself by division or by rooting stem joints directly in pots. It's a fast crop, a great addition to containers, and a beautiful contrast to coarse textures, yellows, pinks, and silvers. To top it off, it's a great fresh and dried cut flower.

6. <u>Be scentsitive to your customers' needs</u>
   Yes, that's a bad pun, but scent is important in gardens. How many times have your customers asked for "that fragrant little white flower" (*Nemesia* 'White Innocence')? This summer, I was introduced to the "Peanut Butter Plant" -- kids who visited our demonstration gardens were constantly rubbing the leaves, sniffing, and giggling.

   If you'd like to market to those who garden with all their senses, don't overlook the scented geraniums. These plants are members of many species of *Pelargonium*, and offer so many attributes that could be profitably marketed. They're easy to obtain (hundreds of cultivars are available from specialty propagators); easy to grow as long as you don't overwater or allow whitefly to overtake them; easy to maintain in the retail setting and in the garden because of their extreme drought-tolerance.

   A second group of customers is one that has been difficult to reach through garden centers -- people who expendable income but do not consider themselves gardeners. They may appreciate beauty, but don't want to be bothered with plant care. They admire beautiful containers, but would almost rather have them empty. Scented geraniums are elegant plants that require little care. That makes them the perfect plants for these potential and hard-to-reach customers.

A Season of Cut Flowers

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As a grower and retailer of specialty cut flowers at local farmers market it is important to have a consistent supply of cuts during the entire marketing season. This talk will focus on our most important cut flowers for each season.

Selection criteria:
- a) Ease of harvest
- b) Customer appreciation
- c) Economic return
- d) Season of harvest

1) Early season, May-June
- a) Tulips-Darwin Hybrids ('Pink Impression',' Big Chief, Avignon' etc. 'Angelique' (double)
- b) Dahlia-Karma Series
- c) Lily- Oriental, LA Hybrids, Asiatic

2) Mid Season, June-July
- a) Peony- 'Elsa Sass' (dbl.white), 'Monsieur Jules Elie' (dbl.pink), 'Felix Supreme' (red)
- b) Dianthus barbatus- Sweet William- Messenger Series (early single), Electron (mix, contrasting eye, 'Amazon Neon Duo')
- c) Calendula, Princess Series,
- d) Godetia-Grace Series,

3) Late season, July-August-Frost
- a) Zinnia-Sun series, Benary's Giant
- b) Celosia-Plumosa type-'Pampas Plume'-Cockscomb type-'Cramer's Series', Spicata type-'Flamingo Series'
- c) Cosmos-Sensation Series
- d) Sunflower- Sun Series (pollen-less, day-neutral), Prado Red, Sonja

e) Lisianthus-Echo (sprays of double flowers Group1,

f) Grasses and grains

6) Life after Frost??

a) back to the greenhouse

b) Dried flowers

c) Wreaths

d) physalis

Groups:

Association of Specialty Cut Flower Growers
MPO Box 268
Oberlin,OH 44074-0268
Fax 440-774-2435

Books:

<u>Specialty Cut Flowers</u>, Allan Armitage

New Color Introductions in Spoon and Egg Gourds

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History and types of gourds

Gourds are defined as "hard-rinded" fruits within the family Cucurbitaceae (common name cucurbits) that are often used for ornamental purposes, vessels and even musical instruments. The most common gourds fall within two different taxonomic classes: the bottle gourds (*Lagenaria siceraria*) and a variety of gourd types in *Cucurbita pepo*. The species *Cucurbita pepo* includes other familiar cultigens such as acorn and delicata squash, summer squash, and jack-o'-lantern pumpkins.

Bottle gourds have an ancient agricultural history. The wild progenitor species are native to East Africa, however, archaeological evidence has revealed that bottle gourds had worldwide distribution and were used by different human cultures several thousand years ago. How did they get distributed to SE Asia and the Americas as early as 9000 years ago? It was found that if gourds were floated on seawater for several months, the seed could still survive. It was therefore hypothesized that gourds may have been carried far and wide by the ocean currents.

On the other hand, *C. pepo* gourds are native to the southwestern United States and parts of Mexico. Variation in shapes, sizes and colors apparently came about through human selection as the gourds were utilized and propagated by native American cultures during the past three thousand years or more. In pre-Columbian times, *pepo* ranged from the southern border of eastern Canada, south through the East coast of the United States, throughout the Middle West, and into the southwestern United States and Mexico.

Gourd breeding objectives at UNH

The *C. pepo* gourds are represented by an incredible diversity of types in terms of color, patterns of colors, shapes and sizes. Most seed companies offer 'gourd mixes' that include a reasonable multitude of small to medium size gourds of various shapes and sizes. These mixes can be highly variable from one year to the next as to what proportion of the different gourd types are produced.

My interest in gourd breeding came about in the mid-1990s as I pondered what sort of gourd breeding work might be successful in introducing some newer, more reliable types of gourds that would provide growers with some additional crops that could be profitably marketed in the fall season. My own experience in growing gourds in New Hampshire suggested that gourd maturity often occurred late into the fall market window, and that the long vines of traditional gourds were not well suited to the best cultural practices, such as plastic mulching and drip irrigation. In addition, the color and pattern variability in some of the smaller gourds such as spoon, pear and especially egg gourd (Figure 1), were limited. In fact, the only color I found in the attractive egg gourd was white.

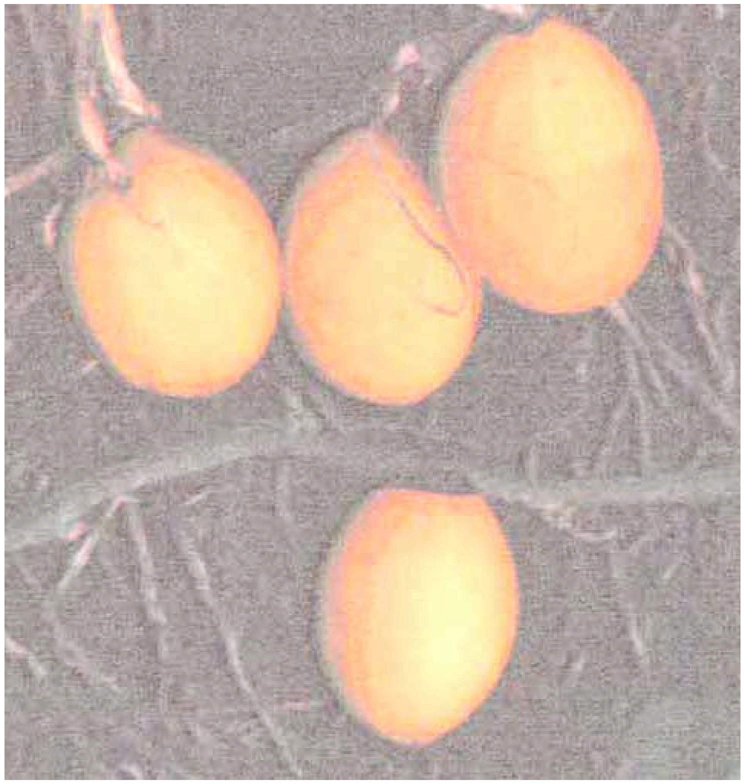

Figure 1. Egg gourds about 2 inches long.

Given the above facts, my objectives were to create some new varieties of spoon, pear and egg gourd with 10 days to two weeks earlier maturity than the current varieties, with a more compact growth habit and a greater variety of colors and color patterns.

Colors and patterns in egg gourd

Transferring the bush gene and genes for earlier maturity to gourds was accomplished by crossing the egg gourd to a small-fruited bush strain of pumpkin. The task was not easy. Even a pumpkin the size of a baseball is genetically very distant from an egg gourd in terms of size, color genes, and genes for maturity. Most of the color and pattern genes for developing new egg gourds were donated from spoon gourds. A surprising array of colors and patterns can be produced from just four genes: white versus light yellow at maturity; striped versus non-striped, precocious orange versus green fruit; and dark green versus light green. There are also genes that affect the pattern of precocious orange versus green rind coloration, but the genetics of these genes is still unclear.

Currently, I have uniform lines that have solid white fruit, solid orange fruit, solid yellow fruit, solid green fruit, green/white striped fruit, green/yellow striped fruit; green/orange striped fruit, and bicolor orange and green fruit with stripes. Many of these breeding lines are extremely productive with individual compact plants able to produce 40 to 60 gourds. Several breeding lines of egg gourd are now being produced by a seed company, so that an egg gourd mix can be released to growers in the near future.

Variation in colors, pattern and shapes of spoon gourd

Breeding early, compact strains of spoon gourd (Figure 2) has proven to be somewhat more formidable than development of egg gourds. Part of the problem is that there is a lot more variability in shape and size of spoon gourd, so there are just more genes with which a breeder has to deal. All the different shapes and sizes look attractive, but only so many can be propagated and released. Everyone has a slightly different opinion on which shape, which size and which color is most attractive. In some ways, this is not such a bad problem because anything new and improved could benefit growers and consumers. In addition to the color and patterns displayed by egg gourds, spoon gourds display more complicated color banding patterns (Figure 2). In some instances, fruit from a single plant may vary from solid green color at maturity to fruit having two bands (orange and green), three bands, four bands and sometimes even five bands.

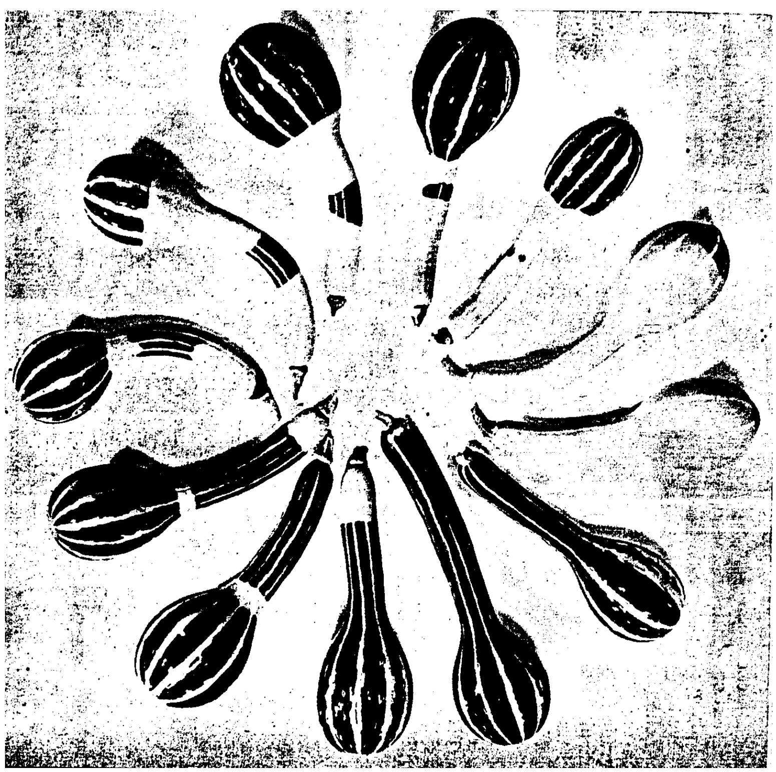

Figure 2. Striped spoon gourds showing different bicolor (green/yellow or orange) banding patterns.

I now have two genetically uniform lines with multiple banding patterns, one line has yellow and green bands and the other lines has orange and green bands. Both of these strains have a spreading bush habit of growth, and they have relatively early maturity. Seeds of these two strains are being increased by a seed company, and hopefully, these new unnamed varieties will be available to growers in 2005.

Summary

Breeding work was initiated in 1996 to develop earlier, more productive and more colorful strains of spoon and egg gourds. Breeding progress has been exceptionally rapid, and the New Hampshire Agricultural Experiment Station now has several strains of egg and spoon gourd that are being produced by a seed company for release to the commercial market. It is hoped that some of these new varieties can translate into increased profit for vegetable growers and an attractive ornamental crop for consumers to purchase.

Soil and Site Selection Considerations for Wine Grape Vineyards

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Terroir is a fuzzy French word that, despite its lack of a clear definition, finds itself at the center of any effort to define wine quality. As defined by French geologist Yves Herody, terroir refers to those elements that interact to produce the liquid that ends up in your glass. The elements include soil, climate, plant and man. Each has its own particular influence on wine quality, and the relative significance may vary from one vintage to the next. Finding the right balance of each one of these important terroir components is the ultimate achievement in wine growing. That perfect balance can be recognized and understood in some very familiar names, such as Romanee-Conti, Lafite-Rothschild, Wehlener Sonnenuhr, Tignanello, To-Kalon and other prized vineyards around the world. Here, an ethereal balance of nature and man result in sublime wines that capture the imaginations of wine lovers everywhere and set standards that all wine growers seek to achieve.

Outside of France, and particularly in the New World, the contribution of soil to wine character has been largely ignored prior to the 1990s. Climate was thought to be of overriding importance in determining wine quality. Even the French, with their illustrious viniculture history, have had to reevaluate the importance of its soils to the uniqueness of her wines, having stripped away much of its character through the overuse of chemical fertilizers and pesticides after WWII. Now, soil quality is consider paramount in the production of fine wines.

When we think of ideal vineyard soils, we must analyze them in their full context – physical, chemical and biological properties. Again, the correct balance of these constituent parts is sought to best accommodate the plant and climate as well as the applied viticulture. Other considerations, such as slope, aspect, and elevation have indirect effects on soil relative to its impact on vine physiology. What is underfoot is an incredibly complex system that we sense is critical to wine quality, yet we don't fully understand how or why.

Site selection is the single most crucial decision to you will make as a wine grower - odd, perhaps, since you have not yet planted a vine or squished a single berry. Once this decision is made, terroir realities can be determined through years, if not decades, of winemaking, and only then can excellent terroir be proclaimed. The best vineyard site is not necessarily the place with the best view, or the most expensive land, or the one closest to the local tavern. It's the one that has the best combination of an infinite set of variables that intertwine to produce a great bottle of wine. Site selection is a process, not a "this is the place" moment. It involves careful study of records, discussion with neighbors, digging holes, soil tests, conversations with consultants and a lot of walking around and scratching your head. The final act of committing to a site is an act of faith.

For many years, soil chemistry was considered the most important part of the soil portfolio. Mainly, growers were trying to maximize yields so nitrogen content was very essential to productivity. For growing fine wine, however, the formula has changed. Now, wine growers look for moderately fertile soils that do not promote an overly vigorous vine. Its no surprise that grapevines can often be found on ground that farmers deemed unsuitable for any other crop. Vines are tenacious plants and their roots will spread far and deep in search for water and nutrients. For this reason, they often do not require very much in the way of additional nutrients, except on the most inhospitable sites. The addition of inorganic chemicals has been the primary postwar method of ameliorating the soil. Essential macronutrients include nitrogen, phosphorus, potassium, calcium, magnesium and sulfur. Micronutrients include iron, zinc, manganese, copper, boron, molybdenum and chlorine. Of these, N, P, K, Ca, Mg, Fe, Zn, and B are most often implicated in nutrient imbalance situations. All of these elements have important roles in vine metabolic functions and need to have minimum levels maintained. Some, such as boron and nitrogen, can also cause toxicity problems for vines. Too much N, in non-toxic amounts, can exacerbate canopy management problems. A soil test by a reputable lab is part of the standard site evaluation protocol. Remember, a test is only a set of numbers. The true value is in the proper interpretation of these results. For this, it is suggested that a vineyard soils expert be consulted. Amendments to the soil should be made prior to planting. Other soil variables include soil pH and cation exchange capacity. These have an influence on nutrient availability to the roots. Recently, composting, compost teas, biodynamic preparations and other organic materials have been used to improve soil chemistry.

The soil food web is relatively new to the viticulture lexicon. It refers to the great diversity of biological life that exists in the soil medium. This myriad of organisms are often present in astonishing numbers (one shovel full of soil may contain as many microorganisms as there are people on earth), and range in size from the tiniest single celled bacteria to small vertebrates (gophers, etc.) and everything in between such as algae, fungi, protozoa, arthropods, nematodes, earthworms, insects and more. Each of these organisms has its own important function in the web and all are food for each other. Actinomycetes help to decompose organic matter. Fungi and bacteria create compounds that help to bind soil particles. Nematodes are involved in nutrient cycling. Soil arthropods help to shred dead plant materials, greatly enhancing decomposition. Earthworms mix and aggregate soil particles and stimulate microbial activity. We are only now beginning to understand how this complex world impacts plant life and how it might influence wine quality. There are laboratories that will analyze you soil for types and amounts of key organisms and make recommendations for treatment. Most of the evidence for any benefit from applying food web products is anecdotal. Grape growers should be attentive to this underground world and employ practices that enhance and preserve the food web. Reducing chemical inputs, aerating soils, reducing soil compaction, improving soil drainage, adding compost when needed are all practices that can contribute to the sustainability of the subterranean life. Some of the organisms that live in the soil, such as nematodes, grape phylloxera, grape rootborer and various bacteria and fungi, maybe harmful to vines. These should all be evaluated and treated before planting.

Soil physical properties are important to wine quality. However, as with chemistry and the food web, these attributes can vary dramatically, yet still contribute to fine wine production. Consider the wines in Napa Valley, where great Cabernet Sauvignon is grown both on the deep bale loams of the valley floor and the shallow, rocky soils on the hills above the valley. Even soils as varied as these have common features that make them suitable for making great wine. The common denominator among all great vineyard sites is that they are well drained. They strike a balance between adequate depth, good drainage and water holding capacity so the vine will not suffer too much in summer, yet the soils will drain amply if late season rains afflict the ripening period. Soil types that provide these features are all over the map – literally and figuratively – from the clays of Pomerol to the calcareous soils of Burgundy and schists of the Mosel. Soil texture and structure, while closely related, describe different physical properties. Texture is the way a soil feels in your hands – like fine, gritty or coarse. Structure is the way particles are stuck together, described as platy, blocky or granular. The space between these particles is also important. Adequate aeration is vital to the food web and root function. In evaluating a potential vineyard soil, soil pits are necessary to determine the physical nature of the soil at effective rooting depth – texture, structure, as well as chemistry and biology should be analyzed. Again, there is no substitute for an experienced eye and hand to complement the lab results.

Soil surface characteristics are also an important consideration. The reflective and re-radiation effects of the soil is an important part of the quality equation, especially in cooler growing regions where every heat unity is needed to fully ripen the grapes. Cover crops will also have an effect on soils, both their drainage capacity as well as fertility. The use of herbicides and other chemicals will affect soils, especially over long periods as they build up. A soil should be analyzed with its history in mind as well. If it was a pasture, years of manure have added to its fertility. If it was a reputable peach orchard, perhaps it is particularly well suited to be a vineyard.

So what is the ideal vineyard soil? The only sure way to truly find out is to plant vines and make wine. Short of that, use every tool at your disposal to predict the performance of your soil. You should first determine your wine making goals. If the best possible wine is the main objective, then you are looking for a well drained soil of moderate fertility, adequate depth that will grow a small to medium size vine. While a balanced vine is always the viticultural goal, it is commonly recognized that smaller vines on higher density spacing tend to produce the best wines. If the goal is high production and moderate quality, then deep, rich, fertile soils are appropriate. Soil vigor will impact many other pre-plant decisions such as variety, clone and rootstock selection, vine spacing, trellis system, irrigation and more and all of these will determine the costs of vineyard development.

You have one shot at the right soil. If you are in Napa or Bordeaux, you can look over the fence or across the road and see what your neighbor's vines are doing. If you are in New England, you have to use a crystal ball and any information you can develop on your own to make the best educated decision possible to validate a site for wine grapes. As part of this process, you may wish to include the following resources, which I referenced for this presentation:

1. Terroir. James E. Wilson. 1998. The University of California Press.
2. Viticulture and Environment. John Gladstones. 1992. Winetitles.
3. Viticulture: Vol 2. Practices. B.G Coombes and P.R. Dry. Winetitles
4. Soil Biology Primer. Soil and Water Conservation Society. 2000. NRCS.

Consultants

1. Todd Mason. Soil and Viticulture Consultant. Ontario, CAN. 905 332-8480
2. Lucie Morton. Viticulture Consultant. Virginia. 540.347.5262

3. Alex Blacburn. Soil Scientist. Loudon County, VA. 540 955-2687
4. Paul Skinner. Terra Spase. Napa Valley. 707-967-8323 x12
5. Kinsey Agricultural Services - http://www.kinseyag.com/

Soil Analysis Labs

1. Penn State Agricultural Analysis Services Lab - http://www.aasl.psu.edu/
2. Brookside Laboratories, Inc. - http://www.blinc.com/
3. A and L Eastern Laboratories, Inc. - http://www.al-labs-eastern.com/

Web Sites

1. BBC Laboratories, Inc. - http://www.bbclabs.com/
2. Soil Food Web Inc. - http://www.soilfoodweb.com/sfi_html/index.html

Grape Disease Management

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Introduction

Grape growers through the ages have battled grapevine diseases with varying success. Most diseases that affect grapes are caused by fungi, although bacteria, viruses, and nematodes also take their toll. Some diseases cause direct losses by destroying fruit and flower clusters. Others affect fruit quality by lowering sugar accumulation or imparting off-flavors. Yet others reduce vine vigor, yield, and winter hardiness by damaging or destroying foliage, roots, and canes. Many factors affect the prevalence of diseases in a vineyard. The most obvious of these is cultivar, since innate resistance determines to what degree a vine is attacked by a particular pathogen. Another important factor is climate, as some pathogens are adapted to cool climates and others to warm climates. The amount of rainfall is naturally a critical variable, since most fungi and bacteria need moisture for growth, infection, sporulation, and spread. Viruses are less affected by these variables but are more dependent on vectors such as insects and nematodes, which in turn are most influenced by temperature and soil moisture, respectively. To manage diseases in grapes effectively, a grower should understand the characteristics of his or her vineyard and how these characteristics influence disease development. I will discuss the characteristics of the most important diseases that a grower is likely to encounter in northeastern growing regions.

Powdery mildew – *Uncinula necator*

The powdery mildew fungus can infect all green tissues, resulting in a whitish gray, dusty or powdery appearance. Powdery mildew colonies are mostly present on the upper leaf surface. Infections of young, expanding leaves can result in distortion or stunting. Early berry infections can result in splitting of berries, secondary rots, and undesirable flavors in wine. Late infections are largely invisible except for a web-like necrotic pattern on the berry surface, which can still predispose the berries to rots. Severe infections reduce vine growth, yield, fruit quality, and winter-hardiness. In late summer, the fungus produces small golden-brown to black fruiting bodies (cleistothecia) on infected plant parts. The cleistothecia overwinter in bark crevices of the vine and release wind-disseminated ascospores in the spring. Leaves in proximity of the bark tend to get infected first. Powdery mildew is favored by high humidity and moderately high temperatures (68-81ºF). Temperatures above 95ºF inhibit new infections. Begin monitoring for the disease early in the season, checking inside the canopy first.

Downy Mildew – *Plasmopara viticola*

Downy mildew can infect leaves as well as flower and fruit clusters. Initial leaf symptoms show up as light green or yellow spots. These are termed "oil spots" because of their sometimes greasy appearance. The lesions eventually turn brown as the infected tissue dies. On older leaves, lesions are typically smaller and more angular as they are delimited by leaf veins. Leaf infections may lead to premature defoliation, which can reduce winter hardiness in severe cases. Under warm, humid conditions (>98% humidity and > 55°F) at night, white, fluffy sporulation develops on the lower surface of the leaf.

White spore masses also develop on infected flower and fruit clusters. Infected clusters or berries eventually wither and die. The fungus overwinters in leaves on the ground. Spores are spread to new leaves and clusters by wind and rain. The fungus requires a film of water for infection. Lesions appear within 5-17 days after infection. The disease can spread rapidly under warm conditions with frequent rain or dew. Use the 10-10-10 rule to decide when to first start scouting for downy mildew: 10 cm (4 in.) of shoot growth, 10 mm (0.4 in.) rainfall and temperatures of at least 10°C (50°F) during a 24-hour period. Monitor especially leaves close to the ground as well as in the top of the canopy.

Black rot – *Guignardia bidwellii*
The black rot fungus can attack all new growth, including leaves, petioles, shoots, tendrils, and berries. On the leaves, light brown, roughly circular spots appear in the spring and summer. These can be distinguished from herbicide damage by the presence of a ring of small black fruiting bodies, visible with the naked eye or a hand lens. Even though peak fruit infection occurs around mid-bloom in 'Concord' grapes in Michigan, symptoms only become apparent weeks later. The first symptom of berry infection is a small whitish dot within a rapidly expanding brown area that sometimes contains distinct "growth rings". Within a few days, the berry starts to shrivel and becomes a hard, blue-black mummy. Berries actually become resistant to infection about 3-5 weeks after bloom. If berries are infected close to the time of natural resistance development, lesions remain localized. The fungus overwinters in fruit mummies within the vine or on the ground. Ascospores are released from shortly after bud break until about 2 weeks after bloom, and are dispersed by wind and rain. Leaf spots and newly infected berries can also yield infectious conidia, which are rainsplash-dispersed. The optimum temperature for disease development is 80°F, at which the wetness period required for infection is only 6 hours. At higher or lower temperatures, the wetness requirement increases.

Botrytis bunch rot – *Botrytis cinerea*
B. cinerea can infect all green parts of the vine, though bunch rot tends to be the biggest problem. In early spring, buds and young shoots may be infected and turn brown. In late spring, V-shaped or irregular brown patches may appear on leaves Inflorescences may also be blighted and wither away. Some flower infections can remain latent until veraison. From veraison onward, the fungus can infect grape berries directly through the epidermis or through wounds, and may continue to invade the entire cluster. Compact clusters, powdery mildew infection, hail and insect damage (e.g., grape berry moth), can predispose grapes to Botrytis infection. Infected white grapes turn brown and purple grapes become reddish. During dry weather, infected berries dry out; in wet weather, they tend to burst and become covered with a grayish mold, which contains millions of spores. These spores are spread by wind to new infection sites. The disease spreads rapidly during moist periods, especially close to harvest. In certain cultivars, slow- developing, late-season infections are termed "noble rot" because they contribute to the production of exceptionally sweet wines. The fungus overwinters as mycelium or sclerotia (small black structures) in mummified fruit and other infected plant parts. The disease is favored by temperatures of 59-68ºF and free water or at least 90% humidity.

Phomopsis cane and leaf spot – *Phomopsis viticola*
Phomopsis viticola can infect all green parts of the vine, but infections of the fruit clusters are economically most important. Infected leaf blades show small irregular light green or yellow spots with dark centers and may be puckered. On petioles, shoots, and rachises, chlorotic spots with dark centers develop into elongated black streaks or blotches, which make the tissue brittle and prone to cracking or breakage. Most shoot lesions occur on the basal three to six internodes. Actively growing tissues are most susceptible to infection. Rachis and berry infections become apparent several weeks before harvest and continue to get worse over time. Rachis infections can lead to withering of the rachis, causing berries or sometimes entire clusters to drop prematurely. The fungus can also infect berries, either directly through the skin or through the berry stem. Infected berries turn brown and become soft and rubbery. Pycnidia may appear as numerous small black specks on the berry surface, sometimes oozing cream-colored droplets of spores. The fungus overwinters as in bark of infected canes. Bleached areas, sometimes delineated by black lines, on dormant canes are indicative of infection. In spring and early summer, conidia are rain-splash dispersed from pycnidia on the overwintered canes. Prolonged periods of rainy, cold weather in spring promote disease development. At least 6 hours of wetness are needed for infection at the optimum temperature (59-68ºF). Symptoms may appear 21-30 days after infection. Monitor carefully within 3-6 weeks from bud break. Many spots on the leaves and canes indicate high inoculum levels for rachis and berry infection. Flower clusters are susceptible to infection from the moment they are exposed until harvest.

Eutypa dieback – *Eutypa lata*
Eutypa dieback is a progressive disease of the woody tissues of the grapevine commonly found in older vineyards. The disease develops slowly and symptoms may not be visible for several years after infection. Shoot symptoms are best observed in mid- to late spring. Symptoms typically show up on one arm. The leaves are smaller than normal, cupped upwards, and chlorotic. As the leaves expand, the edges become tattered. Chlorotic streaks may be present between veins and along margins. Shoots are stunted to varying degrees and have fewer and smaller fruit clusters, sometimes with a mixture of large and small berries. Eventually the affected arm or entire vine will fail to develop shoots altogether and die. Upon close examination of the perennial wood bearing symptomatic shoots, a canker can usually be found surrounding an old pruning wound (the fungus infects the vine through pruning wounds). Removal of the bark may be necessary to see the canker. When cut across, a wedge-shaped area of dead wood may be present. Shoot symptoms are thought to be induced by a toxin in the sap flowing from the canker. Most Eutypa infections take place at pruning time. Spores of the fungus are released from fruiting bodies in old cankers during late winter and early spring when temperatures are above freezing and rainfall of 1/25 inch or more has occurred. Moisture from melting snow may be sufficient.

Sour bunch rot – fungi, yeasts and bacteria
Sour bunch rot is caused by a variety of fungi, yeasts and acetic acid bacteria. Low-grade powdery mildew infections or grape berry moth or fruit fly infestations can predispose clusters to infection. Insects can also spread the sour rot organisms on their feet and mouthparts. Sour bunch rot is a wet rot which can spread rapidly throughout the cluster

and cause the berries to smell like vinegar. Unlike with Botrytis bunch rot, mold is usually absent. Prolonged periods of wetness or high relative humidity are conducive to sour bunch rot development. Some cultivars are more susceptible than others.

Crown gall – *Agrobacterium vitis*
Crown gall is a problem in areas where climatic conditions favor freeze injury. It is particularly damaging to *Vitis vinifera* and interspecific hybrids. The major symptom is fleshy galls on the lower trunk near the soil line. Aerial galls may also form as high as 3 ft up the vine. Young vines may be completely girdled by galls in one season. Young galls are cream colored and fleshy but turn brown and woody with age. Affected vines appear weak and portions of the vines above the galls may die. Crown gall is caused by the bacterium *Agrobacterium vitis*, which is a different strain from *A. tumefaciens,* the cause of crown gall on fruit trees and many other plants. The bacterium lives in the soil and enters the plants through wounds caused by mechanical damage, grafting, or freeze injury. The bacterium may also be present on the surface of planting material, which could explain sudden and severe outbreaks of crown gall in young vineyards after frost events. Contaminated pruning or grafting tools may contribute to spread. Removing galls usually does not cure the plant as new galls will continue to form. Sometimes, galls may be confused with abundant callus growth at graft unions. Isolation of the pathogen will be needed to confirm the cause of the galls in this case.

Ringspot virus decline - Tomato ringspot virus (TomRSV) or Tobacco ringspot virus (TRSV)
This disease occurs sporadically in *V. vinifera* cultivars and interspecific hybrids. *Vitis labrusca* cultivars are resistant. A typical symptom in older vineyards is missing or dead vines in a roughly circular pattern. In the first year of infection, the disease is difficult to detect. A few shoots may show leaves with mottling or an oak leaf pattern. In the second year, the disease becomes more evident. New growth is generally sparse because many infected buds are prone to winterkill. Diagnostic symptoms are shortened internodes with small distorted leaves, and sparse fruit clusters with uneven ripening of berries. In the third year, growth is very stunted and limited to basal suckers. The vine continues to decline and eventually dies. The disease is caused by either of two nepoviruses (TomRSV and TRSV) which are transmitted by dagger nematodes (*Xiphinema* spp.). Both can also be transmitted via seed and cuttings. The nematode vectors retain the virus for long periods of time and can acquire it from roots of infected grape or weeds. TomRSV infects a wide range of fruit crops, whereas both TomRSV and TRSV both infect many common weeds in vineyards, including dandelions, sheep sorrel, common chickweed, and red clover. Because of this, is it not uncommon for these viruses to be present in land used to establish new vineyards.

Leafroll - Leafroll virus
Leaf roll is found in most areas where grapevines are grown. Symptoms are most obvious in the fall. Infected vines are slightly smaller than healthy vines. While leaves look normal early in the season, they start to show a yellow or reddish-purple discoloration as the season progresses while the main veins in the leaf remain green. By late summer the leaves start rolling downward (Photo), starting with the leaves at the base of the shoot. At harvest, fruit clusters are small, poorly colored and low in sugar. The disease does not kill

the vine but will remain chronic. Not all infected vines show symptoms. Leafroll is caused by a virus that spreads primarily via infected nursery stock. No vector has been established for the virus and natural spread is slow in commercial vineyards.

Nematodes – Root knot nematode, dagger nematode, lesion nematode
Plant parasitic nematodes are microscopic roundworms that live in the soil and feed on plant roots. In addition to being directly damaging to grapevine roots, some nematodes are important as vectors of viruses. Nematode damage can also predispose roots to root rots. In newly established vineyards, nematodes may be responsible for poor establishment and weak growth of young vines, especially at sandy sites. Nematodes seldom kill vines, but cause a steady decline in vigor. Symptoms on above-ground plant parts are not very specific, e.g., poor growth, low yields, and "off" color. Infected plants are more susceptible to environmental and other stresses. Symptoms may also resemble certain nutrient deficiencies or virus diseases. Below-ground symptoms are poor root development, dark-colored root lesions, and stunting or death of feeder roots. Root knot nematodes characteristically cause small swellings (galls) of the young feeder roots or secondary roots. When the galls are opened, the glistening white bodies of female nematodes can often be seen with a hand lens. Nematodes are spread via infected planting material or movement of soil on farm equipment and in run-off or irrigation water. Once established in a vineyard, nematode infestations tend to be permanent, so care must be taken to prevent new infestations.

Management approaches
Host plant resistance can be very helpful in controlling diseases (see Table 1). If it is not possible to choose a resistant cultivar, at least avoid highly susceptible cultivars, so that you won't be battling certain diseases for the lifetime of the vineyard. Choosing a cultivar that is adapted to the local soils and climate is important to ensure that the vines are not stressed. Certain cultivars are more suitable for organic production because they won't require heavy doses of fungicides to produce an acceptable crop.

Cultural control includes: selecting sites with good drainage and air circulation, avoiding sites with previous soilborne disease problems, planting in the direction of the prevailing wind to encourage air circulation, pruning to create open canopies to reduce humidity build-up, pruning out infected plant parts to remove sources of inoculum, and using a training system that exposes the clusters. Most of these methods work for the fungal diseases mentioned above. Pruning out and destroying dead canes and vines are especially important for control of Phomopsis and Eutypa dieback. Be sure to remove and burn infected plant material since spores can be released for a long time and can travel quite far by wind. Leaf removal around clusters is practiced to reduce humidity and incidence of Botrytis bunch rot. Buying virus-tested planting material is critical for prevention of virus diseases, since virus diseases can't be cured. In contrast, control of crown gall requires avoiding wounding of the vines and disinfecting pruning sheers between vines. Galltroll or Norbac do not work against the grape strain of the crowngall bacterium. At this time, no nursery stock is guaranteed to be free from crown gall. However, buying vines from a reputable nursery in the northeast is recommended.

Chemical control is most commonly used for disease management in grapes. A range of protectant and systemic fungicides is labeled for control of diseases in grapes. They vary in their effectiveness in controlling specific diseases (Table 2). Generally, early in the season, protectant fungicides (e.g., mancozeb) are recommended, while from bloom onwards, systemic fungicides (e.g., Nova, Elite), and surface-systemic fungicides (e.g., Abound, Sovran) become more important. Systemic and surface-systemic fungicides tend to redistribute in/on the plant more readily, which is important as the canopy becomes increasingly dense. They also have varying degrees of post-infection activity. Choice of fungicides depends on relative efficacy, label restrictions, and cost. Sensitivity of grapes to certain fungicides also needs to be considered (see Table 1). Many of the newer fungicides have restrictions on the number of applications per season as well as the number of consecutive applications to prevent or delay the development of fungicide resistance. Some fungicides, such as copper and sulfur, are OMRI listed for use in organic fruit production. Scouting for the presence of diseases before applying fungicides is an important component of integrated disease management. In addition, disease prediction models where available can be used to guide spray decisions.

Biological control is the use of microorganisms to control plant pathogens. A few commercial products are available: Serenade (*Bacillus subtilis* – an antagonistic bacterium), and AQ10 (*Ampelomyces quisqualis* – a fungus that parasitizes powdery mildew). Serenade has moderate activity against downy mildew, powdery mildew, and Botrytis bunch rot, while AQ10 has moderate activity against powdery mildew. Both are OMRI-listed for use in organic fruit production.

Table 1. Relative susceptibility to disease and sulfur and copper sensitivity of grape varieties. (The ratings apply to an average growing season under conditions favorable for disease development. Any given cultivar may be more severely affected).

	Black Rot	Downy Mildew	Powdery Mildew	Phom-opsis	Botrytis	Eutypa	Crown gall	Sulfur Sensitive[3]	Copper Sensitive[3]
Aurore	+++[1]	++[2]	+++	++	+++	+++	++	No	++
Baco Noir	+++	+	++	+	++	++	++	No	?
Cabernet Franc	+++	+++	+++	?	+	?	+++	No	+
Cabernet Sauvignon	+++	+++	+++	+++	+	+++	+++	No	+
Canadice	+++	++	+	?	++	?	++	No	?
Cascade	+	+	++	++	+	++	+	No	?
Catawba	+++	+++	++	+++	+	+	+	No	++
Cayuga White	+	++	+	+	+	+	++	No	+
Chambourcin	+++	++	+	?	++	?	++	Yes	?
Chancellor	+	+++	+++	+++	+	+	++	Yes	+++
Chardonnel	++	++	++	++	++	?	++	No	?
Chardonnay	+++	+++	+++	+++	+++	++	+++	No	+
Chelois	+	+	+++	+++	+++	+++	++	No	+
Concord	+++	+	++	+++	+	+++	+	Yes	+
DeChaunac	+	++	++	+++	+	+++	++	Yes	+
Delaware	++	+++[2]	++	+++	+	+	+	No	+
Dutchess	+++	++	++	++	+	+	++	No	?
Elvira	+	++	++	+	+++	+	+	No	++
Einset Seedless	+++	+++	++	?	+	?	+	?	?
Foch	++	+	++	?	+	+++	+	Yes	?
Fredonia	++	+++	++	++	+	?	+	No	?
Gewürztraminer	+++	+++	+++	?	+++	?	+++	No	+
Himrod	++	+	++	?	+	?	?	No	?
Ives	+	+++	+	?	+	++	+	Yes	?
Limberger	+++	+++	+++	?	+	+++	+++	No	?
Marechal Foch	++	+	++	?	+	+++	?	Yes	?
Melody	+++	++	+	?	+	?	+	No	?
Merlot	++	+++	+++	+	++	+++	+++	No	++
Moore's Diamond	+++	+	+++	?	++	++	?	No	?
Muscat Ottonel	+++	+++	+++	?	++	+++	+++	No	?
Niagara	+++	+++	++	+++	+	+	++	No	+
Pinot gris	+++	+++	+++	?	++	+++	+++	No	?
Pinot Meunier	+++	+++	+++	?	+++	+++	+++	No	?
Pinot blanc	+++	+++	+++	?	++	?	+++	No	+
Pinot noir	+++	+++	+++	?	+++	?	+++	No	+
Reliance	+++	+++	++	++	+	?	?	No	+
Riesling	+++	+++	+++	++	+++	++	+++	No	+
Rosette	++	++	+++	++	+	++	++	No	+++
Rougeon	++	+++	+++	+++	++	+	++	Yes	+++
Sauvignon blanc	+++	+++	+++	?	+++	?	+++	No	+
Seyval	++	++	+++	++	+++	+	++	No	+
Steuben	++	+	+	?	+	?	+	No	?
Vanessa	+++	++	++	+	+	?	+	?	?
Ventura	++	++	++	+	+	?	++	No	?
Verdelet	+	?	?	?	+	?	?	No	?
Vidal 256	+	++	+++	+	+	+	++	No	+
Vignoles	+	++	+++	+++	+++	++	++	No	?
Villard noir	?	+	+++	?	+	?	?	?	?

[1]+ = slightly susceptible or sensitive, ++ = moderately susceptible or sensitive, +++ = very susceptible or sensitive. ? = relative susceptibility not established.
[2]Berries are not susceptible.
Most of the data in this table were obtained from the New York Cooperative Extension Service.
[3]Even tolerant cultivars can be injured by sulfur when the temperature is >85F and by copper under cool, slow-drying conditions.

Table 2. Relative Effectiveness of Fungicides for Grape Disease Control.

Fungicide	Black Rot	Downy Mildew	Powdery Mildew	Botrytis Rot	Phomopsis
Abound (azoxystrobin)	+++	+++	++	+	+++
Alliette (fosetyl-AL)	?	+++	?	?	?
Armicarb (potassium bicarbonate)	++	0	+ / ++	+	+
Basic Copper Sulfate (copper)	+	+++	++	+	+
Bayleton (triadimefon)	+++	0	+++	0	+
Captan (captan)	++	+++	0	+	++
Ferbam (ferbam)	++	+	0	0	0
Copper hydroxide (copper)	+	++	+	+	+
EBDCs (mancozeb)	+++	+++	0	0	++/+++
Elevate	0	0	0	+++	0
Elite (tebuconazole)	+++	0	+++	0	++
Endura (boscalid)	?	?	++	+++	?
Flint (trifloxystrobin)	+++	++	+++	+	+++
JMS Stylet Oil (paraffinic oil)	0	0	++	+	0
Kaligreen (potassium bicarbonate)	++	?	+ / ++	?	?
Lime sulfur (calcium polysulfide)	0	0	+	0	++
Messenger (harpin)	?	?	+ / ++	+	+
Nova (myclobutanil)	+++	0	+++	0	++
Oxidate (hydrogen peroxide)	?	?	+	+	?
Pristine (pyraclostrobin + boscalid)	+++	+++	+++	+ / ++	+++
Procure (triflumizole)	++	0	+++	+	++
Prophyt (potassium phosphite)	?	?	?	?	++
Quintec (quinoxifen)	++	?	+++	?	?
Ridomil Gold MZ (mefenoxam + mancozeb)	++	+++*	0	0	++
Ridomil Gold/Copper (mefenoxam + copper)	+	+++	++	+	+
Rubigan (fenarimol)	++	0	+++	0	0
Rovral (iprodione)	+	0	0	++	?
Serenade (*Bacillus subtilis*)	?	+ / ++	+	+ / ++	+ / ++
Sulfur (elemental sulfur)	0	0	++	0	+
Sovran (kresoxim methyl)	+++	+++	+++	+	+++
Topsin M (thiophanate methyl)	++	0	+++**	++	+
Vangard (cyprodinil)	?	?	+	+++	+
Ziram (ziram)	++	++	+	+	++

0 = not effective, + = slightly effective, ++ = moderately effective, +++ = highly effective,
? = effectiveness not known.
Ratings are based on published information and modified based on observations in Michigan vineyards.
Efficacy is based on applications in total spray volumes of 50-100 gal/acre.
*Ridomil also has eradicative properties.
**If benzimidazole-resistant strains are present, efficacy will be reduced.

Seedless Table Grapes for the Northeast

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About 3,000 tons of grapes are sold each year for fresh consumption in New York State. Most of these are Concord and other seeded grapes, but a growing number of seedless grapes are also being marketed. Grapes are cultivated in many home vineyards, and their value to the commercial industry has increased in the last decade. Some eastern seedless grapes are marketed directly to supermarkets while others are sold in u-pick operations and roadside stands. A wide range of flavors and appearances are available among the grapes that can be grown in the Northeast. *Vitis labrusca* is the parent species of many of the flavorful eastern grapes. Fruit of *V. labrusca* have a pronounced fruity, some say "foxy", flavor. Table grape varieties mature over an eight- to ten-week period and several can be stored for later use.

Generally, the varieties described here are adapted to cool climate growing regions. Cornell Information Bulletin 234 (available from Cornell University Resource Center, 7 Business and Technology Park, Ithaca, NY 14850, Tel. 607-255-2080, Fax 607-255-9946) gives more complete information on relative cold hardiness and disease resistance of many table grape varieties. An internet site based on this publication can be accessed at:

http://www.nysaes.cornell.edu/hort/faculty/reisch/bulletin/table/

Berry color is usually classified as white, red, blue, or black. White grapes usually range in color from light green to amber or light orange. Red varieties may vary from pink to deep red and their coloration may vary with degree of ripeness and exposure of fruit to sunlight. The blue range includes types like New York Muscat, which have a reddish-blue color. Black grapes are typified by a dark purplish-black color.

The degree of seedlessness varies greatly among seedless grape varieties. Most seedless grapes have vestigial seed traces that range in size from very small to large and noticeable. Seed traces in berries of the same variety may vary greatly in size and in the hardness of seed coats. Climate is also known to affect seed trace size. Occasionally the seed traces in some seedless grapes are large enough to be bothersome to consumers. Notes on seed remnant sizes are given for varieties in which problems exist.

A number of new varieties have been released by programs in New York, Ontario, and Arkansas over the past decade. In addition, there are many older varieties developed for the Northeast that are commonly found throughout the region. Some of the most successful and most promising varieties are listed and described below. Along with some of their virtues, it's important to be aware of their faults, so these are summarized as well.

Summary of Seedless Varieties for the Northeast:

White Grapes

Marquis, a cross of Athens x Emerald Seedless released in 1996, is a white seedless grape from Geneva, with excellent, mild American flavor. The berries are large, often 3.5 to 5.0 grams/berry, with juicy, melting texture. Clusters are large and attractive, while the vines are moderately hardy, and very productive. Ripening in New York is between 15 and 30 September. Diseases must be controlled due to powdery mildew and black rot susceptibility. The vine is sensitive to gibberellic acid use, which is therefore not recommended. Cane girdling can be used to improve both cluster compactness and berry size. Ripe fruit holds well on the vine, with the flavors going from a mild fruity flavor when first ripe, to a stronger Labrusca flavor two weeks later. Gibberellic acid treatment is not recommended, but well-timed cluster thinning and cane girdling can increase berry size and improve cluster compactness. Vines are moderately hardy, medium in vigor and productive.

Himrod, produced from a cross between Ontario and Thompson Seedless, is the most successful table grape released from the Cornell University grape breeding program (1952). It produces large bunches of white seedless grapes with excellent, honey-like flavor and melting, juicy texture. The clusters are loosely filled, but cane girdling, gibberellic acid treatments, or cluster thinning may be used to increase cluster compactness and improve berry size. The brittle rachis may break when handled, and the berries may shell in storage. The rachis is also subject to bunch stem necrosis, a poorly understood disorder that causes a shriveling of the cluster stem, often just before harvest. Despite these cultural defects, Himrod is presently the most commercially important of the seedless grapes grown in New York (cluster weight = 0.36 lb., berry weight = 2.1 g).

Lakemont was also produced from the same cross as Himrod but has a milder flavor and more compact clusters of small to medium-sized berries. Cluster thinning prevents overcropping. Bunch rot is sometimes a problem (cluster weight = 0.48 lb., berry weight = 1.7 g).

Red Grapes

Einset Seedless (Plant patent 6160) is a winter-hardy, red seedless grape with a unique, strawberry-like flavor. The medium sized clusters produce bright red, ovoid berries that have good storage potential until the end of November. The clusters respond well to gibberellic acid or cane girdling to improve cluster compactness and berry size. The skin is slightly tough and adheres to the tender flesh. Cultural problems include susceptibility to fungal diseases and a seed remnant that is occasionally noticeable. Along with Vanessa, Einset Seedless probably has the most commercial promise of the red seedless varieties that can be grown successfully in New York (cluster weight = 0.32 lb., berry weight = 2.3 g).

Vanessa was developed by the Horticultural Research Institute of Ontario, Canada, and is a red dessert grape of excellent quality. The vine is moderately vigorous and among the hardiest of seedless grapes. Grafting may be desirable on many sites to increase vine size (however, vines grafted on Teleki 5C at trials in Fredonia, New York have shown poor fruit set with very small berries). The seed remnant is usually large and soft; when noticeable, it is sometimes a cause for limited marketability. Berries are medium in size on medium, well-filled clusters. Storage potential is good. The flavor is mild and fruity, and berry texture is firm to crisp. The fruit quality is among the best of the red seedless types.

Canadice is more winter hardy than most seedless grapes, although trunk injury has occurred on some sites. It produces medium clusters with small red berries that are similar to Delaware in flavor and appearance. With cordon training systems and careful management, Canadice clusters may average 0.5 lb., and the vines can be extremely productive. Fruit rot is a problem in wet years because the clusters are excessively compact (cluster weight = 0.50 lb., berry weight = 1.6 grams).

Reliance (Plant patent 5174), comes from the University of Arkansas, and produces large clusters of round, red, medium-sized berries. The skin is tender, and the flesh is melting in texture, with a sweet labrusca flavor. Coloring may be poor in some years, and fruit often crack in wet seasons. Cold hardiness is among the highest of the seedless varieties (cluster weight = 0.62 lb., berry weight = 2.3 grams in Arkansas)

Saturn (Plant patent 6703)- Produces large, crisp berries on medium clusters. the berries are bright red with adherent skins and a mild flavor. Vines are precocious and moderately hardy and must be cluster thinned. Fruit rot due to cracking may be a problem. Seed traces are quite noticeable some years. (cluster weight = 0.45 lb., berry weight = 3 grams in Arkansas)

Suffolk Red - Produces medium to large clusters of mild-flavored red berries. The clusters are loose but may be made more compact with the use of gibberellic acid or cane girdling. Winter damage is often a problem except on Long Island, where the variety is successfully cultured. Excessive vine vigor may occur following poor crops and winter bud damage. (Cluster weight = 0.32 lb. Berry weight = 2.7 grams)

<u>*Blue Grapes*</u>

Mars (Plant patent 5680), a release from the University of Arkansas, is a vigorous, blue seedless grape. The flavor is mildly labrusca, similar to Campbell's Early, and the berries are slipskin (having a tough skin which separates readily from the pulpy flesh). Clusters are medium-sized, cylindrical, and well filled. Hardiness has been good at Geneva, New York. High vigor; has the least susceptibility to common grape diseases among the Arkansas varieties, but still requires fungicide applications for disease control; resistant to fruit cracking; occasional seed traces found in some berries in some years. Vines may bear fruit precociously, and production should be controlled on young vines to prevent delays in establishment. Mars has been recommended in Arkansas as a home garden grape with limited potential for commercial marketing (cluster weight = 0.40 lb., berry weight = 3 grams in Arkansas)

Glenora - Produces medium-sized blue berries. Has extremely high quality and at its best is an excellent, flavorful seedless variety. Unfortunately, susceptibility to disease, fruit cracking and cold winter temperatures limit its use.

Jupiter (Plant patent 13,309) - This early maturing blue variety has large, firm, non-slipskin berries on medium sized clusters. Fruit has a distinct muscat flavor. It's in very early stages of testing at Cornell, so hardiness is not yet determined. In Arkansas, it is rated as hardier than Einset Seedless, Himrod, and Marquis, but not as hardy as Mars and Reliance. Medium vigor; resistant to fruit cracking; moderate resistance to common fungal diseases but does require fungicide sprays for successful production; small, soft seed traces observed occasionally but not noticeable due to berry texture. (cluster weight = 0.40 lb., berry weight = 4 to 5 grams in Arkansas)

Concord Seedless, though similar in flavor and texture to Concord, is unrelated. The clusters and berries are much smaller than those of Concord. The fruit matures earlier, has high flavor, and makes excellent pies and preserves. Productivity is erratic, and it is not recommended for commercial planting. In warm years, the variety produces fully developed seeds.

Some Recommended Seeded Grapes:

Alden is a reddish-blue variety with very large clusters and large berries. Cluster thinning is necessary to increase cluster compactness and to permit uniform ripening. Berries have firm texture and an adherent skin with a mild labrusca and muscat flavor (cluster weight = 0.72 lb., berry weight = 4.8 g).

Seneca is a white grape with oval berries on medium-sized clusters. Berries have a firm texture, and the skin adheres to the flesh. The flavor is excellent, with pleasing labrusca overtones. The vine is susceptible to winter damage and powdery mildew (cluster weight = 0.37 lb., berry weight = 2.7 g).

Steuben is a bluish-black grape that produces long, tapering, compact clusters that are among the most attractive of all dessert cultivars. The flavor is sweet with a spicy tang. The vines are hardy, vigorous, productive, and easily grown by home gardeners. Cluster thinning is usually required (cluster weight = 0.45 lb., berry weight = 3.1 g).

The information presented here must be used carefully, with full consideration given to site and cultural requirements for grapes. A homeowner may enjoy experimenting with some of the better tasting types if a good growing site is available. But a commercial grower should carefully consider economics and the availability of markets before committing a significant investment to any single variety. New seedless and disease resistant cultivars are under development and breeding programs should continue to provide interesting varieties for many years to come.