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Mark S. McClure checks natural enemies of hemlock woolly adelgid at the Valley Laboratory

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How verticillium wilt affects yield of eggplants, tomatoes, and potatoes

by Francis J. Ferrandino

For the past 5 years, I have been examining the growth and yield of eggplants, tomatoes and potatoes affected by a fungal wilt disease. "Verticillium wilt" is associated with two soilborne fungi: *Verticillium dahliae* Kleb. and *Verticillium albo-atrum*. Either one or both of these organisms can be present in an infected plant. The impact of this disease is increased when the plant parasitic nematode, *Pratylenchus penetrans*, also attacks the plant. This tiny worm drills into plant roots to feed. The wounds it creates provide an easy point of entry for fungal infection.

The fungus first infects the roots and then grows within the circulatory system of the plant towards the main stem. Eventually, the vessels become clogged and the flow of water from the roots to the rest of the plant is reduced. The foliar symptoms of the disease are similar in eggplant (*Solanum melongena*), tomato (*Solanum Lycopersicum* esculentum), and potato (*Solanum tuberosum*) and usually occur as the plants flower. First, a few leaves wilt in the early afternoon when water stress is most severe. After a week or two some leaves turn yellow. This discoloration usually occurs as angular blotches between the veins of the leaf. Eventually, affected leaves die and fall from the plant.

In addition to these dramatic foliar symptoms, the host plant is also stunted, and its overall vegetative growth is slowed. The size of mature leaves is reduced and the stem between successive leaves is shortened. In mildly infested soils, this stunting can be subtle, and plant size may be reduced by only 10%. In extreme cases, plants take on the appearance of a "Bonsai" tree, with tiny leaves and gnarled woody stems.

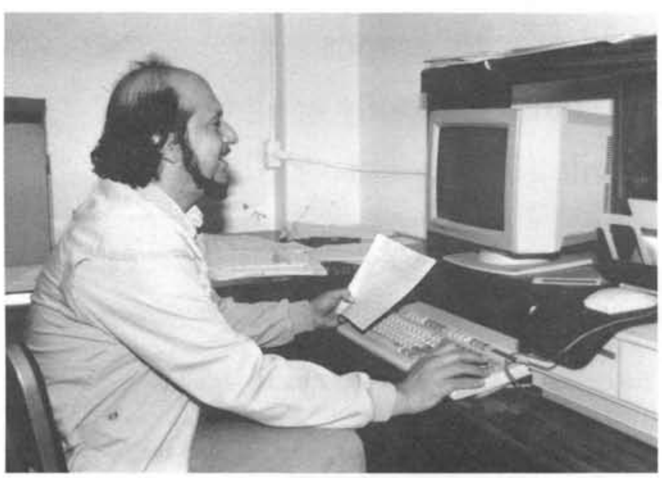

Figure 1. Francis J. Ferrandino entering research data.

The fungus overwinters in plant debris as poppy-seed sized balls of hyphae called microsclerotia. In this state, *V. dahliae* can survive in the soil for as long as 8 years and *V. albo-atrum* can survive for 3 years, even in the absence of susceptible host plants. The various species of this fungus have a wide host range among trees (maple and chestnut), weed species (mints and pigweed), small fruit (strawberries) and other vegetable crops (cabbage family). Long survival times and wide host range compromise the effectiveness of crop rotation as a sole method of control.

In a home garden or a small farm, there is usually not enough room to keep all the possible hosts for *Verticillium* out of an area for 3 to 8 years. Thus, some level of disease is always present. The alternative control by chemical soil fumigation at the commercial level is a temporary and costly practice which, with the current concern for the hazards due to the chemical contamination of groundwater, might best be avoided.

Fortunately, resistant cultivars have eliminated Verticillium wilt as an economic concern in tomato production. Such resistance is denoted by a "V" following the cultivar's name. For example, "Celebrity VFNT" is a tomato cultivar which is resistant to Verticillium wilt, as well as Fusarium wilt (F), Nematodes (N), and Tobacco mosaic virus (T). Unfortunately, no suitable resistant cultivars have yet been developed for either eggplant or potato.

We grow eggplants and tomatoes to obtain the fruit and potatoes for their tubers. The importance of any disease must be evaluated in terms of its effect on the edible harvest. Edible yield depends on the efficiency of leaf photosynthesis and the size and duration of healthy leaf area during fruit expansion for eggplant and tomato or during tuber growth for potato. However, since only a portion of the total plant is harvestable, the degree to which a plant directs its output to the edible product also comes into play. Disease can reduce yield via a direct reduction in the efficiency of a leaf, the reduction in the size and number of leaves, and/or a decrease in the allotment of sugar directed towards the fruit or tuber. Each of these components of total productivity must be ex-

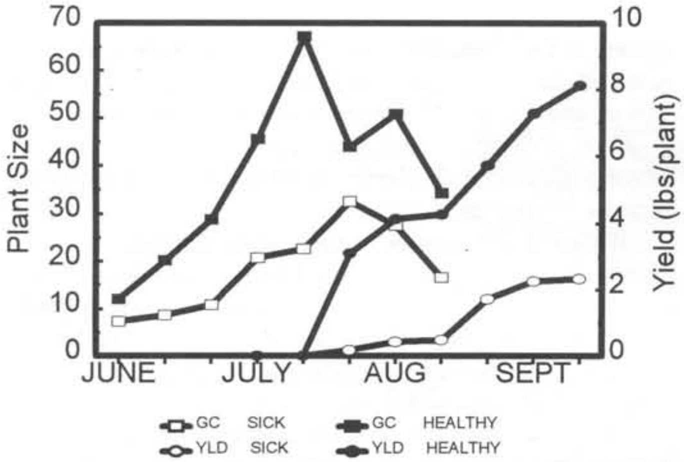

Figure 2. A comparison of eggplant growth (squares) expressed as ground cover (GC) and eggplant yield (YLD; circles) for sick (open symbols) and healthy plants (filled symbols).

amined in order to fully understand the ways in which yield is affected by disease.

In the process of photosynthesis, plants produce sugar from atmospheric CO_2 (carbon dioxide) and water using the energy of the sun. My colleagues Martin P.N. Gent and Wade H. Elmer and I enclosed eggplants in clear plastic chambers to measure the changes in the concentrations of CO_2 and water vapor. In this way, we could estimate the total amount of sugar produced. After the chambers were removed, leaf area and disease symptoms were determined. We found that Verticillium wilt reduces the total photosynthesis of infected eggplants; but, on a per leaf area basis, the rate of sugar production was not affected by disease.

This result suggests that we should examine the relation between yield and the average size of a plant over the growing season (Figure 2). In our field trials, most of the variation in yield can be accounted for by differences in plant size, irrespective of whether plants are infected. Thus, if bigger plants produce more yield, our first objective is to find ways to make infected plants grow bigger. Second, we must make sure that plants put their energy into increasing yield and not just making extra leaves and stems.

Over three growing seasons, Wade H. Elmer and I grew 38 cultivars of eggplant in field plots infested by the wilt fungus (Table 1). In general, yield was determined by plant size; however, some long season cultivars ("Florida Market 10" and "Florida High Bush") produced large plants but few fruit. This is probably because our growing season is shorter than in the South where these cultivars perform well.

A good yield for a healthy eggplant varies from 7-10 lbs per plant (Table 1). In general, the yield of Italian type eggplants, which produce long and thin cylindrical fruit with a green calyx, was low (4-7 lbs per plant) but less affected by

Table 1. Eggplant cultivars grown, average fruit size and average yield per plant, and average percent loss in yield due to Verticillium wilt.

Cultivar	Fruit Size (lbs)	Yield (lbs)	Loss (%)
	CYLINDRICAL		
ITALIAN			
Viserba	0.5	5.2	6
Long Purple	0.6	5.8	10
Bellaria	0.6	6.0	15
Elondo	0.8	7.7	29
Prelane	0.5	7.7	35
Ipiaceri d'ell orto	0.4	5.4	41
Avan	0.7	7.8	43
Vittoria	0.5	8.5	45
Megal	0.7	8.1	62
ORIENTAL			
Orient Express	0.5	8.5	37
Ichiban	0.4	6.1	39
Millionaire	0.5	8.2	46
Pingtung Long	0.3	4.8	65
	INTERMEDIATE		
Casper (White)	0.4	7.2	8
Vernal	0.8	8.5	25
Dourga (White)	0.6	9.5	32
Epic	1	10.3	35
Black Pride	1.2	12.2	39
Classic	1.2	10.9	39
Agora	1.1	10.1	52
Harris Highbush	0.8	5.1	60
Florida Highbush	1	9.4	65
Florida Market 10	1.3	7.7	69
	OBLONG		
Early Bird	0.5	5.0	-17
Rosa Bianca (White)	0.7	5.4	10
Ghostbuster (White)	0.7	8.9	45
Beauty	1	6.9	46
Dusky	0.6	10.3	47
Black Beauty	1.3	8.9	49
Agway Super Hybrid	1	8.6	49
Burpee Hybrid	1	8.8	50
Midnite	1.2	9.8	52
Black Enorma	0.5	8.1	52
Tasca	1.3	8.6	56
Black Magic	1.1	11.0	59
	SMALL FRUITED		
Little Fingers	0.2	2.1	13
Pirouette	0.3	3.5	29
Easter Egg (White)	0.3	6.0	51

the wilt disease. The usual "Black Beauty" type cultivars (large oblong fruit) and most of the oriental-type eggplants (long, thin fruit with a purple calyx) have large yields in fumigated soil (8-15 lbs per plant) but wilt reduced yield by at least half.

Notable high yielding cultivars are "Vernal", "Classic", "Epic", and "Black Pride" for the main market varieties whether or not soil is infested. These cultivars have a shape that is intermediate between the long, thin Italian-type and the wide, oblong "Black Beauty"-type. An honorable mention must be given to the small-fruited oblong-type "Early Bird" which maintained its modest yield even in infected soil. This cultivar is ideal for the home garden. For the novelty market, "Rosa Bianca" and "Casper" are worth noting for their ability to maintain yield in infested soil. "Rosa Bianca" produces white softball-sized fruit blushed with lavender and "Casper" produces pure white cylindrical fruit.

Black plastic mulch increased the yield of eggplant affected by Verticillium wilt. Wade H. Elmer and I have shown that mulched plants were 50-100% larger and yielded 33-37% more fruit by weight than unmulched plants, although the visual symptoms of disease were unaffected. Replacement of nitrate-based fertilizers with ammonia-based fertilizers also increased yield without affecting disease symptoms when infestation was moderate. Plants grown in fumigated plots produced well regardless of fertilizer form, and plants grown in heavily infested plots were stunted and produced few fruit.

The replacement of conventional fertilizers with composted animal manure reduced the loss of yield from Verticillium wilt of eggplant. My colleague Abigail Maynard has shown that eggplant yield from compost-amended plots increased 22% from 1989 to 1990 while yield of conventionally fertilized plots declined 11%. This effect may have been due to increases in soil populations of organisms antagonistic to *V. dahliae*, or simply due to reduced water and/or nitrogen stress on the host plant. Whatever the mechanism(s) by which yield of infected plants is increased, these results suggest that crop rotation and modified cultural methods may reduce yield loss due to Verticillium wilt.

These encouraging results persuaded me to do further investigations into the beneficial effects of compost-amendment in 1992 and 1993. In my experiments half of each Verticillium-infested field was fumigated to kill the fungus. Then two cultivars each of eggplants, tomatoes, and potatoes were planted using three cultural treatments: 1) conventional fertilizer alone, 2) conventional fertilizer and mulch (black plastic for eggplants and tomatoes and straw for potatoes), and 3) compost-amended plots.

For the eggplants, compost-amendment and the use of black plastic increased fruit yield in infested plots by 40-80%. However, the number of yellow leaves and the number of fallen leaves increased. A detailed examination of the growth of the plants indicated that although there were more diseased leaves per plant in these treatments, the average size of leaves was 61% larger, and the average height of a plant was 35% taller. Thus, the beneficial effect of compost-amendment and black plastic mulch appear to be due to an increase in plant size.

The yield of tomatoes in these plots was unaffected by disease and was slightly increased by both compost amendment (+10%) and the use of black plastic mulch (+17%). However, the degree of blossom end rot was tripled by the presence of *Verticillium*. Blossom end rot is a physiological disorder usually associated with water stress.

The yield of potatoes was reduced by 17% in 1992 and 35% in 1993 by the presence of the fungus. This yield was unaffected by the application of straw mulch. However, compost amendment decreased tuber yield by 25-45% whether or not the fungus was present. Paradoxically, this loss in yield corresponded to an increase in plant growth and a decrease in wilt symptoms for the compost-amended plots.

In general, any treatment that encourages the vegetative growth of the plant was observed to decrease the foliar impact of disease. However, reduction of foliar symptoms was not always accompanied by an increase in yield. In order to understand this result, one must examine not only the way in which an infected plant grows but, also, the effect of the plant on the infecting fungus.

It has been hypothesized that the onset of "Verticillium wilt" symptoms depends on low levels of soluble sugar in the host plant. Basically, while the fungus is well fed with sugar, it doesn't need to destroy plant material to obtain food. The appearance of wilt during flowering, when much of the sugar produced is directed towards the fruiting or storage organ, supports this hypothesis. This may also explain the apparently contradictory effect of compost amendment on foliage versus tuber growth in potato. Since compost delays the production of tubers, plants grow more quickly and exhibit fewer symptoms of disease; but, the total amount of sugar directed to tubers decreases and, of course, the planting yields less tubers.

I also tested the sugar-hypothesis for eggplant over three seasons (1992-1994). In these experiments, eggplants grown in infested and fumigated soil were subjected to two pruning treatments. Either all flowers were removed or the plants were allowed to branch and flower at will. In every year, flower-pruning delayed the onset of disease by at least 3 weeks and multiplied the maximum leaf area of infected plants by a factor of from two to three times when compared with the unpruned controls. This corresponded to a 40-50% increase in leaf area for the flower-pruned plants in the fumigated plots. Unfortunately, this method of reducing the foliar symptoms and the stunting effect of disease, totally eliminates the harvest.

As is often the case, the solution to a complex problem is not simple. The strategy to maximize yield when this disease is important must take into account the nature of plant growth and its effect on the damage done by the fungus. A compromise must be reached between factors which increase vegetative growth and factors which increase the harvestable yield. In this way the sugar level in the plant remains adequate to keep the destruction of leaves at a minimal level while still siphoning enough sugar to the final harvest to give a reasonable level of yield. In order for this strategy to succeed, crop rotation must be combined with the planting of suitable cultivars with the proper growth and yielding behavior in combination with the use of beneficial cultural practices (mulching, ammonia fertilization and compost amendment where applicable). In summary, it is only by examining the entire system, which includes both the plant and the fungus, that we can understand how to deal with the problems caused by "Verticillium wilt".

Using natural enemies from Japan to control hemlock woolly adelgid

By Mark S. McClure

Eastern hemlock (*Tsuga canadensis*) is an important tree species in the forests and ornamental landscapes of eastern North America, but its future is threatened by the hemlock woolly adelgid (*Adelges tsugae*), a small aphid-like insect that was introduced from Japan. Although this pest can be controlled on ornamental hemlocks by applying chemical pesticides, chemical control is difficult or impractical in forests. Therefore, the persistence of hemlock in the forest may ultimately depend upon biological control, a process whereby natural enemies successfully regulate pest numbers. Unfortunately, none of the native natural enemies that inhabit adelgid-infested hemlock forests in eastern North America are effective biological control agents.

In 1992 the Experiment Station launched an investigation in Japan to study the adelgid in its native habitat and to search for natural enemies. I discovered five natural enemies at 33 of 37 forest sites and at 34 of 37 ornamental sites and found that they play an important role in keeping adelgid populations at low densities (Table 1). Four insect predators including a ladybird beetle (Coccinellidae), a green lacewing (Chrysopidae), a gall midge (Cecidomyiidae), and a flower fly (Syrphidae) killed at least 96 and 69% of the adelgids at forest and ornamental sites, respectively. These predators were especially voracious on adelgid eggs, although larger immatures and adults were also attacked, particularly by beetles and lacewings. The excellent searching ability of these insect predators, the voracity with which they attack their prey, and their particular affinity for hemlock woolly adelgid make them excellent biological control candidates.

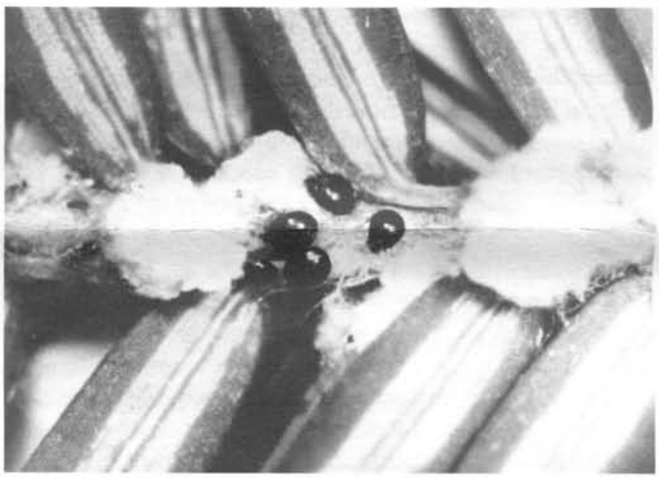

Figure 1. Adults of the oribatid mite, *Diapterobates humeralis*, feeding on the woolly filaments and dislodging eggs of hemlock woolly adelgid.

The oribatid mite, *Diapterobates humeralis* (Figure 1), occurred at 17 forest sites and 23 ornamental sites in Japan where it destroyed 91 and 98% of all adelgid eggs, respectively (Table 1). I determined from field and laboratory experiments that mites were not eating the adelgid, but were instead consuming the woolly material surrounding the eggs. However, in so doing mites dislodged nearly all adelgid eggs from the trees to the forest floor where they either dried up or were eaten by ants and spiders. In an experiment to test the ramifications of egg dislodgment by mites on adelgid survival, none of the more than 2,000 adelgids that I placed on the forest floor was able to successfully colonize hemlock saplings less than 1 meter away.

Changes in adelgid density at two ornamental sites where no other natural enemies occurred provided further evidence of the ability of this mite to control adelgid populations in Japan. Mites dislodged 97% of the eggs and reduced adelgid

Table 1. Natural enemies and their impact on hemlock woolly adelgid in Japan.

	Number of sites where present		% mortality of adelgids	
Natural enemy	Forest (37)	Ornamental (37)	Forest (37)	Ornamental (37)
Ladybird beetle: Coccinellidae *Pseudoscymnus* n. sp.	13	11	99	86
Green lacewing: Chrysopidae *Mallada prasina* (Burm.)	4	6	99	79
Gall midge: Cecidomyiidae *Lestodiplosis sp.*	5	3	96	9
Flower fly: Syrphidae unidentified sp.	1	2	97	70
Beetle mite: Ceratozetidae *Diapterobates humeralis* (Hermann)	17	23	91	98
ALL ENEMIES COMBINED	33	34	95	89

numbers by 90% during 3 weeks in May at both sites.

Included among the ornamental sites where the mite occurred were two sites where several *T. canadensis*, the susceptible North American hemlock species, have grown vigorously for several decades in the presence of the adelgid. This provides further evidence that *D. humeralis* can control adelgids and offers encouragement for the use of this mite in biological control efforts in North America.

Oribatid mites like *D. humeralis* usually feed on decaying plant tissues, algae and lichens. The chemical nature of the adelgid's woolly secretion and its possible nutritional value to the mite are unknown. However, the voracity with which the mite seeks out and destroys adelgid egg masses suggests that the woolly material is an important and highly preferred component of its diet. However, the mite occurs in many areas where the adelgid does not and, therefore, it exploits adelgid egg masses opportunistically rather than obligatorily. The ability of a natural enemy to persist on alternate food sources, such as decaying plants, algae and lichens and to exploit a pest species opportunistically is an important quality of an effective biological control agent.

After I had identified potential biological control candidates in Japan, I began the complex procedure for clearing the way for their introduction into North America. The first order of business was to obtain the necessary federal and state permits to have the natural enemies shipped from Japan to the federal quarantine facility in Ansonia, Connecticut. Information gathered from my intensive studies in Japan, from an exhaustive search of the literature, and from months of laboratory investigation in Connecticut was used to prepare a federal environmental assessment on each enemy before permits for release could be issued. After fulfilling these rigorous requirements, I received several shipments of *D. humeralis* and *Pseudoscymnus* n. sp. from colleagues in Japan. I am now rearing colonies of these natural enemies in my laboratory and studying their life cycles, generation times, consumption rates, and reproduction.

Propagating oribatid mites and ladybird beetles in the laboratory has been a challenge. Although adult beetles can be maintained for several weeks on dilute honey, their development and reproduction require a constant supply of living adelgids. Similarly, mites enthusiastically consume the woolly material secreted by the adelgid, as well as the algae which normally occur on the bark of hemlock twigs. Therefore, hemlock twigs must be collected frequently from the field and caged with the beetles and mites. It has been difficult during this process to ensure that other arthropods, including several native species of mites that closely resemble *D. humeralis*, do not contaminate the colony. Furthermore, it is essential that old twigs be examined carefully so that the tiny eggs and immatures of beetles and mites are not discarded.

There are numerous other challenges as well. For example, immature beetles must be caged individually so that development time and consumption rate can be measured accurately and to prevent cannibalism. Mating pairs of adults must be caged together in order to measure reproduction and longevity. Eggs are often laid singly or in small groups in cracks and crevices in the bark and in bud scales which makes locating them difficult.

The ladybird beetle completes several generations each year in the laboratory and its life cycle is well synchronized with that of its adelgid prey, both of which are important attributes of a biological control agent. All stages of the beetle feed on adelgid eggs; the older beetle larvae and adults also feed on the other adelgid stages including adults. Each larva develops through four stages in about 1 month and consumes nearly 500 eggs during that time. The adult consumes another several hundred adelgids and can live for at least 1 year. Females lay up to about 300 eggs starting about 2-4 weeks after they mature.

The mite has at least two broadly overlapping generations per year and adults live for 10 months or more during which females lay about 20 eggs each. All life stages of the mite consume the woolly material that surrounds the adelgid eggs as in Japan. During fall 1993 I released mites at two sites in Connecticut, one a field plot in Hamden and the other a forest in Windsor. The mites survived the subsequent winter, which was among the most severe on record, and have reproduced and spread in the hemlock forest.

I am now developing methods to rear natural enemies, to release and establish them throughout the hemlock-growing areas of North America, and to evaluate their effectiveness as biological control agents of hemlock woolly adelgid. The persistence of hemlock in the forests of eastern North America may well depend upon the successful establishment of natural enemies such as *D. humeralis* and *Pseudoscymnus* n. sp. from Japan.

Testing wine grapes for hardiness and yield helps Connecticut growers select varieties

By Richard K. Kiyomoto

Since the passage of the Farm Winery Bill in 1978, the acreage of grapes in Connecticut increased from fewer than 20 acres to 325 by 1989, and the number of farm wineries increased from one to eight during the same period. Although there are now at least ten wineries and vineyards, the acreage devoted to wine grapes has remained relatively static while the demand for grapes exceeds local supply.

From discussions with winery and vineyard personnel, I concluded that important research should center on two major problems—(1) Identifying a red wine grape cultivar which has both high productivity and good juice characteristics for making wine, and (2) Identifying cultural methods or cold-tolerant variants which would increase productivity of Vinifera cultivars. Current research at The Connecticut Agricultural Experiment Station focuses on these two goals.

Figure 1. Richard K. Kiyomoto pruning grapes.

Table 1. A partial list of grapes utilized by Connecticut wineries.

Cultivar	Classification	Juice Color
Baco Noir	French Hybrid	Red
Chancellor	French Hybrid	Red
Leon Millot	French Hybrid	Red
Ravat	French Hybrid	White
Seyval	French Hybrid	White
Marechal Foch	French Hybrid	Red
DeChaunac	French Hybrid	Red
Vidal Blanc	French Hybrid	White
Vignoles	French Hybrid	White
Aurore	French Hybrid	White
Cayuga White	Domestic	White
Cabernet Franc	Vinifera	Red
Cabernet Sauvignon	Vinifera	Red
Chardonnay	Vinifera	White
Gamay Noir	Vinifera	Red
Gewurztraminer	Vinifera	White
Merlot	Vinifera	Red
Pinot Noir	Vinifera	Red
Riesling	Vinifera	White

Connecticut's wine districts have been divided into several regions; however, it is simpler to view them as two regions based upon their proximity to the moderating effects of the waters of Long Island Sound—the Coastal District and the Interior District. The Coastal growing areas usually experience higher winter temperatures and lower summer temperatures than the Interior. Within the Interior District are highlands, protected slopes, and bodies of water which may also influence the local temperatures. In the Coastal District high winter temperatures can cause plants to lose their cold hardiness and deplete the protective snow cover.

The frequently desired Vinifera cultivars are not as cold hardy as domestic and French hybrid cultivars; thus they are primarily grown near the coast with French hybrid cultivars. Interior vineyards generally grow domestic hybrid and French hybrid cultivars because of their ability to withstand the colder winters. Table 1 lists some of the grapes that have been utilized by Connecticut wineries and their classification.

My initial studies focused on evaluating vine vigor and fruit set in eight table and 18 wine grape cultivars listed in Table 2. Among the wine grapes evaluated were 14 domestic and French hybrid grape varieties and four Vinifera cultivars (Riesling, Gamay Beaujolais, Chardonnay, and Gewurztraminer). Vine vigor was rated by noting the amount and condition (i.e., diameter and presence of dead wood) of new cane growth. Relative fruit set was based upon the total number of fruit-bearing bunches produced. This initial study showed the French hybrid grapes Seyval, Chambourcin, Villard Blanc, Villard Noir, Vignoles, Seibel 10868, and JS26-627 and the domestic hybrid Horizon were worthy of further evaluation. The best Vinifera cultivar for hardiness was Riesling, but it ranked only with the poorest of the domestic and French hybrid varieties.

Yields from four cultivars that consistently set large numbers of grape clusters and showed little winter injury were taken from 1990 through 1993 and the results are shown in Table 3. The yields are reported on the weight of fruit per vine and may appear relatively low because the vineyards were undergoing renovation and fruit clusters were thinned to 1-2 per cane. Better yields would be obtained by leaving a minimum of two clusters per cane. Although the average yields of the four cultivars were not significantly different, Chambourcin was highest and Horizon was lowest. The relatively high yield of Chambourcin, a red wine grape cultivar, suggested to me that it may be a useful cultivar in Connecticut. The low yields in 1993 resulted from drought and my thinning to one bunch per cane.

Chambourcin and Villard Blanc compared favorably in sugar and acid content with the high-yielding cultivar Seyval. While Horizon compared favorably with the other cultivars in sugar content, its acidity was low compared to the other cultivars. This high pH may have resulted from my harvesting Horizon in an overripe condition, but it is a characteristic worth noting and guarding against when making wine. A new replicated trial with Seyval, Chambourcin, Villard Blanc, and Villard Noir has been planted at Lockwood Farm in Hamden in order to further characterize yield and cultural requirements.

I initiated a cooperative study with Nick Smith of Stonington Vineyard to identify hardy Vinifera cultivars. The replicated planting was made in 1992 of the Vinifera cultivars Riesling, Chardonnay, Pinot Noir, Merlot, Cabernet Sauvignon, and Cabernet Franc. Plant survival was scored through spring 1994, and the results are shown in Table 4.

Riesling and Chardonnay have shown the most promise to date. I do not know how Vinifera cultivars will grow in the Interior District, but I shall continue to search for Vinifera cultivars and their variants with greater adaptation to growing conditions in Connecticut.

Table 2. Grape cultivars in trials at Hamden, 1990-93.

Table Grapes	Wine Grape Cultivars	
Concord	Cayuga White	JS26-627
Einset	Chambourcin	Riesling
Himrod	Chancellor	Seibel 10868
Interlaken	Chardonnay	Seyval
Lakemont	Chelois	Verdelet
Remaily	DeChaunac	Vidal 256
Romulus	Gamay Beaujolais	Vignoles (Ravat 51)
Vanessa	Gewurztraminer	Villard Blanc
	Horizon	Villard Noir

Table 3. Yield among exceptional cultivars at Hamden over a 4-year period (1990-93).

	Yield (lb/vine)				
Cultivar	1990	1991	1992	1993	Mean*
Seyval	16.7	9.7	8.4	2.2	9.3
Chambourcin	16.5	9.6	11.5	3.3	10.2
Villard Blanc	16.2	7.0	8.6	2.3	8.5
Horizon	6.6	5.9	10.2	2.9	6.4

* Values in the mean column are not significantly different by Duncan's Multiple Range Test (P=0.05).

Table 4. Stonington Vineyard Vinifera cultivar hardiness trial (1993 and 1994).

Cultivar	Plants surviving*
Riesling	92%
Chardonnay	80%
Pinot Noir	63%
Merlot	52%
Cabernet Sauvignon	40%
Cabernet Franc	29%

* All values significantly different by Duncan's Multiple Range Test (P=0.05).