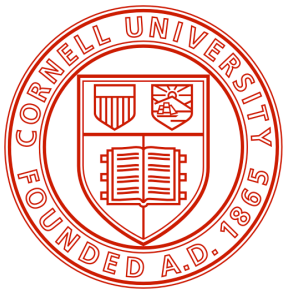

Long Island Vegetable Pathology Program
2001 Annual Research Report

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Epidemiology of the cucurbit powdery mildew: additions to the host range and early spring occurrence of powdery mildew on greenhouse-grown verbena.

Investigators: N. Shishkoff, M. McGrath
Location: Long Island Horticultural Research and Extension Center

A new host for *Podosphaera xanthii*, the cucurbit powdery mildew, was found when a specimen of diseasesd *Nierembergia caerulia* (purple robe) was sent in for diagnosis. The powdery mildew on its foliage could infect cucurbits, and isolates of *P. xanth*ii from our collection could infect nierembergia seedlings. This is the second greenhouse-grown ornamental found to be a host of *P. xanthii* (the first being *Verbena x hybrida*). As with verbena, this raises the possibility that nursery stock could be a source of primary inoculum for cucurbit powdery mildew epidemics. This year scouting of retail nurseries found both infected verbena and infected cucurbit transplants being sold in early spring (infected verbena was first seen on May 23).

POWDERY MILDEW OF PUMPKIN: EVALUATION OF CURRENTLY REGISTERED FUNGICIDES AND NEW FUNGICIDES

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Application of fungicides continues to be the principal practice for managing powdery mildew in pumpkin. There are very few resistant varieties. It is the most common disease occurring every year throughout Long Island. The primary objective of the experiment conducted in 2001 was to evaluate protectant fungicides for their suitability as replacements for chlorothalonil. Products tested and rate/A used were Serenade 6 lb, Kaligreen 4 lb, Armicarb 4 lb, Nutrol 20 lb, Prudent Plus 1.4 qt, Milsana 0.5% and 1%, Kocide 2000 2 lb, JMS Stylet-oil 1.5%, Microthiol Disperss 4 lb, and Bravo Ultrex 2.7 lb. Milsana bioprotectant is in a new group of compounds called plant activators which stimulate the natural defense mechanisms of plants so that they become more resistant to diseases. This response is called systemic acquired resistance or SAR.

'Appalachian' pumpkin seeds were planted on 25 June. Two Milsana treatments were started about 3 weeks after planting on 16 July to determine if a preventive schedule is needed in order to get SAR stimulated before powdery mildew starts to develop. Four applications were made before powdery mildew was observed (16, 25, and 31 July and 7 Aug). Nutrol and PrudentPlus treatments were started on 31 July. All other treatments were initiated on 15 Aug after the IPM threshold of one leaf with symptoms of 50 old leaves examined was reached in all plots. This threshold was shown previously to be as effective as using a preventive schedule. Applications were made on 15, 22, and 30 Aug, and 6 and 13 Sept with a tractor-mounted boom sprayer equipped with D3-45 hollow cone nozzles spaced 11 in. apart that delivered 88 gpa at 200 psi. Powdery mildew severity on upper and lower (under) leaf surfaces was determined weekly. AUDPC, a

cumulative measure of disease severity, was calculated for each leaf surface. The higher the AUDPC value the more severe the disease.

Symptoms were found on only 2 of 2000 leaves examined on 2 Aug. The IPM threshold had been reached in all plots on 14 Aug. Powdery mildew became severe as usual at this location. All treatments provided some control of powdery mildew on AUDPC upper leaf surfaces. Microthiol Disperss, JMS Stylet-oil, and Bravo were the most effective protectant fungicides. Bravo was more effective than the others for powdery mildew on upper leaf surfaces; Microthiol Disperss and JMS Stylet-oil were more effective than Bravo on lower leaf surfaces. Fruit were largest for Microthiol Disperss among the eight treatments examined. With this sulfur product, average weight of mature fruit and quantity of fruit weighing at least 15 lb was significantly greater than with Nutrol, PrudentPlus, and JMS Stylet-oil. Microthiol Disperss was the least expensive fungicide treatment tested. Serenade was the least effective protectant fungicide. Powdery mildew severity of Serenade-treated leaves was significantly lower than nontreated only for AUDPC for upper leaf surfaces. This was the only treatment that did not have less defoliation than nontreated on 6 Sep. More treatments were not significantly different from nontreated on subsequent assessment dates (data not shown). There was no benefit to initiating Milsana applications before disease detection. The preventive program had four more applications than the IPM program. The 1% rate was more effective than the 0.5% rate based on AUDPC values for upper leaf surfaces. There were no significant differences between the two potassium bicarbonate products, Armicarb and Kaligreen. Superior control of powdery mildew on lower leaf surfaces was achieved with the treatments that included systemic fungicides. These treatments also had the least defoliation, but not significantly less than the best protectant fungicides. Pumpkins treated with Microthiol Disperss or the currently recommended program of Quadris alternated with Bravo + Nova had the most fruit with good solid handles, an important measure of quality. These treatments were significantly better than the other protectant fungicides.

POWDERY MILDEW OF MUSKMELON: EVALUATION OF NEW NOZZLES AND AN AIR ASSIST SPRAYER FOR IMPROVING SPRAY COVERAGE AND DISEASE CONTROL ON UNDERSIDES OF LEAVES

Investigator: M. T. McGrath and Andrew Landers
Location: Long Island Horticultural Research and Extension Center

Effective control of powdery mildew in a cucurbit crop necessitates controlling the disease on the underside of leaves. Conditions are more favorable for development of powdery mildew on the lower compared to upper surface. A contact, protectant fungicide applied with conventional nozzles is deposited almost exclusively on the upper surface of leaves. Leaves die prematurely when powdery mildew is not controlled effectively on the underside. Thus systemic fungicides have been critically important for powdery mildew control. Unfortunately, systemic fungicides are at-risk for resistance development. The powdery mildew fungus has demonstrated high potential for developing resistance. A means to improve spray deposition on the leaf underside would reduce grower dependence on systemic fungicides. It would also improve resistance management by increasing the proportion of the pathogen population exposed to the low-resistance-risk contact fungicide used in programs with systemic fungicides. It would be even more valuable for organic growers because there are no systemic fungicides that are approved for organic production.

New nozzles for conventional spray booms reportedly improve coverage by delivering more spray to the leaf underside and also by reducing drift. The sprayer used in this study was a tractor-drawn unit equipped with an air assist boom and a separate hydraulic boom set-up with multiple nozzles on a single nozzle body. Two novel nozzles (twin jet and air induction) were compared to 3 traditional nozzles (flat fan, hollow cone, and cone jet). All are considered ideal for applying fungicides. Twin-jet nozzles use forward and rearward pointing flat fans, thus providing two chances to hit the plant. They apply the same total amount of liquid as a conventional flat fan. Air induction (air inclusion or venturi) nozzles are flat fan nozzles where an internal venturi creates negative pressure inside the nozzle body. Air is drawn in through two holes in the nozzle side, mixing with the spray liquid. The emitted spray contains large (300 micron) droplets filled with air bubbles and virtually no fine, drift-prone droplets. Normally droplets this large would bounce off their target. However, because of the air they explode on impact and spread over the leaf as the air absorbs the impact load. Coverage is similar to that of finer sprays produced by traditional nozzles.

Another approach to improving coverage is to use an air assist sprayer. Air assist sprayers use air as a carrier for the pesticide. A fan is used that moves air at a fast speed thereby pushing the spray into the canopy and also generating turbulence that moves spray to undersides of leaves. Nozzle velocity can be up to 180 mph. This is an expensive means to improving coverage because it entails purchasing a new sprayer rather than just new nozzles. Another benefit of improved deposition is the potential to maintain good control but with lower pesticide rates.

Seedlings were transplanted on 19 June into black plastic mulch with drip irrigation. The contact fungicide Bravo Ultrex (2.7 lb/A) was applied with each nozzle on 1, 8, 16, and 23 Aug and 2 Sept. An additional treatment was the currently recommended fungicide program for cucurbit powdery mildew, Quadris (15.4 oz/A) applied in alternation with Bravo + Nova (5 oz/A) using the flat fan nozzles. This treatment was included to determine if a sufficient amount of Bravo could be deposited on low leaf surfaces with any of the nozzles tested to achieve a similar level of control as that obtained with the systemic fungicides Quadris and Nova. Powdery mildew severity on upper and lower (under) leaf surfaces was determined weekly. AUDPC, a cumulative measure of disease severity, was calculated for each leaf surface. The higher the AUDPC value the more severe the disease. Spray coverage was assessed by attaching water sensitive paper cards in pairs to both leaf surfaces for each nozzle type. Proportion of each card that changed color due to spray deposit was determined using a computer scanning program

Neither the air assist boom nor the novel nozzles improved control achieved with Bravo applied with conventional nozzles on a hydraulic boom. Control was improved on the lower leaf surface only when systemic fungicides were also used. AUDPC for powdery mildew severity on lower leaf surfaces was 961 for nontreated, 601 to 654 for the traditional nozzles, 627 to 780 for the novel nozzles, 549 for the air assist sprayer, and 239 for the Quadris alt Bravo + Nova treatment. The last application was delayed due to 2 days of windy conditions; however, it is unlikely this affected results. Defoliation was significantly lower in fungicide-treated plots than nontreated plots on all assessment dates. There were no significant differences among treatments on 24 Aug when

defoliation was 1 to 5% versus 45% for nontreated. On 17 Sep, defoliation was lower for the Quadris alt Bravo + Nova treatment (21%) than for the Bravo treatments (42 to 61%). Nontreated fruit had the lowest sucrose concentration; however, there were no significant differences among treatments. Spray deposit on water sensitive paper corresponded to powdery mildew control results except that significantly less material was deposited on upper leaf surfaces with the air assist boom than with any nozzles on the hydraulic boom. Spray deposition (% card coverage) on upper leaf surfaces was 70 to 80% for the traditional nozzles, 75 to 76% for the novel nozzles, and 35% for the air assist sprayer. Deposition on lower leaf surfaces was 5 to 14%, 6%, and 8% respectively.

In conclusion, it was not apparent that the novel spray application technologies improved powdery mildew control with Bravo. This experiment has demonstrated that it is challenging to improve spray coverage on the lower surface of muskmelon leaves by changing spray equipment. Similar results were obtained in a parallel experiment with pumpkin (see following report).

POWDERY MILDEW OF PUMPKIN: EVALUATION OF NEW NOZZLES AND AN AIR ASSIST SPRAYER FOR IMPROVING SPRAY COVERAGE AND DISEASE CONTROL ON UNDERSIDES OF LEAVES

Investigator: M. T. McGrath and Andrew Landers
Location: Long Island Horticultural Research and Extension Center

The previous experiment conducted on muskmelon was also conducted on pumpkin. These two cucurbit crops were selected because they have different canopies. Muskmelon leaves are much smaller and shorter than pumpkin leaves. Also, most leaves in the muskmelon canopy are at the same level whereas the pumpkin canopy consists of a few layers of leaves. Fungicide applications were made at the same time.

Neither the air assist boom nor the novel nozzles improved control achieved with Bravo applied with conventional nozzles on a hydraulic boom. Control was improved on the lower leaf surface only when systemic fungicides were also used. AUDPC for powdery mildew severity on lower leaf surfaces was 1104 for nontreated, 968 to 1099 for the traditional nozzles, 1050 to 1054 for the novel nozzles, 989 for the air assist sprayer, and 611 for the Quadris alt Bravo + Nova treatment. The last application was delayed due to 2 days of windy conditions; however, it is unlikely this affected results. Spray deposit on water sensitive paper corresponded to powdery mildew control results except that significantly less material was deposited on upper leaf surfaces with the air assist boom than with any nozzles on the hydraulic boom. Spray deposition (% card coverage) on upper leaf surfaces was 56 to 81% for the traditional nozzles, 70 to 76% for the novel nozzles, and 27% for the air assist sprayer. Deposition on lower leaf surfaces was 2%, 1 to 9%, and 4% respectively.

Similar results were obtained in the parallel experiment with muskmelon (see previous report).

POWDERY MILDEW OF CUCURBITS: DETERMINATION OF PATHOGEN RACE

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Differential melon genotypes were grown near the powdery mildew experiments to determine which races of the pathogen were present. Topmark is susceptible to all races. PMR-45 is resistant to race 1 and PMR-6 is resistant to races 1 and 2.

Powdery mildew began to develop in Topmark and PMR-45 at the same time in 2001; therefore, race 1 and race 2 appeared together, in contrast with previous years when race 2 appeared later in the epidemic than race 1. Symptoms did not develop on PMR-6, therefore race 3 did not occur.

POWDERY MILDEW OF MUSKMELON: ALTERNATIVE FUNGICIDES TO BRAVO EVALUATED ON VARIETIES DIFFERING IN SUSCEPTIBILITY TO POWDERY MILDEW

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Eclipse, which has resistance to race 1, and Apollo, which has resistance to race 1 and 2, were compared with susceptible Superstar. There were three fungicide programs plus a nontreated control. The standard fungicide program was Quadris F (15.4 oz/A) applied in alternation with Nova 40W (5 oz/A) + Bravo Ultrex (2.7 lb/A). Treatment was started after disease detection for each cultivar. The standard program applied to Superstar was Quadris on week 1 (15 Aug), 3, and 5, and Bravo + Nova on week 2 and 4. The standard program applied to Eclipse and Apollo was Quadris on week 2 (22 Aug) and 4, and Bravo + Nova on week 3 and 5. The Bravo alternatives fungicide program was similar to the standard program with potassium bicarbonate formulated as Kaligreen (4 lb/A) used in place of Bravo in its first application and copper hydroxide formulated as Kocide 2000 (1.5 lb/A) in the second. The biocompatible fungicide program was an alternation of Kaligreen and Kocide, which are approved for organic production. Applications were made on 15, 22, 30 Aug; 6 and 13 Sept. Powdery mildew severity on upper and lower (under) leaf surfaces was determined weekly. AUDPC, a cumulative measure of disease severity, was calculated for each leaf surface. The higher the AUDPC value the more severe the disease. Defoliation, predominantly due to powdery mildew, was assessed on 4, 11, and 17 Sept. Ripe fruit were counted and weighed on 4 and 11 Sept. Percentage of sucrose was determined using a hand refractometer for two fruit per plot.

Although both race 1 and 2 were present (see previous report), powdery mildew was significantly less severe on nontreated Eclipse, which has resistance only to race 1, than on nontreated susceptible Superstar. Nontreated Apollo, which has resistance to both race 1 and 2, surprisingly was not less severely affected by powdery mildew than nontreated Eclipse. Apollo exhibited a higher level of resistance in 2000. The biocompatible fungicide program applied to Superstar was not as effective as either the standard fungicide program or the Bravo alternatives fungicide program. Defoliation was only observed in nontreated Superstar (81%) and Superstar receiving the biocompatible program (46%) on 4 Sept. There was significantly more defoliation with the

biocompatible program compared to the other programs on all three assessment dates for Superstar. Sucrose content, a measure of fruit quality, was not significantly improved over nontreated with the biocompatible program, in contrast with the other programs. The Bravo alternatives program differed significantly from the standard program only based on powdery mildew severity on 5 Sept and AUDPC for lower leaf surfaces. All fungicide programs improved control of powdery mildew obtained with genetic control. There were only minor differences among the three fungicide programs applied to the two cultivars with resistance to powdery mildew. The only significant difference was a higher AUDPC value for powdery mildew on lower leaf surfaces with the biocompatible program compared to the other programs. Powdery mildew control in these resistant cultivars did not result in improved fruit quality. Quantity of fruit was not affected by fungicide treatment for any cultivar. However, Superstar receiving the standard fungicide program produced more fruit than both Apollo and Eclipse receiving the same treatment (average of 40, 32, and 30 fruit/plot, respectively).

In conclusion, resistant muskmelon varieties, especially those with resistance to races 1 and 2, are recommended for managing powdery mildew on Long Island. Fungicides will still be needed if other diseases such as anthracnose develop. The Bravo alternatives or the standard fungicide programs are recommended for susceptible varieties. The biocompatible fungicide program is only recommended for resistant varieties.

POWDERY MILDEW OF PUMPKIN: ALTERNATIVE FUNGICIDES TO BRAVO EVALUATED ON VARIETIES DIFFERING IN SUSCEPTIBILITY TO POWDERY MILDEW

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

A powdery mildew tolerant/resistant (PMR) variety (Magic Lantern) and a PMR experimental (HMX 6687) from Harris Moran Seed Company were compared with susceptible Wizard. HMX 6687, which has resistance from both parents, was shown previously to be more resistant to powdery mildew than Magic Lantern. There were three fungicide programs plus a nontreated control. The standard fungicide program was Quadris F (15.4 oz/A) applied week 1, 3, and 5 in alternation with Nova 40W (5 oz/A) + Bravo Ultrex (2.7 lb/A) applied week 2 and 4. The Bravo alternatives fungicide program was similar to the standard program with potassium bicarbonate formulated as Kaligreen (4 lb/A) applied in place of Bravo week 2 and copper hydroxide formulated as Kocide 2000 (1.5 lb/A) applied week 4. The biocompatible fungicide program consisted of fungicides currently or potentially acceptable for organic production: sulfur formulated as Microthiol Disperss 80DF (4 lb/A) applied week 1, Kocide applied week 2 and 4, and Kaligreen applied week 3 and 5. Applications were made on 15, 22, 30 Aug; 6 and 13 Sept. Powdery mildew severity on upper and lower (under) leaf surfaces was determined weekly. AUDPC, a cumulative measure of disease severity, was calculated for each leaf surface. The higher the AUDPC value the more severe the disease.

Genetic control with the highly resistant hybrid HMX 6687 was more effective than chemical control. Compared with fungicide-treated Wizard, powdery mildew on nontreated HMX 6687 was significantly less severe on lower leaf surfaces and equally severe on upper surfaces for most assessments. Control was not as effective with Magic

Lantern. Mildew was more severe on nontreated Magic Lantern than nontreated HMX 6687 beginning with the 22 Aug assessment. Nontreated Magic Lantern became severely infected late in the growing season. It was not significantly different from nontreated Wizard for several assessments (5 Sept upper surfaces, 13 Sept lower surfaces, and 24 Sept both surfaces). Chemical control was more effective than genetic control with Magic Lantern. Mildew was significantly more severe on nontreated Magic Lantern than fungicide-treated Wizard for most assessments beginning on 29 Aug, particularly for the Bravo alternatives and standard fungicide programs. The fungicide programs reduced mildew severity in Magic Lantern beginning on 22 Aug for upper surfaces and on 29 Aug for lower surfaces. A fungicide benefit was not detected with HMX 6687 until 29 Aug and 24 Sept for upper and lower leaf surfaces, respectively. The three fungicide programs were equally effective when applied to HMX 6687. For Wizard and Magic Lantern, the Bravo alternatives program was as effective as the standard program except for a few assessments. The biocompatible program was less effective than the standard program for most assessments on lower leaf surfaces, including AUDPC, and for a few assessments on upper surfaces. Mildew was generally less severe on pumpkin fruit handles of nontreated HMX 6687 and Magic Lantern than fungicide-treated Wizard. Infection of handles is thought to result in more rapid shriveling. All treatments had significantly more fruit with good, solid handles (75 to 94%) than nontreated Wizard (54%) except Wizard receiving the biocompatible program (70%) on 15 Oct. Fungicide treatment did not affect number of mature or green fruit/plant or fruit weight for any cultivar. Magic Lantern fruit were heavier than those of Wizard and HMX 6687 (14.5, 11.1, and 12.0 lb/fruit, respectively).

In conclusion, varieties such as HMX 6687, with high levels of resistance, are recommended over moderately resistant varieties such as Magic Lantern. The Bravo alternatives program was as effective as the standard fungicide program for managing powdery mildew on the resistant varieties. It was not quite as effective with susceptible Wizard, but this did not result in a difference in fruit quality. The biocompatible fungicide program was as effective as the standard fungicide program only with the more resistant variety, HMX 6687.

POWDERY MILDEW OF ACORN SQUASH: EFFICACY OF RESISTANT VARIETIES

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

The objectives of this study were to compare a new powdery mildew resistant hybrid of acorn squash (PS 10705) to an older resistant hybrid (Taybelle PM) and to determine if there is a benefit to augmenting powdery mildew control by applying fungicides to these hybrids. Taybelle PM is described as having intermediate resistance. In addition to a nontreated control, each hybrid received the currently recommended fungicide program (Quadris applied in alternation with Nova + Bravo on a 7-day schedule). PS 10705 also received a reduced fungicide program (standard program applied on a 14-day schedule).

Seedlings were transplanted into bare ground on 28 June. Powdery mildew severity on upper and lower (under) leaf surfaces was determined weekly. Fungicide treatments were initiated on 30 Aug after the first sign of powdery mildew. AUDPC, a cumulative measure of disease severity, was calculated for each leaf surface. The higher the AUDPC value the more severe the disease. Fungicides were applied with a tractor-mounted boom sprayer equipped with D3-45 hollow cone nozzles spaced 11 in. apart that

delivered 88 gpa at 200 psi. Defoliation was assessed on 11 and 27 Sep. Fruit were harvested and weighed on 3 Oct.

Powdery mildew was significantly less severe in PS 10705 than in Taybelle PM. There was a benefit to augmenting genetic control with chemical control in terms of powdery mildew severity. This benefit was most pronounced for Taybelle PM. Powdery mildew was significantly less severe in PS 10705 receiving either the standard or reduced fungicide programs than in nontreated PS 10705 only for AUDPC for powdery mildew on lower leaf surfaces (AUDPC values were 0.2, 0.7, and 29 for these treatments, respectively, compared to 373 for nontreated Taybelle PM and 9 for Taybelle PM receiving the standard program). Improved disease control did not result in reduced defoliation or increased yield. Taybelle PM produced significantly more fruit than PS 10705 (7 and 6 fruit/plant, respectively). Individual fruit weight of these hybrids did not differ significantly (average of 1.9 lb/fruit).

PHYTOPHTHORA BLIGHT OF PUMPKIN: EVALUATION OF BREWERY-WASTE COMPOST

Investigators: M. T. McGrath and A. Rangarajan
Location: Long Island Horticultural Research and Extension Center

Compost has been shown to be effective for suppressing several soilborne plant diseases. Yard-waste compost, however, was not found to be sufficiently effective for management of Phytophthora blight of cucurbits in previous experiments conducted at LIHREC in 1995 and 1996. This may have been due to low microbial activity of this compost. Brewery-waste compost has higher microbial activity, and thus was expected to be more suppressive to soil-borne pathogens. The current experiment was conducted in a field where Phytophthora blight developed in 1991 to 1993 and 1995 to 1999.

Plots were 28.3 ft wide and 51 ft long with 20 ft space between plots. Composted brewery waste (NutriBrew) was obtained from Commodity Specialists in Syracuse, NY. It was spread on 11-12 June at a rate of approximately 45 wet tons/A (20 dry tons/A) with a Millcreek compost spreader, then hand-raked as needed to obtain even distribution. The compost was incorporated by disking to a maximum of 6 in. deep on 16 June. An experimental pumpkin hybrid with a high level of powdery mildew resistance was selected to minimize the need for pesticide applications because tractor traffic through the field could move *Phytophthora* and compact the soil creating favorable conditions for blight. Pumpkin seed were planted in the plots on 28 Jun at approximately 24-in. within row plant spacing. Each plot contained three rows spaced 68 in. apart.

Phytophthora blight was observed first on 1 Aug in a nontreated plot (15% of foliage affected) and the compost-treated plot (3%) in that replication. This treated plot was 1 of 3 that had visible evidence that some compost washed out of it during a severe rain storm on 17 June (4.25 in). Rain on 26 July (1.1 in) most likely provided favorable conditions for disease onset. Soil in these two plots looked wetter than other plots following rain earlier in the summer when plants were small and soil was readily visible. Symptoms were observed in two more plots on 14 Aug and all plots except one treated plot on 24 Aug. More than 0.75 in. rain fell on 10, 20, and 24 Aug. First symptom observed in many plots was collapse of vines that were extending out of the plot. Many fruit were affected by Phytophthora fruit rot. Additionally, many plants died before producing fruit. Numerous affected fruit with abundant sporulation and new symptoms of vine collapse were observed on 7 Sept despite dry conditions. The only rainfall since 24 Aug was 0.1 in. on 28 Aug. Evidently, heavy dews occurring during that time

provided favorable conditions for disease development. No significant differences were detected in proportion of the canopy wilting or dead from Phytophthora blight or in the number of asymptomatic fruit. For example, on 7 Sept the proportion of the canopy affected was 67% for compost and 52% for nontreated. There was a lot of variation among plots for both treatments. Proportion of a plot affected on 7 Sept, for example, ranged from 2% to 100%.

In conclusion, compost with high microbial activity applied about two weeks before seeding pumpkin did not suppress Phytophthora blight.

Epidemiology of *Phytophthora capsici* in cucurbits: spread by wind-borne debris

Investigators: N. Shishkoff, M. McGrath,
Location: Long Island Horticultural Research and Extension Center

Phytophthora capsici is a soil-borne plant pathogen that can cause severe damage to pumpkins and squash. If it appears in a field, measures must be taken to prevent its spread to other fields. Zoospores, the swimming spores that are formed in hot wet weather, are the spores that cause epidemics, and may be spread in irrigation water. They may also be spread long-distance during storms with wind-driven rain. However, little is known about the dispersal of oospores (the overwintering state) or mycelium embedded in organic debris. An experimental plot was set up in a field of diseased pumpkin beginning on Oct. 19 to follow the spread of *P. capsici* within a field during rainstorms. Sixteen small nets were fashioned out of wire frames and fine netting (50 x 24 mesh size). These were randomly arranged in the field with the netting 1 foot above ground to catch large particles of wind-borne debris. Each net was further equipped with 2 strips of double-faced cellophane tape to catch microscopic debris. One piece of tape and the contents of each net were plated onto plates of corn-meal agar on Oct. 22, 25, 26, and 29 and Nov. 6 to try to isolate colonies of Phytophthora from air-borne debris; the other piece of tape from each net was coated with microscope immersion oil, placed under a glass cover slip, and examined at 400x for fungal propagules.

Unfortunately, no major storms occurred after disease was well-developed in the field, so it was impossible to study the dispersal of *Phytophthor*a during large storm events, although there was rain on Nov. 5 (0.01 inches). The debris collected in nets consisted mainly of sand and weed seeds, with little organic debris collected, despite high winds. No *Phytophthora* was isolated from plated debris. If any colonies had formed, they would have to have derived from mycelium in organic debris, because any oospores formed by *P. capsici* would have required a resting period before germinating. Examination of tape samples revealed no oospores, although numerous fungal propagules were observed: aeciospores, urediniospores and teliospores of rust fungi, spores of *Alternaria* and *Septoria,* wefts of thick-walled mycelia, microsclerotia, and even cleistothecia of powdery mildew

fungi. It is likely that most of the field-to-field spread is caused by movement of water or dirty equipment.

Epidemiology of *Phytophthora capsici* in cucurbits: formation of oospores in fruit and seeds.

Investigators: N. Shishkoff, M. McGrath,
Location: Long Island Horticultural Research and Extension Center

Previously, we had shown that both mating types of *Phytophthora capsici* occurred on Long Island. This meant it was possible for the overwintering oospore stage to form. We wanted to infect fruit with both mating types to see if oospores would develop, and if so, whether they would be found in or on seed. Overwintering fruit tissue might harbor oospores and in spring seeds might germinate as "volunteers", either serving as a source of inoculum.

In laboratory experiments, pumpkin fruit (from cultivars 'Hybrid Pam' and 'NH-1040', which has seeds with no hulls) were inoculated with one or both mating types of *P. capsic*i and incubated at 24 C in controlled enviroment chambers. After 2-3 weeks, when fruits had become completely infected and "mummified", samples of flesh and seeds were taken for microscopic examination; seeds were dissected so that the outer hulls and the inner seed coats could be examined. Additional seeds were plated on water agar on Jan. 16 (with or without surface-sterilization in 10% bleach) to detect infection by *Phytophthora*. Remaining seeds were washed, air-dried and refrigerated. Subsamples were plated on water agar to test germination and infection on Feb. 28, Mar. 18 and Dec. 10.

When fruit were inoculated with one mating type, oospores were not observed in tissue or seeds. Mycelium was abundant, however, both on and in seeds. Most seeds with mycelium on the seed coat had embryos that appeared viable; the mycelium was restricted to the seed coat. Most fruits that had been inoculated with both mating types had detectable levels of oospores in flesh and on seeds. On several occasions oospores were detected inside seeds, on the seed coat. Many of these seeds contained embryos that looked healthy, with no sign of rot. Oospores were observed on the cultivar with hull-less seeds, but these were limited to the seed coat, and did not cause seeds to appear rotten. Immediately after harvest, seeds from infected fruit plated on agar yielded colonies of Phytophthora. Because these colonies were just as common from seeds infected by a single mating types as from those infected with both mating types, it was assumed that fungal mycelium in and on seed were detected. In hull-less seeds, germination was as good as in hulled seeds, even though *Phytophthora* was present on the seed coat. After seed had been air-dried and refrigerated for several months, no *Phytophthora* was isolated, suggesting that mycelium is short-lived and unable to overwinter (something that has been shown by other researchers as well). Oospores of *P. capsici* require a resting period before being able to germinate, so while they were probably present on some of the seeds that had been inoculated with both mating

types, they did not cause colonies to form. After 11 months, *Phytopthora* was still not isolated from seeds. Additional efforts will be made to see if the oospores present on seeds inoculated with both mating types will break dormancy.

In a second experiment, pumpkins were inoculated at two sites (each site with one of the two mating types) , 2 pairs of sites, or 4 pairs of sites, to see if this had any effect on the number of oospores eventually detected. There was a slight increase in the number of seeds with oospores in fruit inoculated at 4 pairs of sites. As in the first experiment, seeds plated immediately (Feb 2) after removal from infected fruit gave rise to a high number of colonies forming (40-100%). After air-drying and refrigeration, however, no further colonies of Phytophthora were isolated (on Feb 19, March 19, or Dec 10), suggesting that mycelium had quickly ceased to be viable but oospores were either nonviable or had not yet broken dormancy.

In 1999, an outbreak of *P. capsici* occurred in central upstate NY where Phytophthora blight has never been observed. Thus the pathogen had to have been dispersed over a long distance to this farm. Dispersal in wind-driven rain is not feasible as such a storm did not occur in 1999. Pumpkin seed used at the affected farm was purchased from a small company that was going out of business. Phytophthora blight occurred again in 2000 in new fields. The disease started in 1 variety. To investigate the possibility that the seeds had been the source of the disease, left-over seeds of these 2 varieties ('Autumn King' and 'Howden') were obtained from the grower. Samples of these seeds were germinated in Petri dishes under laboratory conditions and examined for signs of infection by *P. capsici*. None were seen. The remaining seeds were planted in trays of soil-less planting media and observed for symptoms of damping-off. All seedlings were healthy.

COMPARISON OF CUCURBIT CROP TYPES FOR THEIR ATTRACTIVENESS TO CUCUMBER BEETLES AND SUSCEPTIBILITY TO BACTERIAL WILT

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Seedlings at the cotyledon to one-leaf stage were transplanted into black plastic mulch on 15 June. Transplanting was done when plants were very young so that they would be in the field almost their entire life including the cotyledon stage when cucurbit crops are highly attractive to cucumber beetles. Plants were examined weekly for cucumber beetles, feeding damage, and symptoms of bacterial wilt.

Compared to pest and disease pressure in 1999 and 2000, cucumber beetles were less numerous and bacterial wilt was less severe in 2001. Striped cucumber beetles were the main vector observed during this experiment. Very few spotted cucumber beetles were seen. Beetles were first observed at LIHREC on 18 June in another experiment. No beetles were seen in this experiment on 26 June through 3 July. A few beetles and a small amount of feeding damage were seen on 6 July. Similar to previous experiments, the gourd Turk's Turban was very attractive to beetles and highly susceptible to wilt. In contrast with previous experiments in which all plants died before producing fruit, only 6% of these plants became severely wilted (at least 50% of the plant wilted). As in previous years, the pumpkin Merlin was also highly susceptible compared to other crops

and wilt did not develop in watermelon (Crimson Sweet). Wilt also did not develop in summer squash (Lemon Drop), muskmelon (Athena), or winter squash (Buttercup Burgess).

BACTERIAL WILT OF CUCUMBER: EVALUATION OF RESISTANT SLICER VARIETIES

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Host plant resistance has the potential to be an important tool for managing bacterial wilt, a potential devastating disease. County Fair, a resistant pickling cucumber, exhibited a high level of resistance when evaluated at LIHREC in 2000. Only 7% of these plants succumbed to bacterial wilt by 22 Aug compared with all plants of Calypso (pickler) and Dasher II (slicer). Two resistant slicers developed by Dr. Henry Munger, Cornell Dept. of Plant Breeding, were compared to a standard susceptible variety in the 2001 experiment.

Seed were pre-germinated on wet filter paper, then placed in trays of soil-less mix in the greenhouse. Eleven days later, 16 July, seedlings were transplanted into black plastic mulch with drip irrigation. Plants were examined regularly for cucumber beetles, feeding damage, and symptoms of bacterial wilt. Fruit were not harvested as they reached marketable size to avoid damaging vines. Yield was assessed by counting fruit on 13 Sept. Horticultural characteristics of fruit were evaluated by Joe Sieczka.

Cucumber beetle population was much lower in 2001 than the previous two years. No beetles were observed on 24 July, 30 July, or 7 Aug. Plants were tipping over on 7 Aug. Beetles were finally observed on 17 Aug. They were mostly in flowers. A few tiny fruit were present. The first marketable sized fruit were seen on 31 Aug. No wilt was observed. This is most likely because flowers were present when beetles entered this planting. Beetles are more attracted to flowers than to leaves or stems. It seems unlikely that any wilt-causing bacteria that enter flowers would move into the stems and cause the plant to wilt. This hypothesis is supported by results from this study plus those from 2000 when beetles fed on leaves and stems. There were no significant differences among the cucumbers evaluated in number of beetles per plant, which ranged from an average of 0.7 to 0.8 beetles/plant for the 17 and 23 Aug assessments. This is not unexpected, however, because differences were not detected among cucumbers evaluated in 2000. Resistance is thought to affect the bacteria rather than the insect vector.

There were no significant differences among the cucumbers in number of fruit. The hybrid Marketmore 76 had an average of 9.8 fruit/plant, Marketmore 415F X Marketmore 80 BW had 11.1 fruit/plant, and Poinsett 95F X Marketmore 80 BW had 11.5 fruit/plant. All produced fruit that were commercially acceptable in appearance and taste. Quality was rated slightly worse for Marketmore 76 due to its slightly larger seeds and slightly larger seed cavity relative to flesh. Poinsett 95F X Marketmore 80 BWwas rated best.

EVALUATION OF INSECTICIDES FOR MANAGING CUCUMBER BEETLES AND BACTERIAL WILT

Investigator: M. T. McGrath and D. Gilrein
Location: Long Island Horticultural Research and Extension Center

Most management practices for wilt target the insects that harbor and vector the pathogen, which are the striped and spotted cucumber beetles, because the bacterial pathogen cannot be controlled directly with pesticides. Prior to 2000, growers used foliar applications of insecticides such as Sevin and Asana. The insecticide Admire 2F (imidacloprid, Bayer Corp.) was registered for use on cucurbits beginning with the 2000 growing season. It is labeled for use at planting which enables product to be in leaf tissue when an early invasion of beetles occurs. One objective of this study was to compare Admire to a new, similar insecticide. Both were applied in furrow at planting. The second objective was to evaluate Surround (kaolin clay, Engelhard Co.), which is an organically-approved product applied to foliage that reportedly repeals cucumber beetles.

Two parallel experiments were conducted with wilt-susceptible 'Dasher II' cucumber and 'Merlin' pumpkin. Plots were direct seeded by hand on 21 and 22 June. Admire and the experimental material were both applied at 2 rates in the furrow, then the row was closed. The herbicides Command and Curbit were applied in a band over the row on 25 June, then the fields were lightly irrigated. Beginning on 3 July when plants had 1 true leaf, Surround (20 lb/A) was applied weekly or sooner if rain washed off the residue. Plants were examined weekly for cucumber beetles and symptoms of wilt.

Cucumber beetles were first observed on 10 July. Few were observed in this experiment compared to 2000. As expected, dead beetles were only found in plots receiving the soil-applied insecticides. More live beetles were observed in the nontreated and Surround-treated plots than the others. There were no detectable differences among the soil-applied insecticide treatments. Total counts of beetles found in all 4 plots of a treatment over 4 assessment dates (10 July – 6 Aug) in cucumber were 26 for nontreated, 15 for Surround, and 4 to 11 for the soil-applied insecticide treatments. The counts for pumpkin were 15, 12, and 5 to 8, respectively. Wilt was not observed until 6 Aug, and then only at a low level, only in cucumber, and only in 2 plots which were treated with Surround.

Evaluation of Fungicides for Powdery Mildew of Tomato

Investigator: N. Shishkoff and M. McGrath
Location: Long Island Horticultural Research and Extension Center

An experiment was conducted in a field of Haven loam soil. Fertilizer (666 lb/A of 15-15-15) was broadcast and incorporated on 11 May. Six-wk-old seedlings were transplanted at 24-in. plant spacing on 6 Jun into five 300-ft rows on raised beds with black plastic mulch. Plants were watered using drip irrigation as needed based on irrometer readings (29 Jun; 6 and 23 Jul; 1, 10, and 17 Aug; and 4 and 10 Sep). The outer and center rows were left unstaked as guard rows and the remaining 2 rows were staked. Staked rows were divided into 20 ft plots of 10 plants each for 20 plots total, in a blocked design with 5 treatments and 4 replications. Weeds between beds were controlled with Sencor 75DF (0.5 lb/A) applied on 7 Jun, Gramoxone (2 pt/A) applied with a shielded sprayer on 3 Jul, cultivation, and hand-

weeding. Insect pests were managed with Spintor (6 oz/A) applied on 31 Jul, 8 Aug, and 23 Aug and Spintor + Provado (3.75 oz/A) applied on 28 Sep. Bacterial speck was managed by applying Actigard 50WG (0.75 oz/A) on 31 Jul and 8, 14, 23, and 31 Aug. Average monthly high and low temperatures (F) were, 80/63 in June, 80/63 in Jul, 84/68 in Aug, and 75/59 in Sep. Rainfall (in.) was 6.08, 3.43, 4.86, and 2.98 for these months, respectively. Treatments were applied starting on 21 Aug. BAS 500 (0.75 lb/A or 1.0 lb/A) was applied to foliage weekly on 21 Aug, 29 Aug, 4 Sep, 11 Sep and 27 Sep using a CO2-pressurized backpack sprayer that delivered 50 gpa at 55 psi and was equipped with three TJ110-8003 nozzles per row with one nozzle over the row and one drop nozzle on each side. In other treatments, BAS 500 (0.75 lb/A) was alternated with Bravo Ultrex (2.75 lb/A) on a weekly basis, or in blocks of two. Severity of powdery mildew was recorded weekly from 13 Sep to 4 Oct as percent of green leaf tissue with symptoms. Leaflet death (% defoliation) was also recorded. Data were collected from two leaves of the middle 8 plants in each plot and averaged. Because disease development was so low, no fruit yields were recorded.

Powdery mildew developed naturally. Symptoms were first observed on 16 Aug in a spreader row and incidence on staked plants remained low through plant senescence. No significant defoliation was observed. All treatments were effective under this low disease pressure.

OZONE CONCENTRATIONS IN RIVERHEAD IN 2001

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

There were two periods that the ozone monitoring equipment was not working: 11–31 May and 10–12 Aug. Ozone concentration was quite high (99 ppb) at 4:00 pm on 10 Aug when this second period started. Therefore ozone was actually higher in 2001 than reported here. Ozone was $\geq$80 ppb for at least 67 hrs on 17 days in 2001: 2-4 May; 19, 28, and 30 June; 1, 9, 10, and 25 July; and 1, 2, and 6-10 Aug. Ozone was $\geq$80 ppb for 60, 124, 121, 184, and 77 hrs in 1996, 1997, 1998, 1999, and 2000, respectively. The first high ozone episode in 2001 was much earlier than previous years. This accounts for early reports of ozone injury in several ornamental crops. The highest concentration (122 ppb) was reached on 9 Aug, which was about 1 month later than previous years. Ozone was $\geq$100 ppb only during 7-9 Aug; it was at this level for 8 hours. It may have exceeded this level when the equipment was not working 10–12 Aug. Typically high concentrations occurred between 1200 and 2400, as in previous years.

ASSESSMENT OF OZONE CONCENTRATIONS IN RIVERHEAD USING A CLOVER BIOINDICATOR SYSTEM

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

An ozone-sensitive clone and an ozone-resistant clone of the commercial white clover line ‘Regal’ were used to estimate the concentrations of ambient ozone and its effects on plants. These clones were selected because they have similar growth rates in

the absence of ozone stress. This system is being used in other locations throughout the world. Cuttings were planted in 1-liter pots on 25 April and then either transplanted to 15-liter pots on 25 May or transplanted into the field on 7 June. Landscape cloth was used for weed control around the plants in the field. Clover was harvested every 4 weeks. Cutting was done at 7 cm above the soil surface. Both wet and dry weights of harvested forage (leaves, stems, and flowers) were measured.

The forage dry weight ratios (sensitive/resistant) were 0.82, 0.91, 0.74, and 0.81 for tissue harvested from clover growing in pots on 2 July, 30 July, 31 Aug, and 26 Sept, respectively. The highest ozone episode occurred during the third growth period when the weight ratio was the lowest and thus the sensitive clone's growth was reduced the most compared to the resistant clone (see previous report for more details). In contrast, the ratios were 1.09, 1.04, 1.15, and 1.08 for tissue harvested from field-grown clover on these dates, respectively. Plants did not grow as well in soil as in pots and there was much more variation among plants. The weights of harvested tissue for the two clones grown in the field did not differ significantly at any harvest. Thus the ratios were not significantly different from 1. In conclusion, field-grown clover is not suitable for the bioindicator system.

INVESTIGATION OF PESTICIDE IMPACTS ON OZONE RESPONSE FOR A SNAP BEAN BIOINDICATOR SYSTEM

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Research on ozone-sensitive and ozone-resistant snap bean lines was continued in 2001 with an additional objective, which was to determine if pesticides used for crop management affect plant response to ozone. These lines are being developed at the USDA-ARS Air Quality Research Unit in Raleigh, NC, to be used as bioindicators of ozone pollution. These lines yield similarly when ozone concentration is low. Information on pesticide effects is needed before using this system as a research tool to assess the impact of ambient ozone on plant productivity. In previous research these lines have demonstrated that ambient ozone on Long Island can have tremendous impact on yield.

A split plot design was used with pesticide treatment as the main plot and snap bean line as the subplot. Beans were seeded by hand on 21 June. Bean lines S156 and R123 were used. Then the insecticide Di-Syston 15 (0.34 grams/ft) was applied to the pesticide-treated plots in a furrow on each side of the row. The furrow was about 1-inch deep and about 2 inches from the seed. It was opened with a hoe, then closed after treatment. The herbicide Dual (1.3 pt/A) was sprayed over the plot shortly afterwards. Bean plants were emerged on 29 June. Di-Syston 15 was re-applied on 23 Aug. Plot coverage with weeds was rated on 9 July, then the plots were cultivated and weeded by hand. Beans were harvested when immature for fresh-market consumption from half of each plot on 16 and 23 Aug and 13 Sept. Mature bean pods were harvested for seed from the rest of the plants on 24 Sept. Plants were examined routinely for ozone injury. Injury and defoliation due mainly to ozone injury were rated.

Dual effectively controlled weeds. Only 1.4% of the ground was covered by weeds in treated plots versus 20% in nontreated plots. Most of the weeds present on 9 July were lambsquarters. Purslane, pigsweed, lady's finger, and barnyard grass were also present. Bean plants had 1 or 2 trifoliate leaves open. Leafhoppers were the only insects

observed in any plots. They can cause brown discoloration on leaves that resembles ozone injury.

Ozone injury was first observed on the sensitive line on 7 Aug. Ozone was at least 50 ppm for 87 hours during July and 187 hours during Aug, including 11 hours on 2 Aug when the concentration reached 92 ppb. Extensive injury was seen on 14 Aug, when bean pods were just reaching marketable size. This injury was most likely caused by the ozone episode beginning on 6 Aug, when ozone was at least 50 ppm for 66 hours (the episode was likely longer but the monitor wasn't working 10-12 Aug). All plants of the ozone-sensitive line exhibited injury when rated on 16 Aug versus 25% of the ozone-resistant plants. Average severity on affected plants was 41% and 10%, respectively, on 16 Aug and 79% and 36%, respectively, on 28 Aug. Defoliation due mostly to death of ozone-injured leaves was evident on 28 Aug, with an average of 67% of the canopy defoliated from ozone-sensitive plants versus 2% of ozone-resistant plants.

Yield of the sensitive line was affected by ozone. The resistant line produced a similar number of pods harvested for fresh-market consumption as the sensitive line but these pods were larger, weighing 38% more for the 3 harvests combined. Pod weight was not significantly different at the first harvest on 16 Aug, which is not surprising considering ozone injury was first seen just 9 days earlier. Mature bean yield was affected substantially by ozone. Resistant bean plants produced 49% more pods per plant by number and 72% more seeds harvested at maturity than sensitive beans. Average seed weight was 43% greater.

Pesticide treatment had a small impact on ozone injury and yield. Ozone injury was significantly more severe on 28 Aug overall in treated than nontreated plots, but this difference was small (59% vs. 56%) and thus not biologically important. Average number of pods and of seeds harvested per plant at maturity was greater for pesticide-treated plants. This difference was mainly in the resistant line and likely reflects yield reduction due to leafhoppers. Thus the impact of ozone was greater for treated plants. Pesticide-treated resistant beans produced 71% more pods per plant by number and 108% more seeds harvested at maturity than sensitive beans.

DEVELOPMENT AND OZONE SENSITIVITY OF BUTTERFLY BUSH VARIETIES GROWN UNDER NATURALLY HIGH OZONE ON LI

Investigator: M. T. McGrath and S. Clark
Location: Long Island Horticultural Research and Extension Center

Butterfly bush (*Buddleia*) was recently shown to be sensitive to ozone and to exhibit varietal differences in ozone sensitive through research using controlled exposures to ozone conducted in AL. The goal of this multi-year study is to examine development of 7 varieties on Long Island where ambient ozone is naturally high every summer. The varieties are Bonnie, Black Knight, Harlequin, Pink Delight, Potter's Purple, Royal Red, and Summer Beauty.

Plants are being grown in a pot-in-pot system and irrigated daily with spray stakes (Roberts Irrigation). Rooted cuttings were transplanted into 3-gallon pots on 20-21 July 2000. Pots were arranged in a randomized block design with 9 replications and 2 plants per replication. Plant height, length of inflorescences, ozone injury were determined, and number of inflorescences with dead flowers, open flowers, and unopened flowers.

Black Knight was the first variety to have open flowers, beginning the last week in June. Thirteen plants had flowers on 2 July. It had the fewest inflorescences with open flowers on 18 Sept. There were no significant differences among the varieties in number of inflorescences with open flowers accept for the 18 Sept count. However, Bonnie, Black Knight, Harlequin, and Pink Delight always had the fewest inflorescences with open flowers. There were significant differences in number of inflorescences with open or unopened flowers. Potter's Purple and Pink Delight had the longest inflorescences; Harlequin and Royal Red had the shortest. Potter's Purple, Royal Red, Bonnie and Black Knight were the tallest plants; Summer Beauty, Pink Delight, and Harlequin were the shortest. Potter's Purple and Pink Delight had the fewest number of leaves with brown spotting suspected of being ozone injury and the lowest severity of spotting on affected leaves; Black Knight, Harlequin, Royal Red, and Summer Beauty had the most spotting.

SUMMARY OF VEGETABLE DISEASE DIAGNOSES

Investigator: M. T. McGrath
Location: Long Island Horticultural Research and Extension Center

Forty-five samples were submitted to the laboratory for diagnosis. IPM scouts brought in 19 of the samples. Bacterial diseases were a greater problem on some vegetable crops than previous years on Long Island. Conditions were particularly favorable as many rain events were storms with heavy, wind-driven rain. After receiving samples of bacterial speck affecting tomato, fields were examined to determine the extent of the problem. Every tomato field examined had bacterial speck; many were severely affected. Samples with bacterial canker affecting tomato were also received. This disease was not as widespread as speck. Bacterial brown spot caused extensive losses in several snap bean fields due to spotting on pods as well as leaves. No samples of this disease have been submitted to the laboratory during the past 14 years. Leaf spotting diseases caused by bacteria also occurred on kohlrabi, radish, bokchoi, and melon. Additional diagnosed diseases and nonpathological problems include: Rhizoctonia damping-off affecting melon seedlings, anthracnose of spinach, tomato spotted wilt virus

(TSWV) affecting tomato, Phytophthora blight on pepper, watermelon, and pumpkin, Cercospora leaf spot on Asian cruciferous crops, and black root rot of strawberry.