

# Great Lakes Fruit, Vegetable & Farm Market EXPO

December 4-6, 2007

DeVo Place Convention Center, Grand Rapids, MI



## Pickling Cucumber

**Tuesday morning 9:00 am**

**Where:** Grand Gallery (lower level) Room A-B

**Recertification credits:** 1 (1B, PRIV CORE)

**CCA Credits:** PM(1.5) CM(0.5)

**Moderator:** Bernard Zandstra, Horticulture Dept., MSU

9:00 a.m. Cucumber Weed Control on the Delmarva Peninsula

- Mark Van Gessel, Plant Science Dept., Univ. of Delaware

9:30 a.m. Honey Bee Colony Collapse and Potential Replacement Pollinators for Cucumbers

- Julianna Tuell, Entomology Dept., MSU

10:00 a.m. Breeding for Resistance to Downy Mildew and Phytophthora Rots in Cucumber

- Rebecca Grumet, Horticulture Dept., MSU

10:30 a.m. The Downy Mildew Situation in Michigan

- Mary Hausbeck, Plant Pathology Dept., MSU

## Cucumber Weed Control on the Delmarva Peninsula

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Weed control in cucumbers is important in order to obtain maximum yield and reduce weed seeds from returning to the soil seed bank. On the Delmarva Peninsula, cucumbers for commercial processing are all direct-seeded, bare-ground production. A high seeding rate produces dense plantings which provide a competitive stand and reduce weed seed germination after the canopy closes. After planting, 90% of cucumber fields are cultivated. Seeding for pickling cucumbers begins between mid-April and early May in the mid-Atlantic, with successive plantings continuing through early August. The growing season of about 180 days allows double cropping of pickling cucumbers or multiple cropping of pickling cucumbers with other vegetables. About 20% of Maryland and Delaware pickling cucumbers are “double-cropped”. All pickling cucumbers on the Delmarva are machine harvested which requires good to excellent weed control for optimum harvesting.

Primary weeds in cucumbers include annual grasses, common ragweed, pigweed species, lambsquarters, jimsonweed, morningglory species, common purslane, and common cocklebur. Secondary pests are yellow nutsedge, johnsongrass, bermudagrass, eastern black nightshade, and velvetleaf. Most species are adequately controlled with labeled herbicides except for eastern black nightshade and morningglory species.

Limited acreage of hand-picked cucumbers is grown for direct-marketing through road-side stands. Some of these cucumbers maybe grown with plasticulture, some are grown with trellises, but many are grown as a directed-seeded crop.

### **Labeled Herbicides for Pickling cucumbers:**

Soil-applied herbicides: Alanap (naptalam) must be applied pre-plant incorporated (PPI) or preemergence (PRE). Alanap will control a limited number of grass and broadleaf weeds. Weed control is reduced on sandy soils with less than 1% organic matter. Alanap provides good to fair control of pigweed and common purslane. Alanap is used on less than 5% of the acreage.

Prefar (bensulide) can be applied pre-plant incorporated or preemergence. Prefar will control some annual grasses (barnyardgrass, large crabgrass, fall panicum, giant foxtail, and johnsongrass seedlings) but only suppression of certain broadleaves, such as common lambsquarters, common purslane, and pigweed species. Risk of crop injury is less with Prefar than with Curbit. Prefar is used on less than 5% of the acreage.

Sandea (halosulfuron) can be applied preemergence. Sandea provides fair to good control of common ragweed, common lambsquarters, pigweed, cocklebur, jimsonweed, smartweed, galinsoga, and yellow nutsedge. Yellow nutsedge control is better when applied as a

postemergence herbicide. Sandea does not control grass species. It is used on 50-75% of the acreage.

Curbit (ethalfluralin) can be applied preemergence only. Curbit controls a number of annual grasses but only a few broadleaf weeds (pigweed and carpetweed). Curbit is often applied in combination with another herbicide (Command and/or Sandea). Curbit provides better weed control than Prefar, yet it has a slightly higher risk of crop injury. Curbit is seldom used with early planted pickling cucumbers due to this reason. Lower rates reduce the risk of crop injury; higher rates cause damage on sandy soils, especially in cold weather. Used on 90-100% acreage.

Command (clomazone) can only be used as a preemergence application. (Previously there was crop injury concern with another formulation of Command). Used predominately for annual grass, velvetleaf, jimsonweed, purslane, and common lambsquarters control. Command alone or as Strategy is used on 90-100% of the acreage. Strategy is a pre-packaged mixture of clomazone and ethalfluralin.

Postemergence herbicides: Alanap (naptalam) will control a limited number of broadleaf weeds. Alanap provides good to fair control of pigweed and common purslane. Avoid use early in the season due to increase risk of crop injury. Used on 5% acreage.

Sandea (halosulfuron) provides good to excellent control of common ragweed, pigweed, cocklebur, smartweed, galinsoga, and yellow nutsedge. Yellow nutsedge control is better when applied as a postemergence herbicides. Common lambsquarters and jimsonweed control is much better when Sandea is applied preemergence. Sandea does not control grass species. Carry over can be an issue. Sandea is used on 50% of the acreage.

Poast (sethoxydim) - 1 to 1.5 pints/A - Used exclusively for grass control. Poast will control annual grasses and certain perennial grasses. Use with crop oil concentrate. Grass control will be best when the plants are treated while actively growing. Poast is used on 25% of the acreage.

Select or Select Max (clethodim) - 6 to 8 oz/A or 12 to 16 oz/A - Used exclusively for grass control. Will control annual grasses and certain perennial grasses, although not as effective on goosegrass as Poast. Select requires crop oil concentrate, while Select Max is labeled for use with non-ionic surfactant. Grass control will be best when the plants are treated while actively growing. Used on 10% acreage.

**Methods of application for cucumber herbicides:**

Herbicide	Under plastic	Soil between rows of plastic	Broadcast for bareground production	POST for row middles**	Broadcast POST treatments
Alanap			XXX	XXX	XXX
Command		XXX	XXX		
Curbit		XXX	XXX		
Prefar	XXX	XXX	XXX		
Sandea		XXX	XXX	XXX	XXX
Strategy		XXX	XXX		
Poast				XXX	XXX
Select				XXX	XXX

\*\*Used in combination with Gramoxone Inteon with shielded sprayers for control of emerged weeds.

For cucumbers grown under plastic-culture, Gramaxone Inteon (paraquat) is used with shielded sprayers to control emerged weeds. A residual herbicide is included with paraquat.

Recently, the manufacturer of Alanap, Chemtura, has voluntarily cancelled the EPA registration for Alanap herbicide on cucurbits. There is no time limitation regarding when a distributor may sell Alanap or when a grower may use the product. There is a 2.5-year supply of Alanap in inventory and this product will move to distribution channels within the next few months. The product should hold up well in storage for 3 or more years if properly stored.

**Herbicide-resistant weeds:**

Group 2-resistant pigweeds and common ragweed have been identified in DE. These plants have been selected for by repeated Pursuit or Sandea applications in vegetables. The resistant biotypes can not be effectively controlled in cucumbers.

# Honey Bee Colony Collapse and Potential Replacement Pollinators for Cucumbers

Julianna Tuell, Department of Entomology, Michigan State University

It has been long known that cucumbers require pollination by bees to set commercially viable fruit (Delaplane and Mayer 2000). Flowers are most receptive to pollination in early morning. Multiple visits result in larger and better developed fruit (Collison 1976).

Honey bees are the most important pollinator of cucumbers and colonies added to cucumber plots can produce a 3-fold increase in yield over plots with no honey bees added (Gingras et al. 1999). However, cucumber flowers are not the most attractive forage for honey bees because of honey bee nutritional needs and because of low flower density per plant, particularly when other more attractive forage is in bloom nearby (Delaplane and Mayer 2000). The recommended density for honey bee colonies on average is 2.2 colonies per acre or 1 colony per 50,000 plants (Delaplane and Mayer 2000).

Recently honey bee colonies in more than half of the United States and in other parts of the world have been affected by colony collapse disorder (CCD), in which hives are found to be empty of workers, but full of larvae and honey. A number of different causes have been suggested, and there is a virus that has been found in association with bees from hives exhibiting CCD symptoms (Cox-Foster et al. 2007). The best explanation for CCD is a combination of factors, including poor nutrition, and stress from colonies being transported from one monoculture crop to another resulting in a suppressed immune system. The price of hives rented for crop pollination has increased in some areas, especially in California almond production, and there is potential for further increases in rental costs if CCD continues to be a problem.

Fortunately, honey bees are not alone in their ability to pollinate cucumbers. There are other bee species that may serve as alternative or supplementary managed pollinators if honey bee colonies become less available. Bumble bees have been shown to be effective pollinators in field cucumber in North Carolina (Stanghellini et al. 1997) and may be particularly suited to this crop because they start foraging earlier in the morning than honey bees (Heinrich 2000). Another potential alternative is the alfalfa leafcutter bee, which has been used for pollination of cucumbers in cages, but their success for use in field studies has yet to be determined.

## References

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# Breeding for Resistance to Downy Mildew and Phytophthora Rots in Cucumber

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The past several years have been marked by a dramatic increase in occurrence of oomycete diseases on cucumber due to infection by *Pseudoperonospora cubensis* (causal agent of downy mildew) and *Phytophthora capsici*. The significant losses to cucumber production require development of control strategies for these diseases. Resistant varieties are highly desirable to reduce yield losses, fungicide costs, and production inputs. This report will provide an update on efforts to identify genetic sources of resistance to downy mildew and *P. capsici* in cucumber.

## Downy mildew:

Although virtually unknown as a cucumber disease for decades, downy mildew was a problem for cucumber production in the early part of the 1900's (Colucci et al., 2006). In the 1940's it was considered the most important cucumber disease. In the 1950's and 1960's downy mildew resistant cucumber varieties were developed leading to control in the U.S. for approximately 50 years.

The first source of resistance used in breeding efforts led to the moderately resistant cucumber cultivar, Palmetto, which was released in 1948 (Colucci et al., 2006). Later, a more highly resistant cultivar, Poinsette, was developed and released in 1966. The resistance used in Poinsette became the source of resistance bred into the majority of our current commercial cucumber cultivars. The resistance in Poinsette was characterized as due to a single recessive gene, *dm*, although there have been other contradictory studies suggesting the effect of two additional genes (Colucci et al., 2006).

Despite the success in controlling downy mildew on cucumber in the U.S., it remained a serious problem for cucumber production in Europe and Asia (Shetty et al., 2002). The persistence of downy mildew problems in other parts of the world suggested the existence of different pathogen races that could overcome the sources of resistance available in the American cultivars. Testing of germplasm at locations in Poland, India, and North Carolina showed differences among locations, with India the most different from the other two (Shetty et al., 2002). The best US lines showed intermediate or susceptible responses in India, and vice versa.

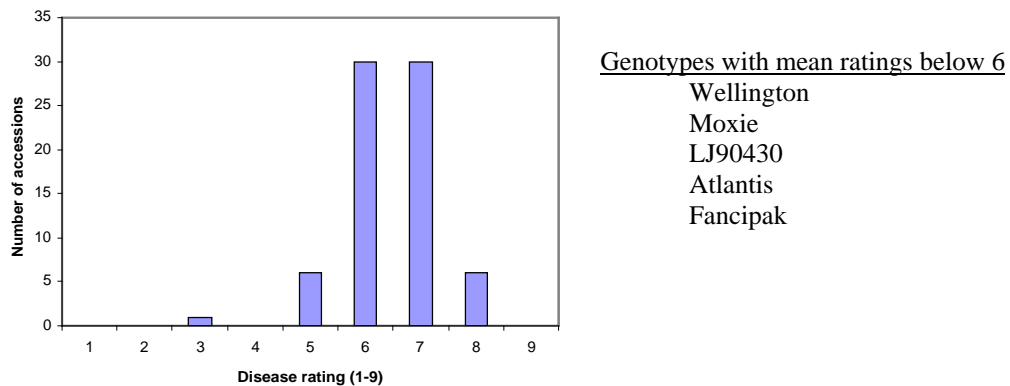
In 2004, downy mildew reappeared as a serious problem for cucumbers in the US with devastating losses throughout the eastern states, especially North Carolina and Florida (Colucci et al., 2006). This has led to renewed efforts to identify and breed useful sources of resistance. Dr. Todd Wehner (North Carolina State University) initiated an intensive screening program of available cucumber germplasm to identify new sources of resistance. The major seed companies are also seeking to develop downy mildew resistant cultivars.

The trials performed by Dr. Wehner have not identified a source of resistance that is able to provide full protection. Dr. Wehner is now seeking to determine if there are other sources of resistance that may be combined with the *dm* gene to increase overall resistance to this disease. The existence of cultivars with

resistance to downy mildew in India but not North Carolina and vice-versa, may allow for pyramiding of resistance genes that together will increase overall resistance.

This summer we performed a germplasm trial in conjunction with the Wehner program to serve as a second test location for the materials being evaluated in North Carolina. Our trial at the MSU Muck Farm was performed in accordance with the procedures developed for the North Carolina trials. In testing for possible resistance, it is critical to ensure conditions for complete infection, so that the absence of infection is due to resistance and not lack of contact with the pathogen or appropriate environmental conditions to establish infection. To achieve a uniform high level of disease pressure, the plots were planted in two phases. In the first phase, the field is surrounded and intersected by rows of highly susceptible plants to serve as spreader for the disease. These plants were inoculated using downy mildew-infected cucumber tissue collected from a farm in Arenac County and brought back to the MSU trials. The diseased material was placed on top of plants throughout the spreader rows and the were plants subjected to daily overhead irrigation for one week to increase humidity and facilitate disease development and spread. While the disease was incubating on the spreader rows, seeds of the test genotypes were planted so they would be exposed to the disease as young seedlings.

Infection rate on the test genotypes was essentially 100% and very severe, indicating success in uniform disease pressure. The test genotypes were rated for disease response based on symptom severity on fully expanded leaves using the 1-9 scale established by Jenkins and Wehner (1983). Ratings of 1-3 are considered resistant, 4-6 intermediate, and 7-9 susceptible. Cotyledons of the test genotypes exhibited severe symptoms and eventual necrosis. As the plants grew, the disease became less severe and newer leaves showed reduced symptom development. Thus the mean disease ratings for total experiment the decreased with time over a two week observation period from 8.9 (complete strong infection on cotyledons) to 7.3 to 6.9. At the third rating (Sep. 14), there were a few lines that had intermediate, rather than severe, ratings (Fig. 1).



**Figure 1.** Distribution of mean downy mildew disease ratings for accessions in field screening trial as rated on 9/14/07.

Although none of the lines showed strong resistance under these very severe pressure conditions, it is possible, that as the plants continued to grow, we would observe more differentiation and better resistance ratings. Unfortunately, an untimely, early frost at the muck farm killed the field preventing further observations.

Comparisons of ratings between North Carolina and Michigan did not show a significant correlation between the different locations ( $r=0.146$ ,  $P=0.014$ ;  $r=0.119$ ,  $P=0.045$  for average NC rating and maximum NC rating vs. MI rating, respectively). At this time it is not known whether the lack of correlation is due to different pathogen races prevalent in the two locations, or differences in environmental or experimental conditions. There was a small number of cultivars that was in the best performing group in both locations (with ratings for NC average < 4.0 or NC maximum <6.0, and MI average < 6.5) (Table 1).

**Table 1.** Cultivars that exhibited low downy mildew disease ratings in both North Carolina and Michigan trials, 2007.

Cultivar	Seed source	Average rating, NC <sup>a</sup>	Maximum rating NC <sup>a</sup>	Average rating MI
LJ90430	USDA, LaJolla	2.6	5.3	5.6
Picklet	Seminis	3.4	5.5	6.0
NC Davie	Zeramin Gedera	3.6	6.0	6.3
Navigator	Seminis	4.2	5.8	6.4
Fancipak	Seminis	4.2	6.0	5.9
Excel	Seminis	4.3	5.8	6.4
Vlaspik	Seminis	4.6	6.0	6.1

<sup>a</sup> North Carolina data are from Dr. Todd Wehner, Department of Horticulture, North Carolina State University.

Despite the lack of sufficient resistance to prevent infection, the presence of a base level of resistance can facilitate disease control with fungicides. It has been recommended to use a combination of *dm* cultivars with chemical treatments to reduce losses while efforts continue to breed for resistance (Colluci et al., 2006).

### **Phytophthora**

Fruit rot caused by *Phytophthora capsici* also causes serious losses in cucumber production in Michigan and the midwest (Hausbeck and Lamour 2004). Although the preferred method of control would be genetic resistance, screening of ca. 480 *Cucumis sativus* accessions did not identify a significant source of resistance that is superior to commercial cultivars such as Vlaspik (Gevens et al., 2006).

Observation of cucumber fruit response to infection, however, indicates that cucumber fruit become resistant to *P. capsici* as they develop (Fig. 2). Young fruit undergo a distinct transition from susceptibility to resistance at 10-12 days post pollination (dpp) which coincides with the end of the period of rapid fruit elongation. The loss of susceptibility also occurs as a developmental gradient along the length of the fruit. The blossom end, which continues to grow for 2-3 days longer than the stem end, remains susceptible longer than the stem end, and is typically the primary site of infection in the field. The developmental resistance was observed in both the greenhouse and field, for several cucumber cultivars, and for several other cucurbit crops (Ando and Grumet, 2007). Experiments with peel sections show that the resistance can be localized to the upper 1-2 mm of the fruit surface (Ando and Grumet, 2006), and tests of parthenocarpic fruits indicate that the resistance does not require with seed development.

These observations provide an excellent starting point to examine possible disease resistance factors by narrowing genes of interest to those that are differentially expressed in cucumber fruit, in the surface region, at the end of the period of rapid elongation. We are currently undertaking a genomics approach to examine gene expression from whole fruit, fruit peel, and mesocarp tissue throughout fruit development.

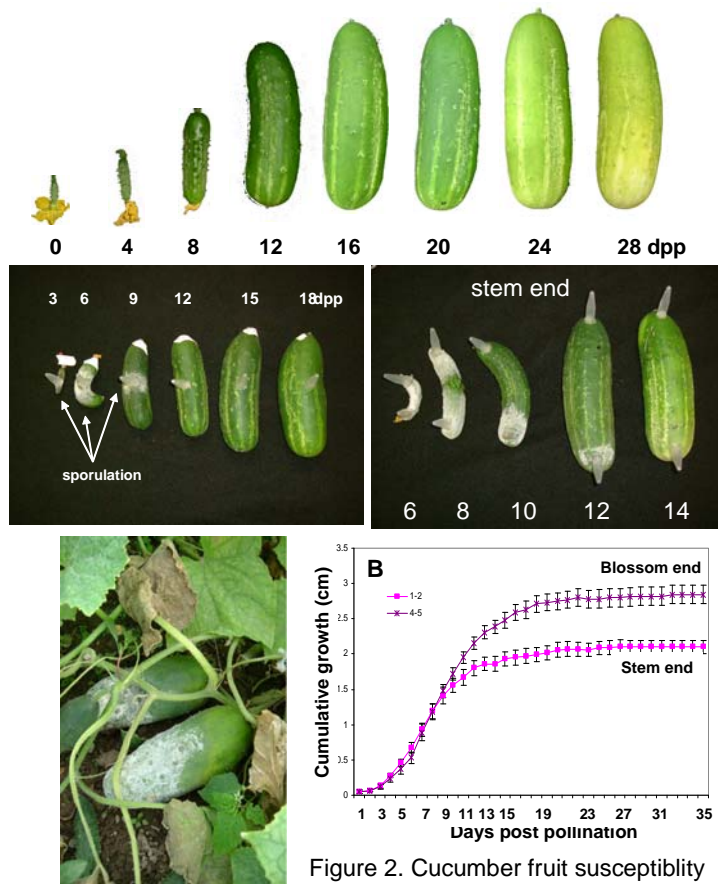


Figure 2. Cucumber fruit susceptibility to *P. capsici* varies with fruit age and position.

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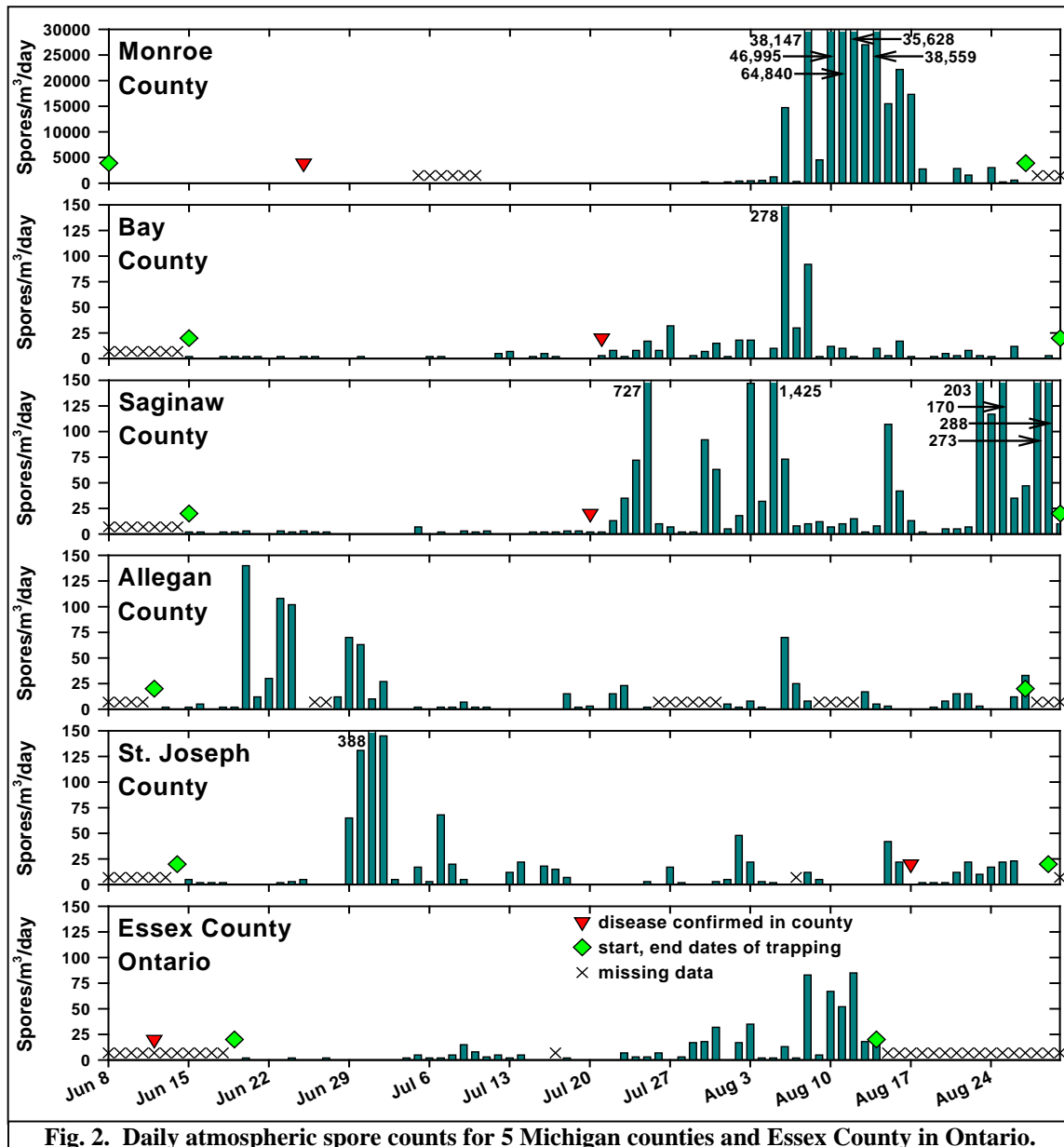
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## Downy Mildew Spore Trapping 2007

The downy mildew reproduces via tiny, microscopic spores that act as seeds of the pathogen. Spore traps were placed in five Michigan counties spread across the state and Essex County in Ontario (Fig. 1). A compound microscope is needed to have enough magnification to identify any downy mildew spores that may be present on the tapes. The spore traps helped to alert us to any influx of spores into those production regions, but were not used to time fungicide sprays. Since we did not have a trap in each field, it is possible that we could miss an isolated spore mass coming into a particular region (Fig. 2).



## Fungicide Trials

Chemical control must be focused on using the most effective products, alternating the products, and applying fungicides at short intervals. Results from our downy mildew research in past research trials indicate that an effective spray program includes the following: Previcur Flex (propamocarb

hypochloride) plus Bravo (chlorothalonil) alternated with Tanos 50DF (cymoxanil + famoxadone) plus mancozeb. Presidio is a new product that will be registered soon and is highly effective against downy mildew. All fungicides, including Presidio, should be used in a tank mix with another fungicide effective against downy mildew.

**Table 1. Results of downy mildew field trial.**

Treatment and rate/A, <i>applied at 5-7 day intervals, unless otherwise specified</i>	Infection (%)*	
	5 Sep	
Untreated.....	98.8	f
Previcur Flex 6SC 1.2 pt + Bravo Weather Stik 6SC 2 pt <i>alternate</i> Tanos 50WG 8 oz + Manzate 75DF 3 lb.....	11.3	a
Bravo Weather Stik 6SC 3 pt.....	46.3	b-e
Equus 720 SST 6SC 3 pt.....	28.8	a-d
Equus 82.5WDG 2.73 lb.....	53.8	c-e
Previcur Flex 6SC 1.2 pt + Bravo Weather Stik 6SC 2 pt, <i>app 1,4,7</i> Ranman 3.6SC 2.7 fl oz + Manzate 75DF 3 lb, <i>app 2-3,5-6,8-9</i> .....	13.8	a
Revus 2.09SC 8 fl oz + Dithane Rainshield 4SC 4 pt + NIS 8.33EC 8 fl oz <i>alternate</i> Quadris Opti 5.5SC 3.2 pt.....	27.5	a-d
Revus 2.09SC 8 fl oz + Dithane Rainshield 4SC 4 pt + NIS 8.33EC 8 fl oz <i>alternate</i> Previcur Flex 6SC 1.2 pt + Dithane Rainshield 4SC 4 pt.....	26.3	a-c
Revus Opti 3.67SC 3 pt + NIS 8.33EC 8 fl oz <i>alternate</i> Previcur Flex 6SC 1.2 pt + Dithane Rainshield 4SC 4 pt.....	33.8	a-d
Ridomil Gold Bravo 3.67SC 2.5 pt, <i>app 1</i> , Revus 2.09SC 8 fl oz + NIS 8.33EC 8 fl oz, <i>app 2,4,6</i> , Quadris Opti 5.5SC 3.2 pt, <i>app 3,5,7</i> .....	57.5	de
Curzate 60DF 3.2 oz + Manzate 75DF 3 lb.....	31.3	a-d
Curzate 60DF 5 oz + Manzate 75DF 3 lb.....	31.3	a-d
Tanos 50DF 8 oz + Manzate 75DF 3 lb <i>alternate</i> Curzate 60DF 3.2 oz + Manzate 75DF 3 lb.....	33.8	a-d
Tanos 50DF 8 oz + Manzate 75DF 3 lb <i>alternate</i> Curzate 60DF 5 oz + Manzate 75DF 3 lb.....	22.5	ab
Manzate 75DF 3 lb.....	72.5	ef
Ridomil Gold MZ 76WP 2.5 lb.....	75.0	ef
Presidio 4FL 2.9 fl oz + Manzate 75DF 3 lb.....	16.3	ab

\*Based on a visual estimation of percentage of plant affected.

\*\* Column means with a letter in common are not significantly different (Fisher LSD Method;  $P=0.05$ ).

**Table 2. Recommended products for managing downy mildew on pickle.**

<b>APPLIED BEFORE DISEASE (7-day intervals)</b>	<b>APPLIED AFTER DISEASE (5-day intervals)</b>
<ul style="list-style-type: none"><li>• Gavel 75WG (5 day PHI)</li><li>• Previcur Flex 6SC (2 day PHI)</li><li>• Ranman 3.6SC (0 day PHI)</li><li>• Tanos 50WG (3 day PHI)</li></ul>	<ul style="list-style-type: none"><li>• Previcur Flex 6SC (2 day PHI)</li><li>• Ranman 3.6SC (0 day PHI)</li><li>• Tanos 50WG (3 day PHI)</li></ul>
Alternate products and mix each with either: <ul style="list-style-type: none"><li>• Dithane (mancozeb) 3 lb or</li><li>• Bravo (chlorothalonil) 1.5 pt</li></ul>	Alternate products and mix each with either: <ul style="list-style-type: none"><li>• Dithane (mancozeb) 3 lb or</li><li>• Bravo (chlorothalonil) 2 pt</li></ul>

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