Celery

**Where:** Gallery Overlook (upper level) Room D  
**Recertification credits:** 2 (1B, PRIV OR COMM CORE)  
**CCA Credits:** PM(2.0)  
**Moderator:** Bill Steenwyk, District Vegetable Educator, MSU Extension

2:00 p.m.  
Apply Pesticides on Target - Improving Sprayer Performance  
- Andrew Landers, Pesticide Application Technology Specialist, Cornell University

2:40 p.m.  
Recognizing a New Look for Aster Yellows in Celery  
- Bill Steenwyk, District Vegetable Educator, MSU Extension

2:45 p.m.  
Celery Disease Control Research Update  
- Brian Cortright, Plant Pathology Dept., MSU  
- Mary Hausbeck, Plant Pathology Dept., MSU

3:10 p.m.  
What Have We Learned About Black Streak?  
- Mathieu Ngouajio, Horticulture Dept., MSU

3:35 p.m.  
Insect Control Update  
- Zsofia Szendrei, Entomology Dept., MSU
Vegetable growers can improve their sprayers using many modern techniques but undoubtedly nozzle selection is one of the important factors which must be taken into consideration. For the Great Lakes Expo vegetable education program, 2010 I have written two abstracts:

IMPROVING SPRAY APPLICATION: FINE TUNING THE SPRAYER for the carrot session and

CONTROL OF ONION INSECTS AND DISEASES –SELECTING THE CORRECT NOZZLE FOR THE TARGET for the onion session. I would commend these abstracts to you on nozzle selection.

Further information on sprayers in general and nozzles in particular maybe found on the internet at:-

http://www.c-spray.com

This web page contains product information on agricultural and industrial nozzles. Albuz offer a variety of nozzles and whirl plates for application systems. There are also a number of educational fact sheets about Albuz nozzles located on the webpage: www.hyropumps.com. Also on the web page they offer technical training and information about the use of each nozzle.

http://www.delavanagspray.com/Index.htm

This web page contains product information on nozzles, nozzle accessories, sprayer accessories, high pressure guns/nozzles, pumps and high pressure washers. They offer educational material on calibration of nozzles and sprayers. They also have a nozzle type selection guide that is very useful to help select the right nozzle for your specific application. There are conversion factors for broadcast nozzle spacing and metric and imperial gallon conversion.


This web page contains product information on sprayers for all crops, nozzles, pumps and electronic controllers. They feature new products in the marketplace and educational materials which provide knowledge on servicing your sprayer. Also there is an online nozzle selection guide that is very useful in selecting the correct nozzle for your specific application.
This web page contains product information on Ag pumps, boom and sprayer components, nozzle bodies, pressure washer pumps, and spray tips. They also list educational guides that help you select the correct nozzle for your specific application. They are the distributor for Albuz nozzles in US.

This web page contains product information on nozzles and sprayer components. They offer many educational resources including a conversion program for sprayers and other aids to assist you in nozzle selection and sprayer use. They have catalogs you can download about their nozzles and other sprayer components such as nozzle bodies. They have a section that features all their new products, you can also shop online for spray nozzles and parts.

This web page contains product information on all different types of nozzles, spray guns, valves, manifolds, boom components, electronic controls and guidance systems. They provide educational support with the use of a spray calibration calculator. They also have a nozzle selection guide you can download to help you in making a decision on which nozzle is good for your application.

This web page contains product information on nozzles for turf, vegetables and other crops. The featured products are the turbodrop, spraymax and airmix nozzles. There is a nozzle guide to assist you in locating a nozzle for your application. There are educational materials such as droplet size data, independent test data and news articles you can look through.

This web page contains product information on various sprayer parts and nozzles. Some of their featured products include tips, caps, strainers, nozzle bodies and flow indicators. Their web page also has a nozzle selection calculator called tip wizard which helps you locate the correct nozzle for your application. Tipnology is another link on the web page which explains everything about each nozzle.

This webpage contains information on various types of sprayers (air-blast, boom and knapsack etc). There are links to most of the manufacturers of orchard, vineyard, turf and vegetable spraying equipment. The website contains useful information on sprayer calibration, nozzles, sprayer manufacturers and agricultural links for that particular crop. In each one of the specific crop spraying sections also there are extension publications and research publications covering research projects conducted on sprayers in the northeast.
Celery Disease Control Research Update

Dr. M.K. Hausbeck (517-355-4534), B.D. Cortright, and L. Rodriguez
Michigan State University, Department of Plant Pathology, East Lansing, MI

Foliar Diseases

Foliar diseases of celery may reduce quality and yield if not properly managed. The fungal foliar blights known as early blight (Cercospora api) and late blight (Septoria apiicola) cause major problems and occur every season. Yield losses occur as a result of defoliation and stunting of the plants and petiole blighting. Both pathogens can be seedborne, making disease-free seed from resistant cultivars important as a first step in control. Symptoms of Cercospora early blight include yellow to tan spots, circular-shaped lesions on the upper and lower surface of leaves and elongate lesions on petioles. Septoria late blight is the most common disease of celery in Michigan, and spreads quickly. Symptoms of Septoria late blight include yellow to brown, irregularly shaped lesions on the leaves and petioles. Embedded in these lesions are small, black pycnidia, which are the reproductive structures of the fungus. Bacterial leaf spot of celery is caused by Pseudomonas syringae pv. api. The disease was previously known as northern bacterial blight. The lesions only appear on leaves and are initially water-soaked around the margin. Lesions of bacterial leaf spot may resemble those of late blight but can easily be distinguished by the presence or absence of pycnidia.

Table 1. Fungicides used in field trial to manage Alternaria and Cercospora.

<table>
<thead>
<tr>
<th>Product</th>
<th>Active ingredient</th>
<th>Labeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bravo WeatherStik 6 SC</td>
<td>chlorothalonil</td>
<td>yes</td>
</tr>
<tr>
<td>Fontelis 1.7SC</td>
<td>penthiopyrad</td>
<td>no</td>
</tr>
<tr>
<td>Kocide 3000 46.1WDG</td>
<td>copper hydroxide</td>
<td>yes</td>
</tr>
<tr>
<td>Q8Y78 2.08SC</td>
<td>--</td>
<td>no</td>
</tr>
<tr>
<td>Quadris 2.08SC</td>
<td>azoxystrobin</td>
<td>yes</td>
</tr>
<tr>
<td>Tanos 50DF</td>
<td>famoxadone + cymoxanil</td>
<td>no</td>
</tr>
<tr>
<td>YT669 2.08SC</td>
<td>--</td>
<td>no</td>
</tr>
</tbody>
</table>

The 2010 celery field trial included new, unregistered fungicides for the control of Septoria and Cercospora foliar blights in comparison to the industry standards that included Bravo WeatherStik 6SC, Kocide 3000 46.1WDG, and Quadris 2.08SC. All products tested were effective in keeping foliar Septoria nearly 100% controlled (see graph, next page). Cercospora foliar blight tends to be more difficult to manage than Septoria. The new, unregistered products showed a good level of disease control in the Cercospora rating and compared favorably with Bravo WeatherStik and Kocide. Tanos will no longer have a label for celery.
New Celery Problem.

Celery growers noticed extensive leaf curling and distortion of the petioles in some celery varieties. Although the symptoms were similar to Aster Yellows, many plants retained their green coloration. Since viruses can cause unusual plant growth, an extensive viral screen was conducted and included the following viruses: i) alfalfa mosaic virus, ii) arabis mosaic virus, iii) cherry leafroll virus, iv) cucumber mosaic virus, v) peanut stunt virus, vi) strawberry latent ringspot, vii) tobacco ringspot virus, viii) tomato ringspot virus, and ix) potyvirus group test. All celery samples tested negative for viruses. After further field sampling later in the season, cracks along the petioles were found to have a fungal pathogen not normally found on celery in Michigan. This pathogen has been partially identified as *Colletotrichum* sp. Additional sampling was conducted in several celery fields to determine how widespread the problem was and whether additional disease symptoms could be found. In general,
*Colletotrichum* symptoms were limited to the petioles (Fig. 1). Lesions or blighting of the foliage were not found. Studies are ongoing to learn more about this pathogen on celery and to determine the best control strategies. This fungal pest on other crops is controlled with fungicides that include chlorothalonil and azoxystrobin. The fungicide Cabrio EG (pyraclostrobin) has *Colletotrichum* listed for control on the label. Cabrio is also effective on Cercospora and Septoria and should be rotated with a chlorothalonil product.

![Fig. 1. *Colletotrichum* lesions on celery.](image)

This research was supported by Celery Research, Inc.
Effect of Temperature and Boron on Celery Black Streak Disorder

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A440-D Plant and Soil Sciences Building, East Lansing, Michigan, USA 48824

For the last couple of years, Black streak has caused significant losses to the celery industry. The incidence of the problem has generally been extremely high following hot weather, suggesting that high temperatures may be implicated in the occurrence of the disorder. Preliminary studies conducted in the greenhouse suggest that the effect of temperature is likely indirect. It is suspected that high temperatures may trigger other processes within the plant system. Symptoms of black streak in celery look very similar to symptoms of boron deficiency in sugar beet. However, these symptoms are not similar to stem cracking generally observed on celery subjected to severe boron deficiency. However, it is possible that temperatures may enhance plant growth and disorder due to nutrients insufficiency. There is limited (if not no) published information on the occurrence of black streak in celery, its causal factor, and control methods. Therefore, studies were conducted in summer 2010 to test the combined effect of high temperature and boron on celery black streak disorder.

Methodology

Field studies were established at the MSU Muck Research Farm in 2010. Celery cultivar Dutchess, the most susceptible cultivar was used. Simultaneously, greenhouse studies were also conducted.

Celery ‘Dutchess’ was transplanted on 42-inch raised beds with 5.5 feet centers, on 27 May 2010. Double rows (1 foot apart) of celery were transplanted per bed; plant spacing inside individual celery rows was 7 inches.

The experiment was a factorial in a split plot design. Boron was the main plot effect with two levels (boron and no boron). Row cover was the subplot factor with five levels (no row cover, and row cover installed at 5, 6, 7, and 8 weeks after transplanting).

Boron was applied at 4 quarts per acre, with three split applications on June 28, July 16, July 23 with 50%, 25% and 25% of the full rate, respectively. Row covers were used to elevate temperatures, and were installed at 4 separate dates (July 2, July 9, July 16, July 23) to target different growth stages. The dates corresponded to 5, 6, 7, and 8 weeks after transplanting (WAT). A perforated clear polyethylene plastic mulch was installed over the double celery rows using hoops and the edges were buried. Temperature and humidity sensors (Watch Dog Data Loggers) were placed within each treatment to monitor climatic conditions.

Ratings consisted of plant heights after row cover applications, plant sampling after boron applications, yields (August 20). At harvest, 14 plants were sampled and total weight before and after trimming recorded. Celery stacks were then cut progressively from the top to the base (about 1 to 1.5 inches each cut) to assess the presence of back streak (BS). The number of plants and the number of petioles with Black Streak symptoms was recorded. The proportion of plants with the symptoms was then calculated as well as the ratio of affected petioles by the total or affected plants.
Results

Effect of boron:

Celery yield was not affected by boron application (Table 1). However, boron application appeared to increase the incidence of black streak on both the number of plants and the number of petioles affected (Table 1 and 2).

Effect of row cover:

All row cover treatments depressed celery yield, regardless of the timing of row cover installation. The control treatment (no row cover application) produced the highest yield. The application of a row cover at week three (July 16), or the eighth week of celery growth, yielded the least biomass.

Row cover installed 7 WAT (Weeks after celery transplanting) exhibited the highest incidence of Black Streak on both the total number of plants and the number of petioles affected. Further, the control without row cover had the lowest incidence of the disorder. Temperature readings during row cover treatments varied, however, the treatment with the greatest black streaking, had the lowest temperature readings suggesting that celery growth stage is as important as temperature.

Table 1. Effects of Born and Row Cover on Celery Yield and the incidence of Black streak*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Celery yield</th>
<th>Black streak incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Untrimmed Wt (kg)</td>
<td>Trimmed Wt (kg)</td>
</tr>
<tr>
<td>Boron (Br)</td>
<td>15.16</td>
<td>11.44</td>
</tr>
<tr>
<td>No Boron</td>
<td>14.90</td>
<td>11.38</td>
</tr>
<tr>
<td>Control</td>
<td>17.19 a</td>
<td>13.40 a</td>
</tr>
<tr>
<td>5 WAT</td>
<td>13.91 b</td>
<td>10.73 b</td>
</tr>
<tr>
<td>6 WAT</td>
<td>15.01 b</td>
<td>11.34 b</td>
</tr>
<tr>
<td>7 WAT</td>
<td>14.13 b</td>
<td>10.56 b</td>
</tr>
<tr>
<td>8 WAT</td>
<td>14.92 b</td>
<td>11.03 b</td>
</tr>
</tbody>
</table>

* BS = Black Streak, WAT = Weeks after celery transplanting

Table 2. Effects of Born and Row Cover on the incidence of Black streak in celery

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Black streak incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Plants affected (%)</td>
</tr>
<tr>
<td>Boron (Br)</td>
<td>76.79 a</td>
</tr>
<tr>
<td>No Boron</td>
<td>58.93b</td>
</tr>
<tr>
<td>Control</td>
<td>52.68 c</td>
</tr>
<tr>
<td>5 WAT</td>
<td>60.71 c</td>
</tr>
<tr>
<td>6 WAT</td>
<td>75.00 ab</td>
</tr>
<tr>
<td>7 WAT</td>
<td>86.61 a</td>
</tr>
<tr>
<td>8 WAT</td>
<td>64.29 bc</td>
</tr>
</tbody>
</table>

* BS = Black Streak, WAT = Weeks after celery transplanting
Table 3. Temperature reading within row cover treatments

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Temp (Min)</th>
<th>Temp (Max)</th>
<th>Temp (Mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>51.1</td>
<td>90.7</td>
<td>69.4</td>
</tr>
<tr>
<td>5 WAT</td>
<td>45.9</td>
<td>110.7</td>
<td>85.0</td>
</tr>
<tr>
<td>6 WAT</td>
<td>58.5</td>
<td>111.6</td>
<td>83.5</td>
</tr>
<tr>
<td>7 WAT</td>
<td>55.8</td>
<td>96.3</td>
<td>76.8</td>
</tr>
<tr>
<td>8 WAT</td>
<td>54.9</td>
<td>107.1</td>
<td>80.1</td>
</tr>
</tbody>
</table>

WAT = Weeks after celery transplanting

**Conclusion**

Heat stress imposed seven weeks after transplanting of celery resulted in the highest incidence of Black streak. Boron application exacerbated celery black streak. Furthermore, there was a significant interaction between boron and temperature. Under hot conditions, boron application seemed to increase the incidence of the disorder. From these studies it is clear that Black streak is not due to boron deficiency and in fact could be exacerbated by boron application.
Celery Insect Pest Management Update

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What were the abundant light brown moths in my celery field this year?
During the 2010 growing season a little known insect pest called the celery leaffier was frequently the focus of attention for many vegetable, greenhouse, and nursery producers in the Midwest. University extension personnel were often contacted to report that small brown moths were rising up in great numbers as people and equipment moved through vegetation. Even homeowners reported these moths in the lawn in large numbers. One of the concerning issues was that in many cases celery leaffier was misidentified as the European corn borer because the adults are similar at first look. Making this mistake is likely because years can go by without the appearance of this insect pest, therefore its not one of the “usual suspects”. This year was an exceptionally good year for the development of high numbers of this pest, likely because the growing season started earlier than usual and temperatures stayed favorable for their development. As reported by many people, the little moths were found "everywhere", since the larvae of the celery leaf tier feed on many plant species of cultivated flowers, weeds, and vegetables including beets, cabbage, spinach, beans, and celery. In the greenhouse its hosts include calendula, dahlia, daisy, geranium, pansy, chrysanthemum, and vegetables such as lettuce and cucumber. This insect is not a pest of soybeans or corn.

How quickly do these moths develop, and how can I recognize the adults or larvae?
The insect’s life cycle is up to four generations per year in the Midwest under field conditions. In the greenhouse, it can complete its lifecycle in a month. Eggs are tiny, shiny dots; whitish initially and grow darker as they age. They are deposited on the undersides of leaves singly or in groups of about 10. Eggs hatch in about 4-10 days, and the newly emerging larvae are pale yellow. As the larvae grow, they turn pale green, with a single dark line on their backs and a broad whitish band on each side. The larvae are sparsely covered with long hairs. The larvae feed on leaves and they web leaves together with silk to create protective shelters (hence the name, leaffier). When feeding on celery, they often start on the outer leaves then work their way down to the heart. Larvae take 3 to 4 weeks to develop and at maturity they measure 0.75 inches long. Pupation occurs in the folded leaves and the adults emerge in about two weeks. Adults live for about a week, with females surviving slightly longer than males. They remain hidden on the underside of leaves during the day. Mating occurs immediately upon adult emergence and the females deposit their eggs at night within the first few days of her life. Adult celery leaf tier resembles European corn borer on first look, except that they are smaller and have a snout-resembling mouthpart. The adult celery
leaffier’s wingspan is about 0.75 inches compared to the European corn borer’s 1 to 1.25 inch wingspan.

**What kind of damage do leaf tiers cause in celery?**

The caterpillar feeding appears as holes in the foliage and petiole damage looks like circular depressions in the tissue. Tied leaves, webbing, and the presence of the larvae are contaminants at harvest.

**How can I control celery leaf tier?**

Growers report once they found the larvae in the plant, one spray controls the problem in most cases. Since they are caterpillars, most pyrethroid insecticides will control them. Small larvae are easier to kill and can be controlled with Bt products. Because this pest is sporadic (meaning that it only occurs in large numbers in some years and not in others), there is no treatment threshold developed specifically for the Midwest. According to a recommendation from Virginia Tech, the following treatment threshold is recommended: “at five different locations in a field inspect 20 plants for larvae on a weekly basis. Treatment is warranted if there are more than 4 weeks before harvest and there are 2 or more larvae per 100 plants.” Monitoring can be done by visually inspecting the foliage for the presence of larvae.

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In addition to the celery leaffier, there were other, more regularly occurring insect pests damaging celery in 2010. Two of these that may have been prevalent in the past production season in some areas are aphids and asterleafhoppers.

**Aphids**

**How can I recognize aphids?**

Aphids are about 1/16th of an inch or smaller and have two exhaust-pipe-like structures at the rear end. There are a number of aphid species that occur on celery in the Midwest, but the most commonly occurring ones are the green peach aphid (green), the bean aphid (black), and the sunflower aphid (green). These insects come in a variety of colors, shades, shapes, and forms. Aphids usually have wings at the early and late part of the season, but are wingless during the rest of the season. Adults and young look similar, except that immatures are always smaller and wingless. Aphids live in large mixed-age colonies on the plant, usually on the underside of young leaves. They cast their old skins as they mature, and these white castings are visible on the under-side of leaves among the live insects.
How do they develop in the field?
During the middle of the summer, when aphids have settled down on celery, females give birth to live offspring, without needing to mate. This is why they can quickly build up in significant numbers on the plants, especially during the hottest time of the summer. During the season there are many overlapping generations.

What does aphid damage look like on celery?
Aphids especially like to feed on the youngest parts of celery. In celery, aphids suck plant-sap from leaves and stems. When large colonies are present on the plant, leaves will curl, and the plants look deformed. In extreme cases, leaves turn yellow and die. When examining the underside of these deformed leaves, aphid colonies can be seen.

When should I expect large aphid infestations?
There are two conditions that favor aphid development: (1) hot and humid weather and; (2) frequent use of broad-spectrum insecticides. Part of the reason for this latter is that insecticides kill the natural enemies (parasitoids) of aphids more easily than the aphids themselves, and also because aphids live inside the protection of curled leaves where insecticides typically don’t reach. Celery seldom needs to be treated for aphids, unless the natural enemies are killed with insecticides that do not kill aphids. Fungicides can also increase aphid survival by killing fungal diseases of aphids.

How should I control aphids in my celery?
The best way to keep aphid populations down is to preserve the natural enemies of aphids. If an insecticide treatment is needed, good coverage with the insecticide is essential. To ensure good coverage, use high pressure (100 psi or higher) and high water volume (50 gallons per acre or higher). Because of these, insecticide application by air is notoriously ineffective at suppressing aphid populations. The MSU vegetable entomology lab set up an insecticide trial in celery for aphid control in 2010, but aphid infestation did not occur in the test plots, therefore results could not be attained.

Aster leafhoppers

How can I distinguish aster leafhoppers from other leafhoppers?
Usually 1/8 inch long, this light smoky-green to yellowish-green leafhopper is sometimes called the six-spotted leafhopper, because this species has six black spots arranged in pairs on the front of the head. Use a hand lens to take a closer look at the leafhopper to determine if you have aster leafhopper infestation. Adults and young look similar, except that immatures are always smaller and wingless, therefore they can’t fly. Aster leafhoppers scurry sideways when disturbed, and hide on the underside of leaves.

Why are aster leafhoppers important pests of celery?
Aster leafhopper feeding causes very little direct damage to celery, but they transmit a disease, called the aster yellows phytoplasma. The leafhoppers have to feed on an infected plant (many species of plants carry this disease) for hours to days to pick up the disease. The phytoplasma
circulates in the insect body and multiplies during a two to three week latent period, during which time the insect cannot transmit the pathogen. Once the leafhopper becomes infectious, it may infect healthy plants for the rest of its life, and this transmission process only takes a few minutes to a few hours of feeding. Once plants acquire the phytoplasma, nothing can be done to cure the plant; control efforts should prevent further spread of the disease by stopping aster leafhoppers from feeding on healthy plants.

**What are the symptoms of the aster yellows in celery?**
Leaves turn yellow, and eventually the infected plant becomes stunted and twisted. Often, there are multiple infected plants in the same area in the field. This is due to the feeding of an infected aster leafhopper within that area, and NOT due to the plant-to-plant transmission of the disease. The disease can only be transmitted from field to field or from weeds to celery field by the leafhopper.

**How can aster leafhoppers be managed in celery?**
Aster leafhoppers are monitored by sweep net sampling one or two times per week, when the weather is calm and dry. Crop scouts are often involved in aster leafhopper sampling. The leafhoppers are collected into a container and sent to the MSU Plant Diagnostic Lab in East Lansing, MI, where the number of infected leafhoppers is determined. The number of aster leafhoppers in 100 sweeps and the number of infected individuals are compared to a predetermined treatment threshold value, which is 35 in the case of celery. If the index value surpasses the treatment threshold, a control treatment for the leafhopper is recommended. Results of this test from the MSU Plant Diagnostic Lab are relayed back within a few days either by phone or email to the person who sent in the sample. The MSU Plant Diagnostic Lab will not only give the percent leafhoppers infected with the disease, but they will also calculate the index and compare it to the treatment threshold. So ideally, growers or scouts do not need to do any calculating on their own.

\[
\frac{\text{\% infected leafhoppers} \times \text{number of leafhoppers in 100 sweep-net samples}}{35} \begin{array}{c} < \\ > \end{array}
\]

Example: 2.5% x 14 = 35

Insecticide treatment for aster leafhopper is not necessary within 2 weeks of harvest, since disease symptoms need at least two weeks to show. Most broad-spectrum insecticides will work against leafhoppers, but overuse of these products can lead to aphid outbreaks.

**References**

**Photo credits**
Celery leaf tier adult: Carol Wolf; Celery leaf tier larva: Thomas Dudek, Bean aphid: William Steenwyke