Celery

Wednesday afternoon 2:00 pm

Where: Gallery Overlook (upper level) Room C

Recertification credits: 1 (1B, PRIV CORE)
CCA Credits: SW(0.5) PM(1.5)

Moderator: Bill Steenwyk, District Vegetable Educator, MSU Extension

2:00 p.m. Controlling Insect Pests in Celery

- Beth Bishop, Entomology Dept., MSU

2:20 p.m. Black Streak Update

- Mathieu Ngouajio, Horticulture Dept., MSU

2:40 p.m. Celery Disease Management

- Mary Hausbeck, Plant Pathology Dept., MSU

3:00 p.m. Celery Weed Control Update

- Bernard Zandstra, Horticulture Dept., MSU

3:20 p.m. Managing Muck Soils After Flooding

- Darryl Warncke, Crop & Soil Sciences Dept., MSU

CONTROLLING INSECT PESTS IN CELERY

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Celery is attacked by many different pest insects. Three of the most persistent are: aster leafhoppers, aphids, and tarnished plant bugs. All three feed by sucking plant fluids. Aphid populations can grow to high densities. Their feeding distorts foliage. Aphids tend to concentrate in celery hearts and their bodies cause contamination at harvest.

Tarnished plant bug adults are mobile insects that feed on a variety of plants. They may move into celery fields, feed, and then move out, leaving only their damage behind. While feeding they inject toxic saliva that collapses vascular tissue, creates brown “stings” and provides an entry site for bacterial rot.

Aster leafhopper damage plants by spreading a disease, aster yellows, during feeding. Aster yellows infection results in stunted, distorted and discolored foliage and death of younger plants. The disease is transmitted through feeding by infected aster leafhoppers. No treatment is effective once plants have aster yellows; the only way to control the disease is to control the leafhopper vectors.

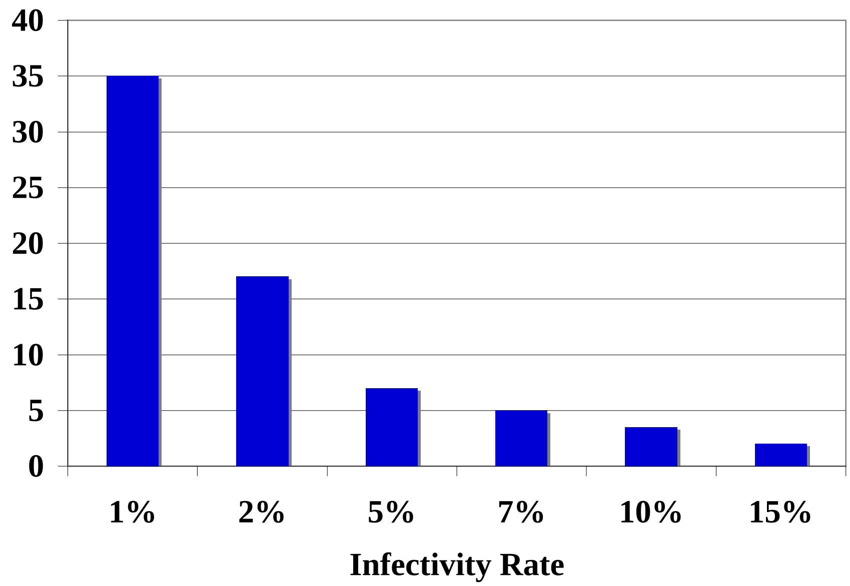

Figure 1. How the proportion of aster leafhoppers carrying aster yellows (infectivity rate) affects the treatment threshold (number of aster leafhoppers caught in 100 sweep net samples above which an insecticide application is necessary to prevent economic damage) in celery.
The risk of aster yellows to celery depends on both the number of aster leafhoppers and the prevalence of aster yellows in the leafhopper population. The proportion of aster leafhoppers carrying aster yellows varies from year-to-year, location-to-location, and over the season. This proportion, the infectivity rate, determines the populations level at which insecticide treatment is required to prevent economic damage

(treatment threshold). Small changes in infectivity rate can significantly influence treatment threshold (Figure 1). .

Since 2001, we have coordinated the testing of aster leafhoppers collected from Michigan celery fields to determine their infectivity rate. We have found that the infectivity rate varies considerably from year to year, between locations, and over the course of the season. This variation in infectivity rate reflects a corresponding variation in treatment threshold. In order to manage aster leafhoppers and prevent aster yellows growers must know current treatment threshold. This testing, provided by MSU Diagnostic Services (http://www.pestid.msu.edu/) allows them to do so.

In 2006 and 2007 very few of the aster leafhopper populations collected from celery fields were infected with aster yellows. In 2007 only 20% of the leafhopper samples tested positive for the disease. Consequently, treatment thresholds were relatively high (25 to 35 aster leafhoppers per 100 sweeps) for most of the season at most locations. In 2008, by contrast, almost half of the leafhopper samples collected from celery fields tested positive for aster yellows. Infectivity rates of positive samples ranged from 1% (Threshold of 35 alh/100 sweeps) to 29% (threshold of 1- 2 alh/100 sweeps

Prior to 2000, when faster, less expensive methods became available to test aster leafhoppers for aster yellows infection, a single treatment threshold was used for the entire state and the entire season. This treatment threshold depended on a presumed infectivity rate, or one that was determined very early in the season. Usually that infectivity rate was 1 to 3%.

We compared treatment thresholds and resultant insecticide application recommendations between those that would have resulted from the older method (using a constant infectivity rate of 2.5%) and those generated by testing leafhoppers and using the most recent infectivity rate.

In 2008, 23 of the 76 leafhopper sample results gave treatment recommendations that differed from those of the older method. In 12 samples, the old method would not have triggered an insect application when one was actually required. In 11 samples the older methods would have recommended an insecticide application when none was needed. Although the incidence of aster yellows in celery fields was higher in 2008 than in previous years, timely insecticide applications made on the basis of accurate treatment thresholds undoubtedly reduced the disease.

Tarnished plant bugs and aphids are both challenging to control for celery growers. Winged tarnished plant bug adults can move into a celery field, feed for a few hours, and fly out again leaving only their feeding damage behind. Aphid populations can build very quickly in the hot, dry days of late summer, causing problems close to harvest. Many insecticides only exacerbate aphid populations by killing the natural enemies that keep them in control. Over the past several years we have investigated the efficacy of pre-transplant neonicitinoid insecticides for preventing aphid and tarnished plant bug infestations later in the season.

In 2008 we evaluated the length of control provided by three different rates of at-plant neonicitinoid insecticides against tarnished plant bugs and aphids. Treatments included imidacloprid (Admire Pro ®) at 9 oz, 4.5 oz and 2.3 oz./Acre, thiamethoxam (Platinum ®) at 10 oz, 5 oz and 2.5 oz per acre, and an untreated control. Treatments were applied to flats five days prior to transplanting. Celery was transplanted on June 12, 2008 at the MSU Muck Soils Research Farm in Clinton County, MI. Treatments were planted into separate single-row plots (25 ft long), with 4 replications each. Plots were maintained with standard cultivation, irrigation, fertilizer, herbicide and fungicide treatments but without insecticide applications.

In late July, celery plants from each treatment were dug from the soil and petioles were cut and placed in water-filled containers. Containers were placed in cages; each cage contained a different treatment. Tarnished plant bugs collected from alfalfa fields were placed in each cage and allowed to feed for one week. After one week all tarnished plant bugs were removed from the cage and the numbers of live and dead bugs were counted. Petioles were examined for tarnished plant bug feeding ("stings"). The first cages were set up on July 31 (7 weeks after transplanting). The second set of cages was set up August 7 (8 weeks after transplanting).

In both cases, most of the tarnished plant bugs survived, although the highest rates of insecticides produced slightly more mortality. The higher rates also significantly reduced damage to petioles from tarnished plant bug feeding.

Celery plants from each treatment were dug from the soil and transplanted into clay pots on August 18, 2008. They were transported back to the lab and maintained until August 27 (2 ½ months after transplanting). Potted plants were infested with aphids by placing them among aphid-infested untreated plants. After two weeks, petioles were cut and rinsed with ETOH to collect aphids. The rinseate was filtered to separate aphids and the number of aphids was counted.

All treatments had a high number of aphids. There was no significant difference between any of the treatments and the untreated control. Although neonicitinoids applied at transplanting control aphids for 3 months or longer in the laboratory and greenhouse (unpublished data), the length of control in the field is shorter, at least for celery planted in muck soils.

BLACK STREAK DISORDER IN CELERY: DOES BORON DEFICIENCY PLAY A ROLE?

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SUMMARY

Two field and one greenhouse experiments were conducted in 2008 to determine if boron deficiency plays a role in the development of celery black streak disorder. Under field conditions the disorder was observed only on very few plants from plots that did not receive foliar applications of boron. The lack of symptoms under field conditions suggests boron content in the soil was probably enough to meet plant demand. Also there were no major reports of the black streak disorder in commercial fields throughout the state during 2008. In greenhouse studies, the impact of boron was more evident due to a better control of this micronutrient in the growing media. Among the five cultivars tested, 'Greenbay' was more tolerant to boron deficiency and "Dutchess' was less tolerant. In all cultivars, plants that received foliar boron application grew well and showed no symptoms. Plants receiving no boron showed severe growth distortion with many transverse cracks on the petioles and overall petiole twisting. At harvest, symptoms of internal discoloration were observed in most plants that did not received boron. However, boron deficiency was so severe that the plants were highly stunted. This study clearly demonstrates the essential role of boron in celery growth and development. The study will need to be repeated under milder Boron deficiency conditions to definitely determine the role of boron in the occurrence of black streak of celery. Since the disorder usually appears in commercial fields under hot weather conditions, it is possible that high temperatures (rapid plant growth) may increase boron need by the plant.

INTRODUCTION AND RATIONALE

Boron deficiency has been reported to cause significant losses in vegetable crops, including celery. In studies conducted by Wayne Loescher (Michigan State University, Personal communication), symptoms of boron deficiency in sugar beet include black streaks similar to those observed in celery. Boron deficiency has also been shown promote bitter taste in celery, a situation reported by some growers on stalks affected by the lack streak. Based on those observations field and greenhouse studies were undertaken during the summer of 2008 to investigate the role of boron deficiency in the occurrence of black streak in celery.

OBJECTIVE

The goal of this study was to determine if boron deficiency plays a key role in the occurrence of celery black streak disorder.

METHODOLOGY

1. Field studies

Field studies were conducted at a commercial celery farm in Hudsonville Michigan and at the Muck Soils Research Farm in Laingsburg Michigan. The Hudsonville trial had three treatments: 1)Boron at 0.1 lb/A in each spray tank + 0.5 lb/A foliar application (common practice), 2) Boron at 0.1 lb/A in each spray tank + three foliar applications of 0.4 lb/A each, 3)and Boron at 0.1 lb/A in each spray tank . The research farm trial had two foliar B treatments (B or no B) and five celery cultivars: Dutchess, Greenbay, NBS1, NBS2, and NBS3. Seed for the last three cultivars were supplied by the grower cooperator and were produced from Dutchess in previous years. The B treatment received three foliar applications of 0.6 lb/A each. For all foliar applications a 10% concentration derived from boric acid (TRACO™ Liquid Boron, Taylor Chemical & Supply Co, Inc., Orlando FL).

2. Greenhouse experiment

The five cultivars listed above were also used in a greenhouse experiment. Celery seedlings were transplanted in 1-gallon pots containing greenhouse potting mix. BACCTO (Michigan Peat Co., East Lansing) high-porosity professional planting mix was used as the growing medium. Plants were fertilized weekly with 1/2 strength of Hoagland's solution with no B. Foliar B was applied weekly using a solution of 75 mg/L of B made with boric acid. Using a combination of early and late season timings of B applications, four treatments were developed and included:

1. Boron for the entire growing period (YES-YES)
2. Boron for the first 6 weeks then no boron until harvest (YES-NO)
3. No boron for the first 6 weeks then boron until harvest (NO-YES)
4. No boron (NO-NO)

At harvest, plants were evaluated for fresh weight and for incidence of black streak. Black streak symptoms were assessed on a scale of 0 (no symptoms) to 5 (symptoms on entire petiole).

RESULTS

Figure 1. Celery plant showing symptoms of boron deficiency in the greenhouse (Left) and petioles showing symptoms very similar to black streak observed by growers in 2005 and 2006 (right).

Field studies

None of the field trials showed significant symptoms of black streak (data not presented). This was true for all cultivars tested and for all B rates. Also it appears that the 2008 season was not conducive to the appearance of the diseases throughout the state. No major reports of the disorder were received from growers.

Greenhouse studies

Boron deficiency resulted in 100% yield loss in all cultivars except Greenbay (Table 2). The first 6 weeks were most critical for B application (Tables 4, 5, and 6). Correction of B deficiency with late season application was only partially successful. Celery petiole internal discoloration was found in all cultivars grown without foliar B application.

Table 1. Effects of boron program on celery total weight: Greenhouse study.

Cultivar	Boron Treatment			
	YES-YES	YES-NO	NO-YES	NO-NO
	------------------------- [Total fresh weight (g/plant)] ------------------------------			
Dutchess	490.0	421.0	242.5	253.0
Greenbay	434.5	405.5	327.0	315.5
NBS1	349.5	414.5	315.5	230.0
NBS2	479.0	440.0	334.0	187.0
NBS3	474.0	447.5	315.0	176.0

Celery transplanted on May 12, 2008 and harvested on August 22, 2008. Boron was applied either all season (YES-YES), only in the first 6 weeks (YES-NO), only after the first 6 weeks (NO-YES), or was not applied (NO-NO).

Table 2. Effects of boron program on celery marketable weight: Greenhouse study

Cultivar	Boron Treatment			
	YES-YES	YES-NO	NO-YES	NO-NO
	---------------------- [Marketable fresh weight (g/plant)] --------------------------			
Dutchess	298.5	251.0	0.0	0.0
Greenbay	242.5	228.5	193.0	196.0
NBS1	232.0	230.0	186.5	0.0
NBS2	307.5	281.5	209.5	0.0
NBS3	300.0	253.5	90.0	0.0

Celery transplanted on May 12, 2008 and harvested on August 22, 2008. Boron was applied either all season (YES-YES), only in the first 6 weeks (YES-NO), only after the first 6 weeks (NO-YES), or was not applied (NO-NO).

Table 3. Effects of boron program on the number of celery petioles per plant: Greenhouse study

Cultivar	Boron Treatment			
	YES-YES	YES-NO	NO-YES	NO-NO
	-------------------------- (Number of petioles per plant) --------------------------			
Dutchess	14.0	12.5	12.5	12.5
Greenbay	14.5	13.5	14.0	14.0
NBS1	12.5	10.0	12.5	18.0
NBS2	14.0	12.0	13.5	16.0
NBS3	15.0	14.0	9.0	12.5

Celery transplanted on May 12, 2008 and harvested on August 22, 2008. Boron was applied either all season (YES-YES), only in the first 6 weeks (YES-NO), only after the first 6 weeks (NO-YES), or was not applied (NO-NO).

Table 4. Effects of boron program on the percentage of celery petioles affected by the black streak disorder: Greenhouse study

Cultivar	Boron Treatment			
	YES-YES	YES-NO	NO-YES	NO-NO
	----------------------------------- (% petioles affected) -----------------------------			
Dutchess	0.0	0.0	5.6	48.6
Greenbay	0.0	0.0	32.1	57.1
NBS1	0.0	0.0	19.9	65.3
NBS2	0.0	0.0	7.4	75.8
NBS3	0.0	7.7	8.3	63.7

Boron was applied either all season (YES-YES), only in the first 6 weeks (YES-NO), only after the first 6 weeks (NO-YES), or was not applied (NO-NO).

Table 5. Effects of boron program on the incidence of the black streak disorder in celery: Greenhouse study.CALCULATIONS BASED ON ALL PETIOLES

Cultivar	Boron Treatment			
	YES-YES	YES-NO	NO-YES	NO-NO
	---------------------- (Black streak incidence on a scale of 0 to 5) ------------------			
Dutchess	0.0	0.0	0.1	1.3
Greenbay	0.0	0.0	0.9	1.5
NBS1	0.0	0.0	0.4	2.2
NBS2	0.0	0.0	0.2	1.3
NBS3	0.0	0.1	0.1	1.9

Boron was applied either all season (YES-YES), only in the first 6 weeks (YES-NO), only after the first 6 weeks (NO-YES), or was not applied (NO-NO).

Table 6. Effects of boron program on the incidence of the black streak disorder in celery: Greenhouse study CALCULATIONS BASED ONLY ON AFFECTED PETIOLES

Cultivar	Boron Treatment			
	YES-YES	YES-NO	NO-YES	NO-NO
	---------------------- (Black streak incidence on a scale of 0 to 5) ------------------			
Dutchess	0.0	0.0	1.0	2.8
Greenbay	0.0	0.0	2.7	2.9
NBS1	0.0	0.0	1.8	3.6
NBS2	0.0	0.0	2.5	1.8
NBS3	0.0	0.8	0.5	2.8

Boron was applied either all season (YES-YES), only in the first 6 weeks (YES-NO), only after the first 6 weeks (NO-YES), or was not applied (NO-NO).

CONCLUSION

This study suggests that B may play a role in the occurrence of celery black streak disorder. In previous years the disease occurred when hot weather conditions coincided with the exponential (rapid) growth phase of celery. Therefore, both weather conditions and plant B status may have combined effects. It is critical to confirm these preliminary observations with follow up studies in controlled environments.

ACKNOWLEDGEMENTS

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CELERY DISEASE MANAGEMENT

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Damping-off (caused by *Pythium* spp., *Phytophthora* spp. and *Rhizoctonia* sp.) affects all vegetable seedlings and is also common among flowering bedding plants. Damping-off results in collapse of the plant at the soil surface. Avoid overwatering because some damping-off fungi prefer wet conditions.

Good sanitation is the key and ensures that root rot problems from one crop are not carried over to another crop. Root rot pathogens survive in the greenhouse in soil particles or plant parts clinging to containers, benches, walkways, and equipment. If root rot occurs, remove and destroy the diseases plants. Also, remove healthy-appearing plants that are immediately adjacent to the dead plants because the disease may have already spread to them although they may not be showing symptoms yet. Plug sheets containing diseased transplants should not be reused.

Foliar blights must be managed in field situations. Early blight (caused by *Cercospora apii*) and late blight (caused by *Septoria apiicola*) are major problems every season. Yield losses occur as a result of defoliation and stunting of the plants and petiole blighting. Resistant cultivars and disease-free seed are important, as both pathogens can be seedborne. Symptoms of Cercospora early blight include yellow to tan, circular-shaped lesions on the upper and lower surface of leaves and elongated 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. Both Cercospora and Septorial leaf blights can be controlled with registered fungicides such as chlorothalonil (Bravo), propiconazole (Tilt), and strobilurins (Quadris, Flint). These materials are best when used in rotation with one another and all can be tankmixed with copper fungicides for dual control of both fungal and bacterial diseases. When making fungicide applications to celery a grower needs to ensure that they achieve proper coverage of all foliage and stalks of the plants. This is especially important when plants are large enough to form a thick canopy that can limit coverage to the lower portions of the plants. For bacterial blight in the field, a grower should make applications of copper-based fungicides frequently. These frequent applications will help keep the bacterial populations to a level where disease outbreaks in the field can be limited.

Greenhouse fungicide trials for root rots of celery seedlings.

These studies were conducted in the research greenhouses at Michigan State University. Celery ‘Dutchess’ seeds were sown into 288-cell flats containing a soilless medium (Baccto Professional Planting Mix, Michigan Peat Company, Houston TX). Inoculum was prepared by growing mefenoxam-resistant isolates of *Pythium* spp. on dilute V8 agar or *Rhizoctonia solani* on potato dextrose agar for three weeks. Flasks filled with two parts millet seed and one part water were sterilized. Four 1.5-inch plugs of agar infested with *Pythium* or *Rhizoctonia* were placed into the flasks. The infested millet was allowed to grow for three weeks before being mixed (8 oz/1 ft^3) into a soilless medium. Seedlings were transplanted from the cell flat into 3-inch cells containing the infested media. Eight single plant replicates per treatment were arranged in a completely randomized design. Two (*Pythium* trial #2) or three (*Pythium* trial #1, *Rhizoctonia* trial) applications of fungicides (Table 1) were applied as a drench to the cells immediately after transplanting and at 7-day intervals. Plants were watered as needed and fertilized once weekly with 200 ppm of Peter's 20-20-20 water soluble fertilizer (The Scotts Company, Marysville, OH). Data on plant health and death were analyzed.

T**able 1**. Products included in the celery greenhouse seedling fungicide trials.

Product	Active ingredient	Labeled
Aliette 80WDG	aluminum-tris	yes
Banol EC......................................	propamocarb	no
Banrot 40WP.................................	etridiazole/thiophanate-methyl	no
Chipco 26019 50WP....................	iprodione	no
Endorse 11.3DF	polyoxin D zinc salt	no
Kocide 2000 DF...........................	copper hydroxide	yes
Moncut 75DF	flutolanil	no
Phostrol	phosphorous acid	yes
Presidio 4SC.................................	fluopicolide	no
Previcur Flex................................	propamocarb	no
Quadris SC	azoxystrobin	no
Ranman 400F	cyazofamid	no
Reason 500SC..............................	fenamidone	no
Revus 250SC.................................	mandipropamid	not on label
Scholar 50WP	fludioxonil	no
Subdue MAXX EC	mefenoxam	no
Terraclor 75WP............................	pentachloronitrobenzene	yes
ZeroTol	hydrogen dioxide	no

Evaluation of fungicides for control of *Pythium* spp.

Disease pressure in trial #1 was significant as the inoculated control had moderate plant stunting and up to 25% plant death (Table 2). The untreated control was the only treatment in which plant death (25%) occurred. Treatments of Aliette, Banrot, Phostrol and Presidio + Previcur provided significant control of *Pythium* spp. and were similar to the untreated uninoculated. Minor phytoxicity symptoms were observed in the Banrot treatment, including plant stunting and leaf cupping.

A fifteen treatment study, trial #2, was conducted to evaluate the control of Pythium root rot of celery seedlings with fungicide drenches. Disease pressure in this trial was moderate (Table 3). The untreated uninoculated plants were among the healthiest of all treatments. Treatments of Aliette, Phostrol and Presidio + Previcur Flex provided control against *Pythium* and were among the healthiest and tallest of all plants.

Table 2. Results of celery greenhouse seedling *Pythium* fungicide trial #1.

Treatment rate/100 gal	Plant health*			Plant death (%)	
	9 Jan	16 Jan	23 Jan	16 Jan	23 Jan
Untreated uninoculated..............................	1.0 a**	1.0 a	1.0 a	0.0 a	0.0 a
Untreated inoculated................................	1.8 b	2.4 d	3.1 f	25.0 b	25.0 b
Aliette 80WDG 4 lb..................................	1.0 a	1.1 ab	1.4 ab	0.0 a	0.0 a
Banrot 40WP 12 oz	1.0 a	1.0 a	1.5 abc	0.0 a	0.0 a
Kocide 2000 DF 1.5 lb	1.0 a	1.0 a	2.0 bcd	0.0 a	0.0 a
Phostrol 2.5 pt...	1.0 a	1.0 a	1.4 ab	0.0 a	0.0 a
Presidio 4SC 4 fl oz..................................	1.0 a	1.3 ab	1.8 bcd	0.0 a	0.0 a
Presidio 4SC 4 fl oz + Previcur Flex 1.2 pt	1.0 a	1.0 a	1.4 ab	0.0 a	0.0 a
Quadris SC 9 fl oz	1.3 ab	2.0 cd	3.0 f	0.0 a	0.0 a
Ranman 400F 2.75 fl oz	1.0 a	1.4 abc	2.1 cd	0.0 a	0.0 a
Reason 500SC 8.2 fl oz	1.4 ab	1.6 abc	2.1 cd	0.0 a	0.0 a
Revus 250SC 8.2 fl oz...............................	1.5 ab	1.8 bcd	2.3 de	0.0 a	0.0 a
Subdue MAXX EC 1 fl oz	1.4 ab	1.8 bcd	2.9 ef	0.0 a	0.0 a

*Plant health rating is 1 to 5; 1=healthy, 2=minor wilting or chlorosis, 3=moderate wilting or chlorosis, 4=severe wilting or chlorosis, 5=plant death.
**Column means with a letter in common are not significantly different (Fisher's Protected LSD; *P*=0.05).

Table 3. Results of celery greenhouse seedling *Pythium* fungicide trial #2.

Treatment rate/ 100 gal	Plant health*				Height (in)
	21 Oct	28 Oct	4 Nov	11 Nov	11 Nov
Untreated uninoculated................................	1.0 a**	1.0 a	1.0 a	1.0 a	2.6 a
Untreated inoculated....................................	2.8 cd	4.7 e	5.3 d	5.5 e	1.3 e
Aliette 4 lb...	1.8 abcd	1.7 ab	1.2 ab	1.8 ab	2.5 abc
Banol EC 3 fl oz	2.3 bcd	4.2 de	5.2 d	5.0 de	1.6 e
Banrot 40WP 12 oz	2.3 bcd	3.0 bcde	5.5 d	5.3 e	1.9 bcde
Kocide 2000 54DF 1.5 lb	2.0 abcd	3.2 bcde	5.5 d	5.7 e	1.5 e
Phostrol 2.5 pt	2.0 abcd	2.0 abc	2.3 abc	2.3 abcd	2.4 abcd
Presidio 4FL 4 fl oz.....................................	1.7 abc	3.5 cde	3.8 bcd	4.2 bcde	1.8 cde
Presidio 4FL 4 fl oz + Previcur Flex 1.2 pt..	1.5 ab	2.2 abc	2.2 abc	2.2 abc	2.7 a
Quadris 9 fl oz	2.3 bcd	2.8 bcd	3.8 bcd	4.5 bcde	1.7 cde
Ranman 400F 2.75 fl oz	1.5 ab	3.2 bcde	4.8 cd	4.5 bcde	1.8 cde
Reason 5090SC 8.2 fl oz	1.2 ab	2.8 bcd	4.5 cd	4.8 cde	1.9 abcde
Revus 250SC 8.2 fl oz.................................	2.2 abcd	3.7 cde	6.0 d	6.0 e	1.4 e
Subdue MAXX EC 1 fl oz	2.2 abcd	3.3 bcde	6.2 d	6.5 e	1.7 de
ZeroTol 100 fl oz...	3.0 d	4.0 de	5.2 d	5.2 e	1.6 e

*Plant health rating is 1 to 10; 1=healthy, 2=minor chlorosis/minor stunting, 3=severe chlorosis/moderate stunting, 4=severe stunting, 5=minor wilting, 6=moderate wilting, 7=severe wilting, 8=minor necrosis, 9=moderate necrosis, 10=plant death.
**Column means with a letter in common are not significantly different (Fisher's Protected LSD; *P*=0.05).

Evaluation of fungicides for control of *Rhizoctonia solani*.

A ten treatment study was conducted to evaluate the efficacy of fungicide drenches for control of *Rhizoctonia solani*. Disease pressure in this trial was significant, as all untreated inoculated plants were dead by 9 Jan (Table 4). Treatments that prevented plant death and significantly limited infection of *R. solani* compared to the untreated inoculated control included Quadris, Endorse, Moncut, Scholar and Terraclor. Banrot, Chipco and Kocide provided marginal control; however, they were not as effective as the previous mentioned treatments. Phytotoxicity was observed in the Chipco and Banrot treatments; Chipco produced severe wilting and chlorosis of plant leaves while Banrot symptoms included minor wilting and chlorosis of leaves.

Table 4. Results of celery greenhouse seedling *Rhizoctonia* fungicide trial.

Treatment rate/100 gal	Plant health*			Plant death (%)		
	2 Jan	9 Jan	16 Jan	2 Jan	9 Jan	16 Jan
Untreated uninoculated........................	1.0 a**	1.0 a	1.0 a	0.0 a	0.0 a	0.0 a
Untreated inoculated	4.0 c	5.0 c	5.0 d	75.0 b	100.0 b	100.0 d
Quadris SC 9 fl oz	1.1 a	1.2 a	1.9 a	0.0 a	0.0 a	0.0 a
Banrot 40WP 12 oz	1.8 ab	2.4 b	2.5 bc	0.0 a	12.5 a	12.5 ab
Chipco 26019 50WP 2 lb	1.0 a	1.3 a	2.8 bc	0.0 a	0.0 a	25.0 bc
Endorse 11.3DF 6 oz...........................	1.0 a	1.0 a	1.1 a	0.0 a	0.0 a	0.0 a
Kocide 2000 DF 1.5 lb........................	2.3 b	2.9 b	3.3 c	12.5 a	12.5 a	37.5 c
Moncut 75DF 1.1 lb	1.3 a	1.1 a	1.4 a	0.0 a	0.0 a	0.0 a
Scholar 50WP 4 oz	1.0 a	1.0 a	1.3 a	0.0 a	0.0 a	0.0 a
Terraclor 75WP 1 lb	1.1 a	1.0 a	1.5 a	0.0 a	0.0 a	0.0 a

*Plant health rating is 1 to 5; 1=healthy, 2=minor wilting or chlorosis, 3=moderate wilting or chlorosis, 4=severe wilting or chlorosis, 5=plant death.

**Column means with a letter in common are not significantly different (Fisher's Protected LSD; *P*=0.05).

Weed Control in Celery – 2009

Bernard Zandstra
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Herbicides Labeled for Celery 2009

Dual Magnum	Poast
Caparol	Select Max
Lorox	Roundup

Potential New Labels for Celery

- Chateau – 2010
- Prowl H20 – 2012?
- Goaltender – 2012?

Celery Rating and Yield – Hudsonville (1) 2008

	lb/ai	Timing	Rating 6/13	Celery 7/30 KG/Plot
1. **Chateau** **Caparol**	0.096 2.0	POT POST	2.0	46
2. **Chateau** **caparol**	0.192 2.0	POT POST	3.3	42*
3.**Chateau** **Prowl H20** **Lorox**	0.096 1.9 1.0	POT POT POST	2.0	49
4. **Chateau** **Dual Magnum** **Lorox** **Poast**	0.096 1.9 1.0 1.9	POT POT POST PO	3.3	37*
LSD			1.0	11

Celery Rating and Yield – Hudsonville (2) 2008

	lb/ai	Timing	Rating 6/13	Celery 7/30 KG/Plot
5. **Caparol** **Caparol**	2.0 2.0	POT POST	1.0	46
6. **Caparol** **Lorox** **Poast**	2.0 1.0 1.0	POT POST POST	1.0	49
7. **Caparol** **Dual M** **Lorox** **Poast**	2.0 1.9 1.0 0.19	POT POT POST POST	1.3	45
LSD			1.0	11

Celery Rating and Yield – Hudsonville (3) 2008

	lb/ai	Timing	Rating 6/13	Celery 7/30 KG/Plot
8. **Goaltender**	0.5	POT	1.3	42*
9. **Prowl H20** **Caparol**	1.9 2.0	POT PO1	1.0	50
10. **Surpass**	2.0	POT	1.3	49
11. **Dual M** **Caparol**	1.9 2.0	POT PO1	1.0	55
LSD			1.0	11

Celery Rating and Yield – Muck Farm (1) - 2008

lb/ai Timing	Rating 6/18	Rating 7/1	Kg/Plot: 8/8
1. **Chateau** 0.096 POTDR **Caparol** 2.0 POST	2.3	1.3	66
2. **Chateau** 0.192 POTDR **Caparol** 2.0 POST	3.0	1.3	65
3. **Chateau** 0.096 POT **Caparol** 2.0 POST	3.0	1.3	63
4. **Chateau** 0.192 POT **Caparol** 2.0 POST	3.7	2.0	60*
LSD	1.4	1.0	10

Celery Rating and Yield – Muck Farm (2) - 2008

lb/ai Timing	Rating 6/18	Rating 7/1	Kg/Plot: 8/8
5. **Goaltender** 0.5 POTDR	2.7	1.3	70
6. **Caparol** 2.0 POT **Lorox** 1.0 POST	1.0	1.7	61*
7. **Caparol** 2.0 POT **Dual Mag.** 1.9 POT **Lorox** 1.0 POST	2.3	1.0	64
8. **Caparol** 2.0 POT **Goaltender** 0.063 POST **Poast** 0.19 POST	1.7	1.0	65
LSD	1.4	1.0	10

Celery Rating and Yield – Muck Farm (3) - 2008

lb/ai Timing	Rating 6/18	Rating 7/1	Kg/Plot: 8/8
9. **Chateau** 0.096 POT **Dual Mag.** 1.9 POT **Lorox** 1.0 PO1	5.3	2.3	56*
10. **Chateau** 0.096 POT **Prowl H20** 1.9 POT	2.0	1.0	67
11. **Caparol** 2.0 POT **Caparol** 2.0 PO1	1.0	1.3	72
12. **Untreated**	1.0	1.0	65
LSD	1.4	1.0	10

2008 Celery Weed Control Summary

- 1. **Chateau** 0.096 (3 oz.) applied alone POT or POST did not reduce celery yield.
- 2. **Chateau** was safe in tank mix with **Prowl H20**.
- 3. **Chateau** plus **Dual Mag.** POT reduced yield.
- 4. **Prowl H20** was safe POT.
- 5. **Goaltender** was safe POT and POST on celery.
- 6. **Chateau** POT followed by **Caparol** POST consistently produced good weed control and good yield.

Celery Weed Control Ratings – Hudsonville (1) 6/13/08

	Yellow Nutsedge	Ladys-thumb	Horse-weed	Redroot Pigweed
1. **Chateau** 0.096 POT **Caparol** 2.0 POST	2	10	7	10
2. **Chateau** 0.192 POT **caparol** 2.0 POST	2.3	10	8.7	10
3. **Chateau** 0.096 POT **Prowl H20** 1.9 POT **Lorox** 1.0 POST	2.7	9.7	5.5	10
4. **Chateau** 0.096 POT **Dual Magnum** 1.9 POT **Lorox** 1.0 POST **Poast** 1.9 PO	3.3	10	6.3	9.7
LSD	1.9	0.8	2.9	0.9

Celery Weed Control Ratings – Hudsonville (2) 6/13/08

	Yellow Nutsedge	Ladys-thumb	Horse-weed	Redroot Pigweed
5. **Caparol** 2.0 POT **Caparol** 2.0 POST	1.3	9.3	7.3	9
6. **Caparol** 2.0 POT **Lorox** 1.0 POST **Poast** 1.0 POST	2.7	9.3	8.3	10
7. **Caparol** 2.0 POT **Dual M** 1.9 POT **Lorox** 1.0 POST **Poast** 0.19 POST	3.7	10	6.7	10
LSD	1.9	0.8	2.9	0.9

Celery Weed Control Ratings – Hudsonville (3) 6/13/08

	Yellow Nutsedge	Ladys-thumb	Horse-weed	Redroot Pigweed
8. Goaltender 0.5 POT	2.3	10	2.7	10
9. Prowl H20 1.9 POT Caparol 2.0 PO1	1.7	10	4.3	10
10. Surpass 2.0 POT	5.0	10	10	10
11. Dual M 1.9 POT Caparol 2.0 PO1	4.0	9.7	5.7	10
LSD	1.9	0.8	2.9	0.9

Celery Weed Control Ratings – Muck Farm (1) 6/13/08

	Yellow Nutsedge	Common Purslane	Horse-weed	Redroot Pigweed
1. Chateau 0.096 POTDR Caparol 2.0 POST	1.7	10	10	9.7
2. Chateau 0.192 POTDR Caparol 2.0 POST	2.0	10	10	10
3. Chateau 0.096 POT Caparol 2.0 POST	2.3	10	10	10
4. Chateau 0.192 POT Caparol 2.0 POST	2.0	10	10	10
LSD	1.0	0.9	0.6	1.3

Celery Weed Control Ratings – Muck Farm (2) 6/13/08

	Yellow Nutsedge	Common Purslane	Horse-weed	Redroot Pigweed
5. Goaltender 0.5 POTDR	1.7	9.7	10	9.7
6. Caparol 2.0 POT Lorox 1.0 POST	1.3	9.0	10	9.7
7. Caparol 2.0 POT Dual Mag. 1.9 POT Lorox 1.0 POST	3.0	9.7	10	10
8. Caparol 2.0 POT Goaltender 0.063 POST Poast 0.19 POST	1.0	7.7	9.0	9.0
LSD	1.0	0.9	0.6	1.3

Celery Weed Control Ratings – Muck Farm (3) 6/13/08

	Yellow Nutsedge	Common Purslane	Horse-weed	Redroot Pigweed
9. Chateau 0.096 POT Dual Mag. 1.9 POT Lorox 1.0 PO1	2.3	10	10	10
10. Chateau 0.096 POT Prowl H20 1.9 POT	1.3	9.7	10	9.7
11. Caparol 2.0 POT Caparol 2.0 PO1	1.0	9.3	9.3	9.0
12. Untreated	1.0	1.0	1.0	1.3
LSD	1.0	0.9	0.6	1.3

Celery Weed Control Ratings – Muck Farm (1) 7/1/08

	Large Crabgrass	Common Lambsquarters	Common Purslane	Redroot Pigweed
1. Chateau 0.096 POTDR Caparol 2.0 POST	9.3	9.0	8.3	8.3
2. Chateau 0.192 POTDR Caparol 2.0 POST	9.3	10	9.0	9.3
3. Chateau 0.096 POT Caparol 2.0 POST	7.7	8.3	7.3	7.7
4. Chateau 0.192 POT Caparol 2.0 POST	8.7	8.7	8.3	8.7
LSD	1.6	1.8	0.9	1.2

Celery Weed Control Ratings – Muck Farm (2) 7/1/08

	Large Crabgrass	Common Lambsquarters	Common Purslane	Redroot Pigweed
5. Goaltender 0.5 POTDR	9.0	8.7	8.3	7.7
6. Caparol 2.0 POT Lorox 1.0 POST	9.0	9.0	6.7	7.0
7. Caparol 2.0 POT Dual Mag. 1.9 POT Lorox 1.0 POST	9.7	8.7	8.7	9.3
8. Caparol 2.0 POT Goaltender 0.063 POST Poast 0.19 POST	8.0	8.3	5.7	6.3
LSD	1.6	1.8	0.9	1.2

Celery Weed Control Ratings – Muck Farm (3) 7/1/08

	Large Crabgrass	Common Lambsquarters	Common Purslane	Redroot Pigweed
9. **Chateau** 0.096 POT **Dual Mag.** 1.9 POT **Lorox** 1.0 PO1	9.3	9.3	9.3	9.3
10. Chateau 0.096 POT **Prowl H20** 1.9 POT	7.7	9.7	7.7	7.3
11. Caparol 2.0 POT **Caparol** 2.0 PO1	6.7	9.0	6.7	6.3
12. Untreated	1.0	1.0	1.0	1.0
LSD	1.6	1.8	0.9	1.2

Recommendation for Celery Weed Control 2009

1.	**Dual Magnum**	2 qt.	PRE	Transplant
2.	**Caparol**	2 qt.	POST	4-5 weeks after Transplant
3.	**Lorox**	2 lb.	POST	Celery up to 8 inches
4.	**Poast** or **Select Max**		For POST grass control	

Recommendations – (When Chateau is Labeled)

- 1. **Chateau** PRE TP, or POT, depending on the label.
- 2. **Dual Magnum 2 qt.** PRE TP, if needed for nutsedge control.
- 3. **Caparol** 2 lbs ai (2 qt.) 4-6 weeks after TP.
- 4**. Lorox 1** lb ai (2 lbs) POST if needed for broadleaf control.
- 5. **Poast** or **Select Max** for grass control.

MANAGING MUCK SOILS AFTER FLOODDING

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Muck soils have developed in depressional areas that are more likely to flood than the surrounding upland soils. Most production muck areas have good drainage systems to deal with excess rainfall. However, each year there seems to at least one heavy intense rainfall event that overwhelms the drainage system. In 2008, muck areas in the western part of Michigan experienced unusually heavy rainfall that resulted in significant crop damage. When flooding occurs there may be significant unseen physical, chemical and biological damage to the soil. The impact of the rain drops disperses the soil particulates which tend to seal the soil surface resulting in reduced drainage and standing water. The weight of the water standing on the soil surface contributes to compression of the soil. Once the soil is adequately drained and sufficiently dry, till the soil to at least 8 inches deep to facilitate aeration and drying of the rooting zone. Shallow tillage results in drying the surface soil, but may actually reduce drying of the soil underneath.

Heavy rainfall and flooding events can have a big impact on key nutrients essential for plant growth. Nitrogen availability can be impacted in two ways. In the nitrate form, nitrogen can be lost from the soil by leaching with the drainage water or it can be converted to volatile nitrous oxide by the process of denitrification. Denitrification occurs when the soil is saturated with water (lack of oxygen). In muck soils denitrification generally plays a bigger role in nitrogen loss than leaching. In one instance, following a 4 inch rainfall event the available nitrogen level in the top foot of soil was found to have decreased from near 85 lbs/a to only 40 lbs/a. This was in a matter of 48 hours. The longer the soil is saturated the more nitrogen that will be lost. To hedge against nitrogen loss it is best to make several applications of smaller amounts of nitrogen. Including a nitrification inhibitor with the fertilizer will delay the conversion of nitrogen from the ammonium form to the nitrate form, which is the form at risk for loss. Use of one of the new slow-release nitrogen fertilizers may also reduce the risk of N loss.

Celery utilizes very large amounts of potassium, 11.6 lbs K_2O/ ton of biomass produced. Fifty tons of biomass per acre accumulates approximately about 580 lbs K_2O/ acre. Even though potassium occurs in the soil with a positive charge, which is held by the negatively charge organic matter, it is subject to leaching loss. Leaching of potassium occurs because it is weakly bound to the organic matter and more importantly muck soils contain very large amounts of calcium which binds more strongly to the organic matter. Due to mass action calcium displaces potassium into the soil solution where it is subject to leaching. It is not recommended to try to build up high levels of potassium in muck soils. Field observations have shown that, on average, 25 % of the available potassium is loss by leaching from the fall of one year to the spring of the next year. Following heavy rainfall events the available potassium level in the root zone may be reduced by 200 lbs/a or more. For celery and other crops sidedressing or broadcasting additional potassium is important following flooding.

Some phosphorus may leach out of muck soils, but the amount is usually small, except in very fibrous peat soils. Those soils have not developed the capacity to hold P. The other essential nutrient that is mobile in the soil and may be lost by leaching is boron. Boron is very important for growing high quality celery. The normal annual recommendation is to apply 3 to 4 lbs B/a for each celery crop. In dry soil conditions, sometimes B deficiency may occur due to lack of movement of B to the roots. Under leaching conditions significant amounts of boron may leach out of the root zone. After flooding, it is important to apply additional boron to the soil (2 lbs/a) or as a foliage spray (0.3 lb/a). The other micronutrients (copper, manganese and zinc) are held reasonably well by the soil and are not as subject to leaching loss. Sometimes leaching of the soil may result in a decrease in soil pH that may reduce molybdenum availability. The best long term solution when growing celery, if the pH is below 5.5, is to lime the soil to bring the pH up to at least 5.8. On a short term basis a foliage spray of 2 ounces of sodium molybdate per acre may be beneficial.

For nutrient management following serious flooding it is essential to sample and test the soil to determine what changes have taken place. The soil test information provides the base for developing an appropriate nutrient management plan.

Under flooded soil conditions the soils are anaerobic so most of the aerobic microorganisms die or become non-functional. After the soil is drained and dries, it will take some time for these microorganism to be functional again to aid in making nutrients, especially N, available to the roots. In fields that have experienced flood during the growing season, planting a cover crop will help improve soil quality and productivity. The added residue will stimulate beneficial microbial activity.