**Great Lakes Fruit, Vegetable & Farm Market EXPO**
**Michigan Greenhouse Growers EXPO**

**December 4-6, 2012**

DeVos Place Convention Center, Grand Rapids, MI

# Onion

**Where:** Gallery Overlook (upper level) Room C & D
**MI Recertification credits:** 2 (1B, COMM CORE, PRIV CORE)
**CCA Credits:** PM(2.0)
**Moderator:** Bruce Klamer, Byron Center, MI

9:00 am — Onion Insect Pest Management in Onion
- Brian Nault, Dept. of Entomology, Cornell Univ., NYSAES, Geneva, NY

9:30 am — An IPM Approach to Managing Bacterial Diseases of Onions
- Christine Ann Hoepting, CALS Coop Extension, Cornell Univ.

10:05 am — Onion Disease Update
- Mary Hausbeck, Plant, Soil and Microbial Sciences Dept., MSU
- Lina Rodriguez-Salamanca, Plant, Soil and Microbial Sciences Dept., MSU

10:35 am — Growing Onions in a Minimum Tillage System
- Christine Ann Hoepting, CALS Coop Extension, Cornell Univ.

11:00 am — Session Ends

Michigan Onion Committee Annual Meeting immediately follows the end of the session.

# ONION THRIPS PEST MANAGEMENT IN ONION

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Onion thrips, *Thrips tabaci*, is the major insect pest of onion and its control is critical to the production and profitability of this crop. Thrips feeding can reduce bulb yields by 30-50% and losses can be exacerbated if thrips infect the crop with *Iris yellow spot virus* or create damage that permits entry for other plant pathogens. Insecticide use is the most important tactic for thrips control, but this strategy must be used carefully and in a manner that will slow down the development of resistance.

This article provides guidance for managing onion thrips infestations in onion fields using insecticides in a manner that will be successful and should mitigate the development of resistance. To do so, there are three areas that should be considered before making insecticide applications: **(1) general information about commonly used products like Radiant, Agri-Mek and Movento (2) timing applications of these products, and (3) an approach for using these products to manage thrips all season long.**

**General Information**. ***What works?*** A number of products are registered for thrips control on onion **(Table 1)**. However, only four products have consistently demonstrated good to excellent control of onion thrips: Radiant, Entrust, Agri-Mek and Movento. **Radiant** is highly effective against both thrips larvae and adults and has residual activity lasting >7 days. **Entrust** is similar to Radiant, but lacks the residual activity that Radiant provides. **Agri-Mek** provides moderate to excellent control of onion thrips adults and larvae and has a residual activity of 5-7 days. The Agri-Mek label states “thrips suppression” rather than “thrips control” because this product is mediocre against western flower thrips, which is a serious pest of onion in the western US, but not in the Great Lakes region. **Movento** is systemic and has residual activity of >10 days, but it does not work well late in the season or against adults. Therefore, Movento should be used early when it easily moves systemically throughout the plant and when adult populations are often lower than they are later in the season.

**Table 1. Conventional products labeled to manage onion thrips on onion.**

| Spinosyn | Avermectin | Tetramic Acid | Neonicotinoid | Carbamate | OPs | Pyrethroid |
|---|---|---|---|---|---|---|
| Radiant SC | Agri-Mek SC[a] | Movento[b] | Assail 30SG | Lannate LV | MSR Spray | Mustang Max |
| Entrust | | | | | Penncap-M | Perm-Up or OLF[c] |
| | | | | | | Warrior II or OLF[c] |

[a]Labeled for onion thrips suppression only. [b] Section 18 required. [c]OLF: other labeled formulation.

***Are Penetrating Surfactants Important?*** Radiant, Agri-Mek and Movento must penetrate leaves to maximize effectiveness against thrips. Therefore, a penetrating surfactant must be included in the spray tank. There are many types of penetrating surfactants to choose from, and research in New York showed that these insecticides performed equally well against thrips when using any of the following surfactants: **Induce** (non-ionic), **MSO** (methlyated seed oil) or **Silwet L-77** (organosilicone).

In 2011, thrips control was evaluated using Movento with varying rates of Induce. Thrips larvae in all of the Movento treatments were significantly lower than those in the untreated control and Induce-only treatments **(Fig. 1).** The level of thrips control significantly increased as the rate of Induce increased, with the best control being achieved with the 0.5% vol:vol rate.

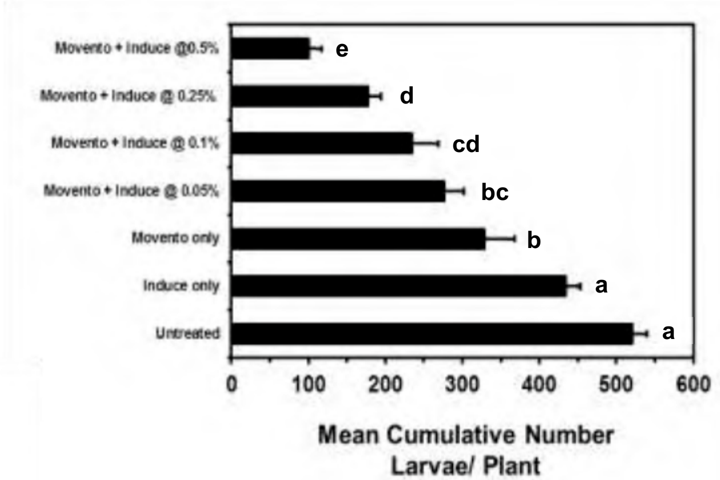


**Figure 1.** Mean number of onion thrips larvae per plant in plots treated with Movento and various rates of Induce.

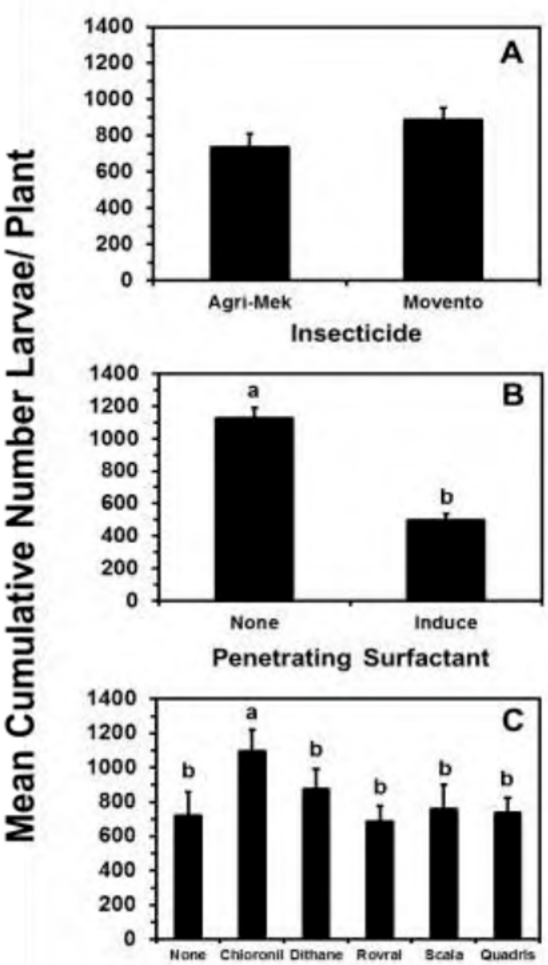


**Figure 2.** Total number of thrips larvae per plant in various insecticide, penetrating surfactant or fungicide treatments in New York in 2011.

***Do Tank Mixes with Fungicides Affect Control?*** We noticed a drop in thrips control when Agri-Mek and Movento were "tank mixed" with a fungicide that included a spreader sticker (e.g., Chloronil and Bravo Weather Stik). We were concerned that the spreader sticker used to aid in leaf disease control interfered with the insecticide's ability to penetrate the leaf surface. While spraying insecticides separately from fungicides would eliminate this problem, it also would be a more costly and less efficient approach to managing thrips and foliar diseases. Therefore, studies were carried out to understand how various combinations of insecticides, penetrators, fungicides and spreader stickers affected the level of thrips control. As we feared, when Radiant, Agri-Mek and Movento were combined with Chloronil 720, which contains a spreader sticker, **thrips control was significantly reduced by 12 to 35%**.

In a similar trial in 2011, the efficacy of Agri-Mek SC and Movento were evaluated when tank mixed with other fungicides to determine if the reduction in efficacy observed with tank mixes of Chloronil 720 occurred with other fungicides. In addition to the insecticide x fungicide mixtures, half of the treatments included Induce @ 0.5% vol:vol, while the other half did not include a penetrating surfactant. Two applications were made one week apart and the numbers of thrips larvae were recorded one week after each spray. The total number of thrips in the untreated control over the two sampling dates was very high, exceeding 1,500 larvae per plant in the untreated control (over 150 larvae per leaf; data not shown). When averaged across all fungicide and penetrating surfactant treatments, Agri-Mek and Movento provided an equivalent level of thrips control **(Fig. 2A).** When compared with numbers in the untreated control, these products reduced the thrips population by around 50%. The total number of onion thrips larvae per plant in plots that did not include Induce was significantly higher than the number in plots that included Induce, indicating the importance of using a penetrating surfactant with Agri-Mek and Movento for controlling thrips **(Fig. 2B)**. When all Movento and Agri-Mek treatments were averaged (with and without Induce), the mean cumulative number of thrips larvae in the Chloronil 720 treatment was significantly greater than numbers in the untreated control and all other fungicide treatments (**Fig. 2C).** No significant differences existed among the other fungicide treatments. Our results indicated that Chloronil 720 interfered with the ability of Movento and Agri-Mek to control thrips. **To manage onion thrips most effectively, these insecticides should be applied with a penetrating surfactant, and should be applied separately from chlorothalonil-based fungicides like Choronil 720 and Bravo Weather Stik.**

***Managing Insecticide Resistance***. Insecticide resistance in thrips populations is a major concern. Resistance in thrips populations to the pyrethroid Warrior has been documented in many onion fields in the Great Lakes region. Resistance in thrips populations to organophosphates and carbamates may be common as well. Caution should be taken when using products in these classes. If you see that you are not getting a high level of control and think resistance may be the cause, contact your extension educator. Because only a few highly effective products are available for thrips control and insecticide resistance is a concern, targeting the same generation of thrips with one product is suggested to slow down resistance. To do this, the same product should be timed within 7 to 10 days of each other.

**Timing Insecticide Applications.** Onion fields should be scouted for onion thrips each time before a decision is made to spray the field. In many cases, infestations will begin along an edge or edges of the field. When weather is hot and dry, thrips populations can build rapidly and thresholds can be reached very quickly. In this case, scouting may need to occur more frequently. In contrast, if weather is cool and wet, weeks may go by before the thrips population increases to the threshold.

Timing insecticide applications following an action threshold can be challenging because of weather events (*e.g*., rain) and other farming practices (*e.g*., timing fungicide sprays). However, using an action threshold to determine when to spray can save money and time and keep resistance from developing as quickly. Based on results from field studies from 2006 - 2012, we found that the utility of an action threshold is highly dependent on the efficacy of the product used **(Table 2).** For example, Radiant continues to be the most effective product and provides excellent thrips control when applied at a threshold of 3 thrips larvae/leaf. Radiant has such good activity against onion thrips that it can control a population even when it has been allowed to build to a relatively high level. In contrast, Movento, Lannate LV and often Agri-Mek need to be applied using a more conservative threshold (only 1 thrips larva per leaf) in order to manage the infestation.

**Table 2. Action thresholds for selected insecticides suggested for managing onion thrips on onion.**

| Products | Active Ingredient | Action Threshold |
|---|---|---|
| Radiant SC | spinetoram | 3 thrips per leaf |
| Agri-Mek SC | abamectin | 1 thrips per leaf |
| Movento | spirotetramat | 1 thrips per leaf |
| Lannate LV | methomyl | 1 thrips per leaf |

**Sequences of Insecticide Applications for Season-Long Control.** Insecticides that belong to the same insecticide class or have the same mode of action used repeatedly against some insect pests can accelerate the development of insecticide resistance. The Colorado potato beetle and diamondback moth are notorious for developing resistance and rotation of insecticide classes has extended the life of products used to manage them. To avoid insecticide resistance development in thrips populations, products belonging to different insecticide classes (a class is based on mode of action- see http://www.irac-online.org/teams/mode-of-action/) are suggested to be applied following the guidelines in **Tables 3 & 4**. Additionally in each field, no product should be applied more than twice and applications of the same product must be made consecutively. Sequences and products selected for the examples below are based on years of experience working in small-plot research trials and commercial fields. **These sequences will provide season-long thrips control AND ideally reduce the development of insecticide resistance**.

The insecticide treatment windows for onion thrips varies considerably among onion fields because the period between thrips colonization and crop maturity varies considerably. In most cases, transplanted onion fields will need to be sprayed earlier and for a shorter period compared with direct-seeded onion fields. For transplanted fields, the first insecticide application is needed in early to mid-June and protection is required for about 4 to 6 weeks. For direct-seeded fields, the first application is often needed in late June to early July and protection is required for 6 to 8 weeks. These generalizations were taken into consideration to estimate the number of sprays needed in a sequence to protect the onion crop from thrips **(Tables 3 & 4)**.

Sequences begin with Movento and end with Radiant (**Table 3 & 4).** Do not use Movento if huge numbers of onion thrips adults have recently migrated into the field from nearby alfalfa or small grains because Movento is weak against adults. Agri-Mek and Lannate LV are options between Movento and Radiant applications. Agri-Mek has a 30-day pre-harvest interval, so it should not be used late in the season. **Radiant is the most effective product against larvae and adults, so it is positioned at the end of the insecticide use sequence when adult thrips populations are often highest.**

**Table 3. An effective sequence of insecticide products to follow for onion thrips control in transplanted onion fields. Each application should be applied based on suggested action thresholds.**

**Transplanted onions***

| Application # | Product | Action threshold/ Timing of spray to consider |
|---|---|---|
| **1** | Movento | 1 thrips larva per leaf |
| **2** | Movento | 7 to 10 days after 1st Movento spray only if needed [1] |
| **3** | Agri-Mek SC | 1 thrips larvae per leaf |
| **4** | Agri-Mek SC | 7 days after 1st Agri-Mek spray |
| **5** | Radiant SC | 3 thrips larvae per leaf |
| **6** | Radiant SC | 3 thrips larvae per leaf |

*Note: If after using Movento and Agri-Mek (first four sprays) there are at least 4 weeks remaining before onions are pulled, consider inserting two applications of Lannate between the Agri-Mek and Radiant sprays (see options for direct-seeded onions below). Conversely, if after using Movento there are only 2 to 3 weeks remaining before onions are pulled, eliminate the Agri-Mek sprays and go directly to Radiant.

[1] If the thrips population is reduced well below 1 thrips per leaf one week after the first Movento spray and does not reach threshold again until 14 or more days after the first application, consider not using Movento a second time. Based on insecticide resistance management principles, an application at this time would affect the next generation of thrips and this should be avoided if possible. The recommendation would be to continue the sequence with the next product, which would be either Agri-Mek or Radiant.

**Table 4. An effective sequence of insecticide products to follow for onion thrips control in <u>direct-seeded</u> onion fields. Each application should be applied based on suggested action thresholds.**

**<u>Direct-seeded onions*</u>**

| Application # | Product | Action threshold/ Timing of spray to consider |
|---|---|---|
| **1** | Movento | 1 thrips larvae per leaf |
| **2** | Movento | 7 to 10 days after 1st Movento spray only if needed [1] |
| **3** | Agri-Mek | 1 thrips larva per leaf |
| **4** | Agri-Mek | 7 days after 1st Agri-Mek spray |
| **5** | Lannate* | 1 thrips larvae per leaf |
| **6** | Lannate* | 7 days after 1st Lannate spray |
| **7** | Radiant | 3 thrips larvae per leaf |
| **8** | Radiant | 3 thrips larvae per leaf |

*Note: If control of thrips using Movento and Agri-Mek (first four sprays) has provided control up to 2 or 3 weeks before onions will be pulled, eliminate the Lannate applications and go directly to Radiant.

**[1] Same as comment in footnote #1 in Table 3.**

**<u>Additional Thoughts on Controlling Thrips</u>.** Insecticides should be applied with ground rigs using moderate pressure and a high volume of water and proper nozzle types and spacing. The goal should be to cover as much of the onion canopy as possible. Research at Cornell showed that applications made using at least 40 gpa, 40 psi and twin-flat fan nozzles achieved excellent coverage and also should minimize drift.

Other ways of controlling thrips besides using insecticides are being studied. For example, our research team at Cornell has shown that thrips populations can build on early season volunteers and that some of these volunteers may be infected with *Iris yellow spot virus*, so removing volunteers as early as possible should be part of an overall management strategy. Our team also has shown that reducing the amount of nitrogen at planting will reduce populations of onion thrips larvae during the season. Reducing the amount of nitrogen applied to onion fields will save money and potentially may reduce the percentage of bacterial rot problems in storage. Additionally, we have shown a difference among onion cultivars in their susceptibility to thrips feeding. Cultivars that have a yellow-green leaf color and lower levels of wax were less susceptible to thrips feeding compared with blue-green color foliage with higher levels of wax. While additional work needs to be done on these alternative management practices, experimenting with other ways of reducing thrips infestations will be important to preserve the very few effective insecticides.

# An IPM Approach to Managing Bacterial Diseases of Onions

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***Bacterial diseases are a serious threat to sustainable onion production:*** Bacterial diseases of onions have become a serious threat to the sustainability of the New York onion industry. Losses up to 40% or more can occur as a result of reduced onion quantity and quality. The bacterial pathogens, *Burkholderia cepacia*, *Pantoea ananatis, Pantoea agglomerans* and *Enterobacter cloaceae* are the most common that plague onions in New York. Most recently, *Rhanella* species have been isolated from about 40% of cull onions out of storage, and these bacteria also cause symptoms when introduced into healthy bulbs. These pathogens have been found to commonly occur in NY soils where onions are grown. Some are known to enter the plant via the leaves and neck, and from there, infection progresses down into the bulb. Because bacterial bulb decay often affects only a single internal scale while the outer scales remain firm, making these infected bulbs virtually impossible to detect. When such onions are shipped and consequently rejected, often entire loads are dumped, despite only a small percentage of bulbs being infected, resulting in significant economic losses for growers.

***The solution lies in an integrated approach:*** Ultimately, an Integrated Pest Management (IPM) approach will be required to manage bacterial diseases of onions, which might involve many different tactics including field sanitation, less susceptible varieties, materials that induce plant resistance, bactericides, crop rotation, anti-bacterial cover crops, soil amendments, strategic curing conditions, imaging technology to detect internal rots prior to shipping, and also, regulating plant spacing and reducing nitrogen fertility. Researchers and Extension professionals at Cornell and Nationwide have been working on several of these components.

***Where does the bacteria come from?*** In combating plant diseases, it is always important to know the source(s) of inoculum. In New York, through a collaborative effort among Plant Pathologist, Dr. Steven Beer and his associates, Extension Educators and onion growers, seed, bare root transplants and soil have been tested for presence of bacterial pathogens.

**Not from infected seed:** Very small samples of 10 seed lots were tested for presence of bacterial pathogens in 2010 and they all tested negative.

**Some bare root transplants are infected with bacteria:** In 2010, five samples of 50 plants of bare root transplants all tested negative for bacterial pathogens. In a follow-up study in 2011, nonpathogenic strains of *Pantoea agglomerans* were isolated from all 11 lots of sampled bare root transplant onions. However, pathogenic strains of endophytic *Pantoea agglomerans* were isolated from two of the 11 (=18%) lots of transplants when the plants were surface sterilized. These results suggest that transplants may carry some pathogenic bacteria into onion fields. The importance of this is likely a function of whether the field into which the transplants are to be planted is free of the pathogen or whether the pathogen is already present in that field.

**Soil is the most important source of pathogenic bacteria:** In 2010, out of 16 muck soil samples collected in the spring from onion fields within a few weeks of onion planting, in 1 (=6.25%) and 16 (=100%) fields, pathogenic strains of *Pantoea ananatis* and *Burkholderia cepacia*, respectively, were isolated. In addition, other bacterial pathogens of onion, *Enterobacter cloacae* and *Pantoea agglomerans* were isolated from several of the soil samples. In 2011, all pathogens were found in more than 78 samples of muck soil samples that were analyzed for pathogenic bacteria of onions. These results suggest that soil may be the most important source of inoculum for several pathogens that are responsible for the extensive losses due to bacterial diseases sustained by onion growers. How and when bacterial pathogens get from the muck soil and into the onion plant is not well understood, although via splashing rain and blowing wind are plausible theories.

***Crop rotation and anti-bacterial cover crops:*** Since soil appears to be the most important source of inoculum for bacterial pathogens of onions grown in muck soils, investigating the potential of reducing this source of inoculum is warranted. Evaluation of Brassica cover crops and soil amendment with mustard meal for reduction of pathogenic bacterial inoculum in muck soil is in its infancy in New York.

Brassicas contain glucosinolates, which are released when the cover crop decomposes, and can serve as a biofumigant against nematodes and soil-borne pathogens. Efficacy against bacterial pathogens has not been documented specifically. In a preliminary study in New York, forage rapeseed and forage radish were planted in late-August following the harvest of an early onion crop. They were not mowed and incorporated in the fall according to the biofumigation protocol, because there is ample evidence for the beneficial effects on the microbial community with just letting them winter kill, and such implementation would be much easier for New York conditions. The cover crops were chosen to differ in their root growth and date of winter kill. Mustards were not selected, despite having higher glucosinolate concentration, because they flower in the fall and onion growers are wary of them becoming weeds. Also, the stems tend to maintain snow cover 2-3 weeks longer in the spring, which is an undesirable trait for onions that need to be planted early. The current challenge with this study is that the protocol to identify and quantify bacterial pathogens in muck soil following these different cover crop regimes is still under development.

***Soil amendments:*** Mustard meal is the pulp that remains after pressing oil from mustard seed grown in the Western US for production of biodiesel. Because it contains glucosinolates, when incorporated into soil, it has shown promise for control of soil-borne pests including nematodes, weeds, and fungi. Several reports suggest that mustard meal is bactericidal, but its effect on soil-borne plant pathogenic bacteria has not been reported. If mustard meal is effective in reducing bacterial rot, it may constitute a novel tool for biological control of bacterial decay of onions. In addition, the other desirable effects of mustard meal, such as weed, fungal and nematode control and nutrient supplying might be realized. Preliminary laboratory studies are underway at Cornell to investigate whether mustard meal applied to muck soil has bactericidal properties against onion pathogens. Unfortunately, this project is also challenged by the need for a reliable protocol to identify and quantify bacterial pathogens in muck soil.

***Bactericides:*** Use of copper bactericides to manage bacterial diseases of onion is the most common practice, although at best they may only suppress bacterial diseases. Best results are generally achieved when copper bactericides are applied with an ethylenebisdithiocarbamate (EBDC) fungicide such as mancozeb and when they are applied preventatively and regularly.. Consequently, growers may make eight or more copper/EBDC applications per season to suppress disease. It has been reported in PA that weekly sprays of various bactericides including Oxidate (hydrogen dioxide) starting as early as the second week in May when onion plants have just 5 leaves and continuing until the pre-harvest entry interval of the bactericide still resulted in unacceptably high incidence of bacterial disease (i.e. >30%). Extensive use of copper bactericides is not sustainable, because bacteria are prone to developing resistance, and their use is expensive and not good for the environment. In order for bactericides to work, they need to be part of an IPM program.

***Resistance inducer materials:*** Resistance inducer (RI) materials are a diverse group of natural products including bacterial and plant extracts and chemically synthesized derivatives of natural products that stimulate the natural defenses of the plants, and offer an entirely different mechanism by which externally applied materials might be used to manage plant pathogens. Of particular interest is induction of systemic acquired resistance (SAR) where the entire plant becomes "primed" to more successfully resist subsequent invasions, and respond more quickly and effectively to new infections. Actigard (active ingredient acibenzolar-*S*-methyl), Employ® (recombinant harpin protein) and Regalia® (biopesticide produced from extracts of the giant knotweed *Reynoutria sachalinensis*) are RI materials labeled for use on onions in New York. The effects of these products on onion diseases have not been evaluated extensively, although Actigard™ has shown activity against Xanthomonas bacterial leaf blight in Colorado. In New York in 2011, preliminary field studies showed that single applications of Actigard and Employ made 15 days prior to artificial inoculation significantly reduced bacterial bulb decay caused by *Pantoea ananatis* by approximately 50%. In the same study, Regalia had no effect on incidence of bacterial disease. These results showed that RIs may have promise as a new and effective tool for onion growers to manage bacterial diseases of onions. Further field testing is underway to confirm their efficacy against different bacterial pathogens and to determine the best spray regime (i.e. crop stage, number of applications, etc.).

***Onion thrips:*** In Georgia, tobacco thrips have been shown to vector *Pantoea ananatis*. In New York, onion thrips are the dominant species of thrips that occur in onions. Late in the season in 2011, samples of onion thrips were collected from onion foliage and found to harbor pathogenic bacteria both on their surfaces and in their internal tissues. *Pantoea ananatis*, *Pantoea agglomerans*, and *Enterobactor cloacea* were detected on both the body surfaces and in internal tissues, while *Burkholderia cepacia* was also found on the body surfaces and *Pantoea vagans* was found in the internal tissues. Whether the bacteria recovered were incidental or capable of being transmitted to bacteria-free plants requires further investigation.

In one study in New York in 2010, incidence of bacterial bulb decay at harvest where onions were sprayed weekly for onion thrips was double that of where the onions were not sprayed for thrips. Currently, there are two theories behind this counter-intuitive finding that require further testing: 1) in the treated plots, there are new thrips colonizing the plants on a weekly basis, and if thrips are capable of introducing bacterial inoculum, than there is more opportunity for such introductions to occur in this scenario compared to when thrips populations are allowed to build uninterrupted in the non-sprayed plots, and 2) the penetrating properties of the adjuvants that accompanied the insecticides used to control the onion thrips may have resulted in easier entry for bacterial pathogens to enter into the onion plant. In 2011, a field study was conducted to determine the role of adjuvants in the development of bacterial diseases of onions.

***Modified Cultural Practices***

**Reduced plant spacing:** In small-scale production of fresh market onions on plastic mulch on mineral soil in New York and Pennsylvania, studies have shown that narrow plant spacing can have profound effects on the degree of bacterial decay. Results showed that narrowing plant spacing by 2 inches compared to the growers' standard of 6 or 8 inches, provided 44 to 66% control of bacterial bulb decay at harvest, while increasing marketable yield by 120% to 220%. The net return to the grower from the narrower spacing was up to $258 more per 100 feet of bed than the growers' standard. Results suggested that wide spacing produced big plants with bushy leaves, thick necks and delayed maturity, and the resulting colossal sized bulbs had more bacterial bulb decay.

In 2011, a preliminary trial was conducted to determine whether narrowing plant spacing was applicable to large-scale onion production that is typical for direct seeded onions grown in muck-land soil at much higher plant densities than onions grown on plastic in mineral soils. Three seeding rates, 5.3, 7.5 and 10 seeds per foot, were evaluated in each of two varieties, Nebula and Prince. Onions were direct seeded into 32" wide raised beds with two single rows of onions spaced 12 inches apart on the bed. The trial was established in muck soil by a grower cooperator in Oswego County, New York.

**Reduced nitrogen fertility:** In 2010, an important observation was made in a small-plot on-farm field trial in onions grown on plastic in Pennsylvania. The plots located at the bottom of the slope had 83% bacterial bulb decay at harvest. The amount of decay decreased progressively in each replicate moving up the slope to 58% to 17% to 0% in the replicate at the top of the slope. The trial was located on a diversified farm that had been heavily manured. Perhaps, heavy rainfall had caused nitrogen to leach from the top to the bottom of the slope, and thus, increased nitrogen at the bottom of the slope may have contributed to the higher levels of bacterial bulb decay.

Also in 2010, incidence of bacterial bulb decay at harvest was assessed in a study that was designed to evaluate the effect of nitrogen on onion thrips. In that study, onions grown with only 2.0 lb/A of applied nitrogen had 0.7% bacterial rot at harvest. Onions grown with the Cornell recommended rate of 125 lb/A of nitrogen had 10.8% bulb decay, which was 15 times more than the rot that occurred at the 2.0 lb/A rate. Compared to the recommended rate, onions grown with reduced rates of applied nitrogen, 62 and 94 lb/A, had significantly less than half (4.9%) and one third (7.3%), respectively, of bacterial decay without any significant differences in yield.

In 2011, 22 muck land direct seeded onion fields were surveyed in New York from seven growers in seven counties, and included six varieties. Levels of bacterial bulb decay occurred at relatively low levels and ranged from 0 to 17.4% at harvest. The variety, Hendrix had the widest range of bacterial rot. In this variety, the strongest correlation occurred between percent bacterial bulb decay at harvest and available nitrate-nitrogen ($NO_3$-N) in the soil in the mid-season at the 7-9 leaf stage. The fields with the highest available nitrogen also had the highest incidence of bacterial rot at harvest. Across the 66 sub-samples, available $NO_3$-N in mid-season ranged from 70 to 936 ppm with an average of 296 ppm. These results suggest that there is opportunity to manage nitrogen fertility more efficiently and effectively with the potential benefit of reducing losses from bacterial diseases.

In 2011, three rates of nitrogen, 0, 45 and 90 lb per acre were also evaluated with the three seeding rates in each of two varieties in the large-scale direct seeded onion field trial in muck soil in Oswego. Unfortunately, soil test results showed no difference between the 0 and 45 lb per acre rates of nitrogen, so they were pooled together as "low nitrogen 0-45 lb/A". In the Oswego County trial, there was an average of 0.44% and 1.5% bulb rot at harvest and out of storage, respectively. Nevertheless, this trial suggested some interesting relationships and revealed several horticultural effects.

***Variety had an effect on bacterial decay:*** Variety was the only variable where there were significant differences in bacterial decay. Nebula had almost double the bulb decay as Prince. Assuming this difference was to transfer to situations where bacterial disease pressure is higher, then selecting less susceptible varieties may be a very important factor in managing bacterial diseases of onion. This warrants further investigation and a preliminary study is underway in New York to evaluate the relative susceptibility of onion varieties commonly grown in New York to bacterial diseases.

***Low nitrogen and high seeding rate had less bacterial decay:*** As expected, when the results were pooled across variety and seeding rate, the incidence of bacterial disease was 1.5 times higher with the high rate of nitrogen (90 lb/acre) than the low rate (0 to 45 lb/acre). Similarly, the highest seeding rate (10 seeds/ft) had only about half the bacterial bulb decay as the standard seeding rate (7.5 seeds/ft). However, not as expected, the lowest seeding density (5.3 seeds/ft) did not have higher incidence of bacterial decay than the standard. A breakdown of the data indicated that Prince had higher incidence of bacterial rot as seeding rate decreased in both rates of nitrogen, but especially at the high rate of nitrogen, while Nebula did not exhibit any consistent trends. Thus, it seems that different varieties respond differently to reduced nitrogen and increased spacing, which may be related to plant vigor, and future studies should aim to understand these interactions.

***An integrated approach should not compromise yield:*** Our preliminary results indicate that applying less nitrogen and decreasing plant spacing may be useful for managing bacterial diseases of onions. For either of these strategies to be feasible, they must not reduce yield. When the results were broken down, the highest seeding rate consistently had the highest yield in both varieties only with the high nitrogen rate. At the low nitrogen rate, seeding rate did not have an effect on marketable yield in the larger variety, Prince. In Nebula, the lowest seeding rate had 49 (= 6.5%) and 57 (=7.6%) cwt/A less total marketable yield than the high and standard seeding rates, respectively. These results remind us that increasing seeding rate and reducing nitrogen to the extent that each component works best independently may compromise yield due to nitrogen deficiency. Different varieties with different vigor and days to maturity may also respond differently to these factors. Small and medium sized onions tend to fetch lower prices and may be in limited demand. Of course, if high nitrogen rates and low seeding rates result in high levels of bacterial bulb decay, increased yields from smaller sized onions may very well be more feasible economically than larger rotten bulbs.

**Post-harvest treatments:** In a study conducted in Washington State in 2009 and 2010, it was shown that bacterial bulb decay caused by *Burkholderia cepacia* increased with curing temperature (77, 86, 95 and 104 degrees F), length of curing (2 vs. 14 days) and number of months in storage (1, 2 or 3 months). These results suggest that postharvest curing at temperatures <95 degrees F for a limited duration can significantly reduce the severity of sour skin in storage. Alternatively, in cases where a single internal scale is infected with *Burkholderia cepacia* while the external scales remain firm making detection on the grading line virtually impossible, curing such a lot of onions at temperatures > 95 degrees F for a several days may accelerate the development of the bacterial bulb decay and make the infected bulbs easier to detect on the grading line. Research is also underway in Georgia to develop imaging technology to detect internal bulb decay prior to shipping.

**At the mercy of the weather:** A tremendous amount of research is underway across the country to understand the bacterial pathogens of onions and to develop an integrated management strategy to manage bacterial diseases of onions. It is expected that tremendous progress will be made within the next five years. However, when weather conditions are conducive to the development of bacterial diseases, specifically, when onions are exposed to hail injury, or wet and hot weather, or continuous wet weather, expect it to be a battle to manage bacterial diseases, and in some fields, the battle may be lost and excessive losses to bacterial bulb decay will occur. Alternatively, in a dry year, losses due to bacterial diseases in onions are usually minimal. The old standby will always apply: in a cool wet year, size and yield go up as quality goes down, while in a hot and dry year, size and yield go down, but quality is very good.

**For more information** on any of the studies mentioned here, contact Christy Hoepting, cah59@cornell.edu or 585-721-6953.

# Onion Disease Update

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Commonly occurring foliar diseases of onion in Michigan include purple blotch (*Alternaria porri*), Stemphylium leaf blight (*Stemphylium vesicarium*), and Botrytis leaf blight (*Botrytis aclada* = *B. allii*, *B. cinerea*, *Botrytis squamosa*). All can defoliate the crop prematurely, and at least one of these diseases was detected in Michigan onion fields for each of the last two years. Foliar pathogens compromise bulb quality, resulting in storage rot caused by secondary bacterial pathogens.

Diseases seen in low incidence recently have included smut (caused by *Urocystis cepulae* = *U. magica* or *U. colchici*) and iris yellow spot virus (IYSV) in 2011-12; bacterial center rot (*Pantoea ananatis* = *Erwinia ananatis*), *Fusarium* spp., onion yellow dwarf virus (OYDV) and aster yellows in 2011; and bacterial flower stalk and leaf necrosis (*Pantoea agglomerans*) in 2012. Smut symptoms include streaks on leaves, leaf sheaths, and bulbs that are filled with a dark-brown, powdery mass of spores. Affected leaves become twisted and deformed and eventually may die or are shed during the second month of the growing period. This fungus is able to cause infection from about the second day after germination of the onion until the seedling has one leaf. Basal rot (*Fusarium oxysporum* f. sp. *cepae*) causes above-ground symptoms of yellowing and curling necrosis at the leaf tips. Infected roots turn dark brown, flatten, and often completely die. White mycelium may colonize the basal plate in advanced stages of infection.

Bacterial center rot symptoms include blighted leaves, bleached and rotted seed stalks, and bulb rot. Bacterial flower stalk and leaf necrosis. IYSV is vectored by onion thrips and symptoms include straw-colored, dry, tan, elongated lesions on the leaves and scapes (flower stalks) of onion plants. Some have green centers with yellow or tan borders, some appear as concentric rings of alternating green and yellow/tan tissue. Infected leaves or scapes will lodge during the latter part of the growing season. Above-ground symptoms may be similar to Fusarium basal rot, but roots are healthy in IYSV-infected plants. The first symptoms of OYDV in young onions are yellow streaks at the bases of the first true leaves. All leaves developing after these initial symptoms show symptoms ranging from yellow streaks to complete yellowing of leaves. Leaves are sometimes crinkled and flattened and tend to fall over. Bulbs are undersized. Aster yellows (phytoplasma) causes yellowing that occurs at the base of the youngest leaves and spreads toward the top. Leaves flatten but do not twist, and become marked with yellow and green streaking.

Onions in all fields sampled in 2011-2012 showed pink root symptoms caused by the fungus *Setophoma terrestris* (formerly *Phoma* or *Pyrenochaeta terrestris*). The disease appears to be common in Michigan and is an especially serious problem during hot summers. Gradually, the pathogen turns the roots turn dark pink to red, and dark purple as the disease advances. As the disease develops, infected roots become water-soaked, shriveled, and later disintegrate. As the root system is reduced, affected plants show drought symptoms, stunting, and reduced bulb size, but are usually not killed.

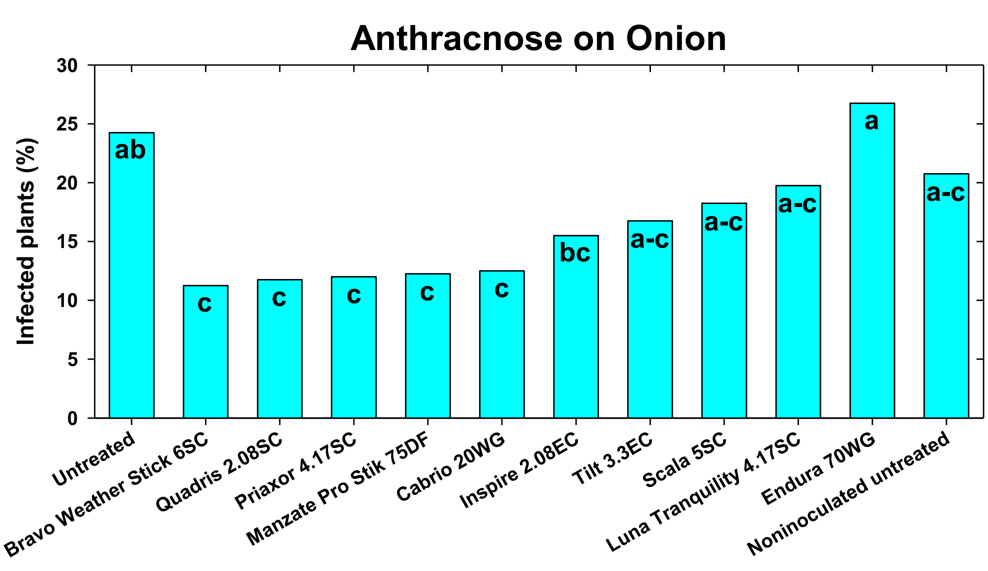
A new fungal foliar disease was observed on Michigan onions in 2010 and has been found in fields each subsequent year. Affected bulbs showed lesions that were bleached in color; lesions all along the leaves including those near the neck and bulb were observed. A *Colletotrichum* sp. was observed and determined to be *Colletotrichum coccodes*. In some cases, other foliar blights common to onions were present along with the *Colletotrichum* lesions. In other fields, the onion leaves were green and healthy, but were peppered with *Colletotrichum* lesions.

**Onion Anthracnose Fungicide Field Trial.** A fungicide trial was conducted at the Southwest Michigan Research and Extension Center (SWMREC), Benton Harbor, MI to investigate different fungicide active ingredients for control of onion leaf and neck anthracnose (Table 1). The first fungicide application occurred when 'Infinity' onion were six weeks old. Seven-week-old onion plots were artificially inoculated with *C. coccodes* using a backpack sprayer. Fungicide applications continued on a seven-day interval after inoculation for 42 days. At the end of the trial, onions were harvested and yield of the plots was graded and weighted.

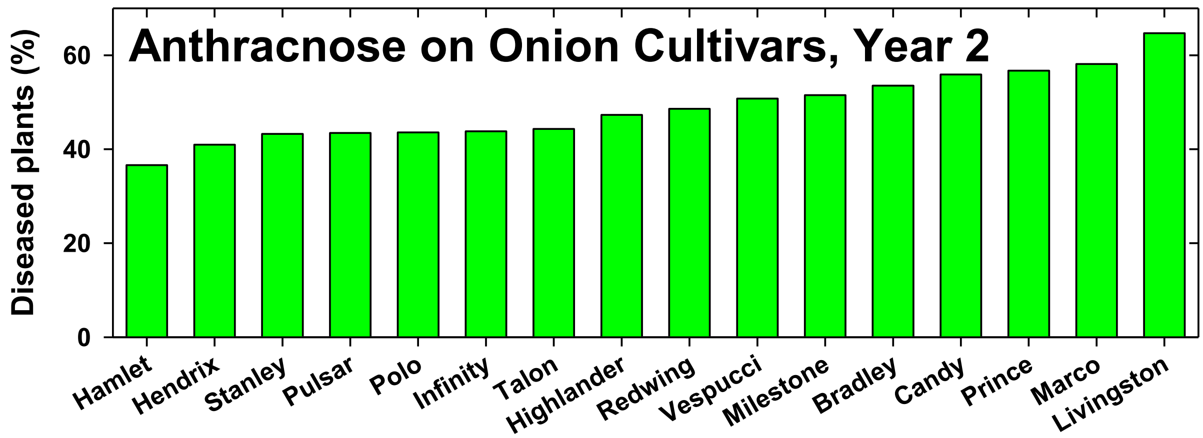
**Table 1.** Products tested for control of anthracnose of onion in 2012.

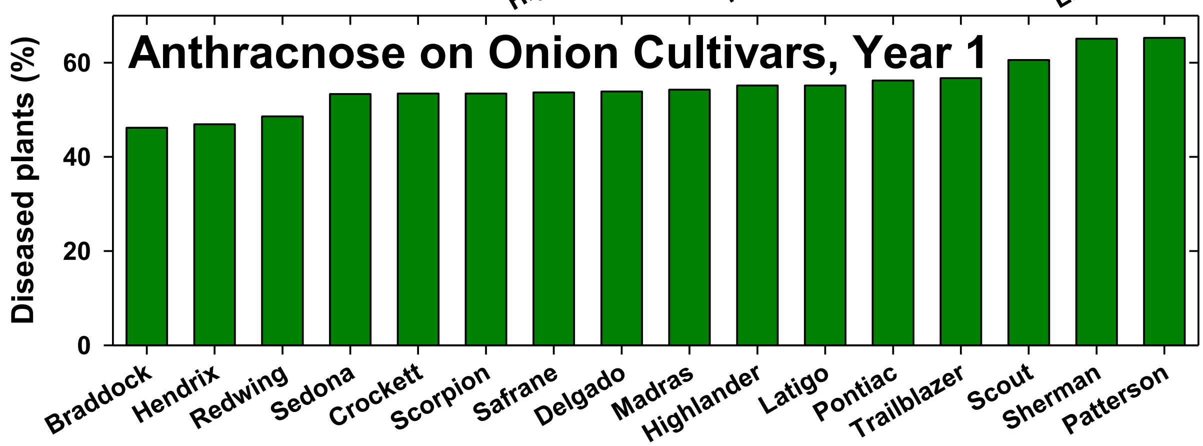
| Treatments | Active ingredient | Rate/A | Labeled |
|---|---|---|---|
| Bravo Weather Stik 6S | Chlorothalonil | 2.0 pt | Yes |
| Cabrio 3.3EC | Pyraclostrobin | 12 oz | Yes |
| Endura 70WG | Boscalid | 0.46 lb | Yes |
| Inspire 5SC | Difenoconazole | 7.0 fl oz | No |
| Luna Tranquility 4.17SC | Fluopyram/Pyrimethanil | 1.0 pt | No |
| Manzate Pro Stik 75DF | Mancozeb | 3.0 lb | Yes |
| Priaxor 4.17SC | Fluxapyroxad/Pyraclostrobin | 0.38 pt | No |
| Quadris 2.08SC | Azoxystrobin | 12 fl oz | Yes |
| Scala 20WG | Pyrimethanil | 1.1 pt | Yes |
| Tilt 2.08EC | Propiconazole | 8 fl oz | Yes |

Bravo, Quadris, Priaxor, Manzate Pro Stik, and Cabrio were especially effective in managing anthracnose on onion (see graph, below).



**Anthracnose cultivar trials.** Two cultivar trials were conducted at SWMREC. Onions were inoculated as described for the fungicide field trial. Onion leaf and neck anthracnose symptoms were observed fourteen days after inoculation. Number of symptomatic plants in 13 ft of row per treatment



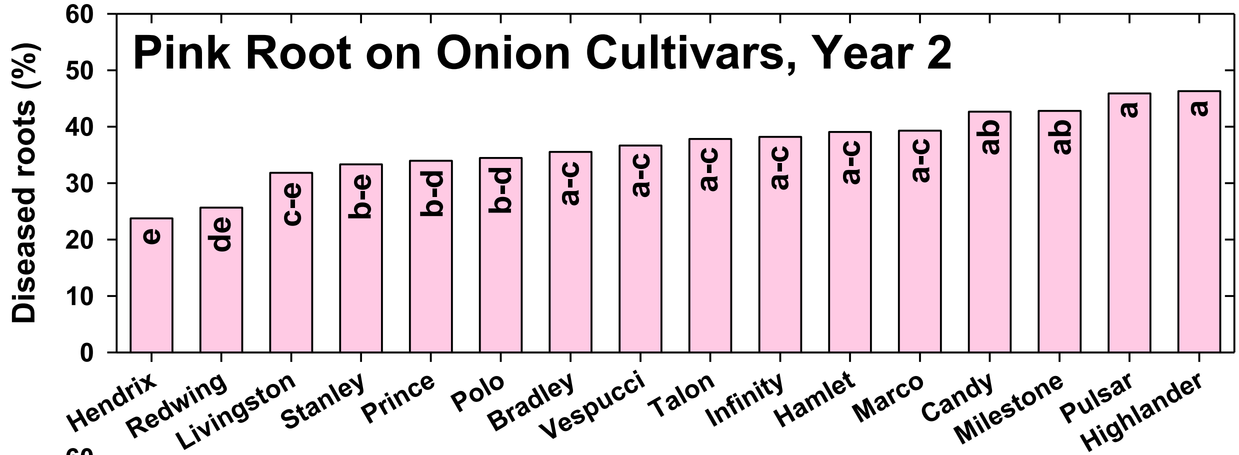



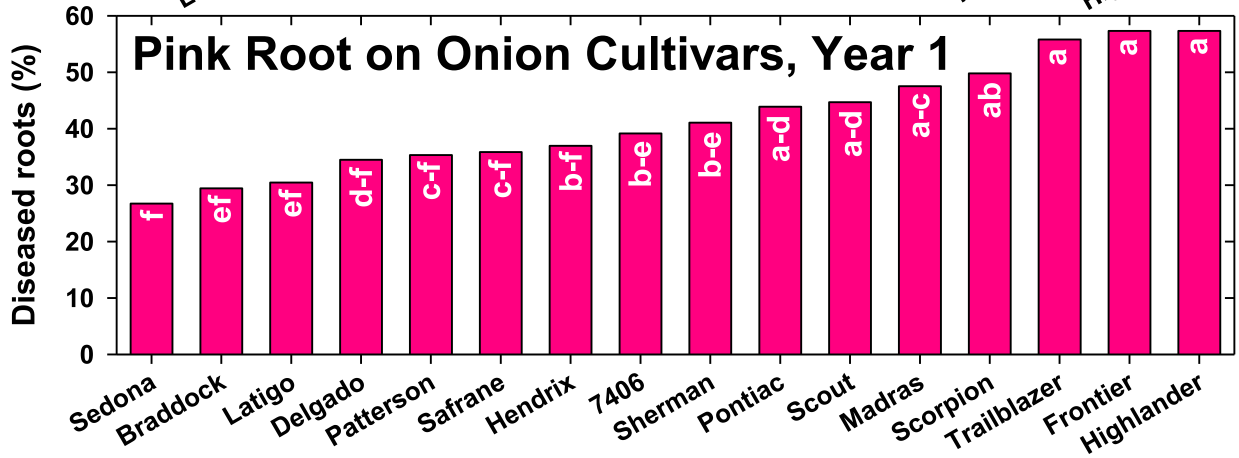

were counted weekly for seven weeks. At the end of the trial, onions were harvested and yield of the plots was graded and weighted.

'Hamlet,' 'Braddock and 'Hendrix' showed a trend of a reduced incidence of infected plants, although all cultivars showed a high incidence of anthracnose (see graphs, above).

**Pink root cultivar trials.** Studies were conducted in 2012 in Lansing, MI, in a field with a history of pink root from the previous year. The field was a muck soil with a history of carrot, potato, and onion as previous rotational crops. The experiment was designed as a randomized block with four replicates. Individual plots were planted with 16 onion varieties in four rows wide by 500 feet in length. Seeds were planted on 12 April. Samplings were conducted on 19 and 27 June, 17 and 31 July, and 22 August. Eight bulbs of each replicate were evaluated for pink root disease (%) = number of roots with pink coloration/total number of roots x 100.

Several onion cultivars had fewer roots infected with the pink root pathogen compared with others included in the trials (see graphs, next page). In each of the two trials, 'Highlander' had a high incidence of pink root compared to other cultivars but did not separate out from other highly infected cultivars (i.e., 'Pulsar,' 'Frontier' are examples).




**Acknowledgments.** This material is based upon work supported by USDA NIFA SCRI Subaward 2010-1365-07, MSU GREEEN GR11-020, and the Michigan Onion Committee.

# Growing Onions in a Minimum Tillage System

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Growing onions in a minimum tillage system would drastically reduce the negative economic and environmental consequences of erosion, while sustaining long-term production of onions grown on muck soils.

**Onions grow best in muck soil:** Large-scale production of direct seeded pungent cooking onions occurs predominantly on muck soils in New York, Michigan and Wisconsin in the United States, and in Ontario and Quebec in Canada. By definition, muck or organic soil contains a minimum of 20% organic matter. High quality muck in New York averages 45 to 55% organic matter. Muck soils are non-renewable resources that were developed underwater by many generations of plants that were preserved under anaerobic conditions. It takes nature about 500 years to accumulate one foot of muck soil. Onions grown on muck soils can be of superior quality and yield than those grown on mineral soils, because the soils' very dark color and high organic matter allow for an early planting advantage for this long season crop, a higher water holding capacity and provision of a steady water supply via tiling and irrigation in muck lands, and the high sulfur content of muck improves onion flavor, cooking quality and storability.

**Muck soils are eroding away at a high price to growers and the environment:** Unfortunately, muck soils are prone to subsidence, which is the permanent lowering of the surface elevation, a phenomenon resulting from the oxidation of soil organic matter by aerobic microorganisms, and by wind and water erosion. An estimated rate of soil subsidence on intensively cropped muck soil is one foot every 10 years. As much as one inch of muck can be eroded during a severe wind storm when dry muck soil is exposed to the elements. Drainage ditches can be filled in and onion seedlings can be decapitated, severely damaged, uprooted or buried during high winds. For example, in spring of 2009, despite traditional wind erosion prevention techniques (i.e. willow windbreaks and inter-row barley nurse crops), three high wind events resulted in at least 600 acres of the 3000 acres of onions grown on the Elba muck land having had to be replanted at an expense of $700 to $800 per acre. Additionally, these later planted fields never reached their full yield potential and were of inferior quality, costing growers additional hundreds of dollars per acre in lost yields and quality.

A water monitoring project conducted by the Soil and Water Conservation District of Orleans County and SUNY Brockport in 2008-2009 identified the Elba muck land as a major source of nutrient loading into the Oak Orchard water shed with excessive levels of total and soluble reactive phosphorous, and total and soluble nitrate. Waterways are certain to be polluted when spring wind storms erode freshly fertilized muck into drainage ditches. Clearly, sustainable onion production practices are absolutely warranted.

**Growing onions in a minimum tillage system will reduce erosion of muck soils:** It is scientifically proven that erosion and subsidence decrease as ground cover increases and cultivation decreases. Therefore, growing onions in a minimum tillage system would drastically reduce the negative economic and environmental consequences of erosion, while sustaining long-term production of onions on muck soils. Through funding from Northeast Sustainable Research and Education (NESARE), a muck onion grower, Matt Mortellaro, Mortellaro & Sons, Inc., and Cornell Cooperative Extension Vegetable Specialist, Christy Hoepting, set out to develop a minimum tillage system suitable for onions. Minimum tillage systems using winter-killed and spring killed cover crops, winter wheat and spring oats and barley, respectively, were compared to conventionally grown onions in large-scale 30 acre field trials in the Elba muck land in 2007-2008 and in 2010-2011.

**How to grow onions in a minimum tillage system**

***Establish a cover crop in rows in the fall, plant onions between cover crop rows:*** In many reduced tillage systems, the crop is drilled into a field that has a lot of residue and trash on the surface from the previous crop or a cover crop and the tillage strips can be five or more inches wide. Minimum tillage in onions is inherently challenging, because onions have very small seeds that are planted very shallow (0.5 to 0.75 inch) and a smooth seed bed is very important for stand establishment and surface trash could easily interfere with this. Onions are grown with relatively narrow row spacing of 10 to 20 inches, which leaves little space for non-tilled zones, almost defeating the purpose.

To overcome these issues, cereal cover crops were planted into rows and then the onions were planted in between the cover crop rows. The only modification that the onion grower made to his regular seeder was to add wavy coulters in front of the press wheel, which avoided the need for tillage in the spring interfering with the ground cover established by the cover crops. After harvesting onions, cover crops, winter wheat (2008 & 2011), spring oats (2008) and spring barley (2011) were planted into 10.5 inch rows in mid-September at 50 lb, 50 lb and 75 lb per acre, respectively. In 2008, 50 lb/A of spring oats did not result in enough ground cover the following spring (10%) to provide sufficient protection from erosion, so in 2011, a higher rate of the winter-killed cover crop was used. The following spring, the winter wheat cover crop was killed with Roundup in early April and then in mid-April, onions were seeded in between the cover crop rows. Auto-steering and global positioning system (GPS) technology were used to plant the cover crops in the fall and to plant the onions precisely between the cover crop rows in the spring, which worked extremely well. In the conventionally grown onions, a spring barley cover crop was planted in the fall, which winter-killed. Then, in the spring, the field was disked and cultimulched, onions seeded and a barley nurse crop seeded between the onion rows for wind protection. The barley nurse crop was killed when the onions were at the flag to first true leaf stage.

In the spring just prior to planting in mid-April, the conventional ground was bare, while the minimum tillage wheat system had 60% and 50% ground cover in 2008 and 2011, respectively. In both studies, ground cover dropped to about 30% late in the season. The minimum tillage oats system had only 10% ground cover in 2008, which was reduced to 0.5% by July 31. In 2011, the higher seeding rate with spring barley gave 30% ground cover in mid-April and this system still had 5% ground cover remaining at harvest on September 13-14, which provided adequate wind protection. The key advantage to growing onions in a minimum tillage system is that the soil is protected from erosion from the time that the cover crop is established in the fall until harvest with the most critical 4-6 week of protection being from early April until late May.

***Apply fertilizer in the spring:*** In the first year of study, in the minimum tillage systems, the full rates of required phosphorous (P) and potassium (K) according to a soil test, and 56 lb/A of nitrogen (N) were applied in the fall and incorporated prior to planting the cover crops. In the spring, 5 gal/A of 6-24-6 NPK pop-up fertilizer was applied in the furrow at seeding and 100 lb/A of sulfur coated urea (46-0-0) was broadcast at the first and forth leaf onion stages for a total of 151 lb/A of applied N. Sulfur-coated urea was used to minimize loss of N until it could be rained in naturally, as the grower cooperator did not have the ability to irrigate. Prior to planting in the spring, soil test results showed that levels of P were low in the minimum tillage systems, which suggested that 35 to 47% of the P applied in the fall was lost over winter. Soil levels of available N were low or very low throughout the spring. Even on June 19 at the 4 leaf stage, just 6 days after the second side-dress application of N, the minimum tillage oat and wheat systems had one-third and one-half, respectively, of the available N in the conventional system (74 lb/A N). Soil tests were not taken later than June 19 in this study. Leaf tissue analysis on July 22 showed that the level of nitrogen in the onions grown in the minimum tillage wheat system was high indicating that nitrogen in the soil did not remain low throughout the growing season. However, N levels in the onions in the minimum tillage oats system were lower and the onion plants were visibly lighter green than those grown in the conventional and minimum tillage wheat systems.

To improve the efficiency of fertilizer use in the minimum tillage systems, in the second study, the full rates of required P and K according to a spring soil test and 75 lb/A N were applied in the spring broadcast and incorporated 1-2 inches using a multivator precisely between the cover crop rows, one day before the onions were seeded. Again, 5 gal/A of 6-24-6 NPK pop-up fertilizer was applied in-furrow at planting and a side dress application of 100 lb of urea was made at the 5 leaf stage for a total of 126 lb/A N. In this trial, the same rates of fertilizer were applied to both the conventional and minimum tillage systems. Available N was measured at the 2-, 5- and 9-leaf stages and P was measured only at the 4-leaf stage and in this study, levels of N and P were significantly higher in the minimum tillage systems compared to the conventional. The levels of P and N in the conventional system were lower in 2011 than they were in 2008, which may have been due to issues associated with the very cool and wet spring. In the minimum tillage systems, applying P and N in the spring resulted in sufficient levels of these nutrients, which were double the levels achieved in the 2008 study. Clearly, applying the full rate of NPK in the spring broadcast and shallow cultivating it in precisely between the onion rows was an effective and efficient strategy for applying NPK to onions grown in a minimum tillage system.

**Nutrient dynamics in minimum tillage systems:** It was estimated based on the amount of cover crop residue in the minimum tillage systems in mid-May that the decomposition of the cover crop residue in the minimum tillage systems provided 20 to 25 lb/A of N to the soil, some of which could be taken up by the onion crop. In 2008, despite having low levels of available N in mid-June, by July 22, leaf tissue analysis results showed that onions grown in the minimum tillage oats system had one-half the N as those grown in the conventional, which had one-half of the N as those grown in the minimum tillage wheat system. Visually, the onions were greener in the minimum tillage wheat system. Because the soil levels of P were also significantly higher in the minimum tillage systems than the conventional in 2011, despite all systems receiving the same amount of NPK at the same time, this suggested that either P was mineralized from the decomposing cover crops, or that the cover crops in the minimum tillage systems retained the P better than the conventional during the cool and wet May and June, or that there was a difference between fertilizer application techniques. Perhaps there is greater nutrient uptake in the minimum tillage systems, because the nutrients were concentrated in a shallower layer due to the inter-row NPK incorporation with cultivation to 1-2 inches compared to the conventional systems where cultivation was to 4 inches. To further support this theory, soil levels of P tended to mimic those of N. Alternatively, when N and P are mineralized via decomposition of cover crops, they behave very differently in the soil. Further research is warranted to understand these types of nutrient dynamics in a minimum tillage system.

**Potential to reduce fertilizer rates:** There appears to be potential to reduce fertilizer rates when onions are grown in a minimum tillage system. Starting in mid-July, soil and tissue levels of N were quite high, especially in the minimum tillage systems, which was a good indication that the rates of nitrogen and possibly other nutrients can be reduced without having any effect on yield. Several recent Cornell studies have demonstrated that rates of nitrogen fertilizer can be reduced to 75 to 90 lb/A without having any significant reductions in yield or bulb size.

Interestingly, in 2008, the minimum tillage oat system, which had low levels of available nitrogen and visibly lighter green foliage than the conventional and minimum tillage wheat system, also had one-third to one-fourth as many onion thrips per plant. Since this study, other Cornell studies have demonstrated that high levels of applied and available soil nitrogen result in higher levels of onion thrips and also bacterial diseases in onions. With the higher levels of nutrients in the minimum tillage systems in 2011, there were no consistent trends with respect to pest pressure. Differences in disease, insect or weed pressure should continue to be monitored so that any differences may be predicted and monitored accordingly.

**Be aware of crop inhibition or allelopathy from winter wheat cover crop:** In 2008 and in one variety in 2011 (2 out of 3 trials), there was a significant 50% stand reduction in the minimum tillage wheat system compared to the conventional. There was no difference in the stand between the onions grown in the minimum tillage oat or barley systems and the conventional in either study. At first, it was thought that the stand reduction in the minimum tillage wheat system was due to the heavier cover crop residue creating a cooler and wetter soil environment, which in turn was favorable for damping off pathogens. In 2011, the grower increased his fungicide treatment against damping off pathogens in the entire field. Also, a small-plot trial was set up in a section of minimum tillage wheat within the field, where we evaluated commercially available seed treatment and in-furrow fungicide combinations for control of damping off. We are convinced that damping off did not cause stand reduction in the minimum tillage wheat system for the following reasons: 1) In the small-plot trial, no significant differences in stand occurred among nine different active ingredients belonging to five different chemical classes, most of which are known to have activity against damping off pathogens; 2) the stand in the minimum tillage wheat system within the rest of the field was similar to the stand in the small-plot trial, while stands in the conventional and minimum tillage barley systems were higher; and; 3) in the field-scale study, the soil in all of the tillage systems was very cool and wet due to the very cool and wet spring, thus seemingly equally as favorable for damping off, but still, the stand in the minimum tillage wheat system was significantly lower than in the other systems.

Therefore, the winter wheat cover crop either had allelopathic properties or otherwise somehow caused crop inhibition of the onions. Allelopathy is the inhibition of growth of one species of plant by chemicals produced by another species. Alternatively, the onion crop may have been weakened by a proliferation of soil microbes that were stimulated to grow because of the winter wheat cover crop, which in turn reduced onion stand. Whether the stand reduction of onions by the winter wheat cover crop was caused by allelopathy or another form of crop inhibition is unknown. If it was caused by soil microbes, unfortunately, our studies showed that there are no fungicides that onion growers can use to combat them, because none of nine different fungicides that were tested improved stand.

**Onions grown in a minimum tillage system yield same as conventional:** In both years of study, the onions grown in the minimum tillage barley/oats system yielded statistically the same or better than the conventional by 56 cwt/A (8% higher) in 2008, 94 cwt (23% higher) in the Festival variety in 2011, and by 82 cwt/A (20% higher) in the Safrane variety in 2011 for total marketable yield. In all cases, the weight of the higher-priced jumbo-sized bulbs in the minimum tillage oats/barley system was double compared to the conventional. When the cost of establishing each tillage system was taken into consideration, which was least for the minimum tillage oats/barley, because it required the fewest passes across the field, the minimum tillage oats/barley system had a net return that was 10% ($982/A), 35% ($1997/A) and 43% ($2,695/A) higher than the conventional in 2008, the Festival variety in 2011 and the Safrane variety in 2011, respectively.

Despite a 50% stand reduction in the minimum tillage wheat system, it had 5x and 8x higher jumbo-sized bulb weight than the minimum tillage oats and conventional systems, respectively in 2008, which made its total marketable yield and net return 95% and 98% of the conventional system. In 2011, in the variety that had a 50% stand reduction in the minimum tillage wheat system, the total marketable yield was significantly 64 cwt/A (15%) lower than the conventional, but the jumbo-sized bulb weight was 3x higher, which made the net return 104% of the conventional. In the 2011 study, there was some unexplained stunting that occurred in the conventional system. Effort was made to select sub-plots for data collection from the best stands possible, but unfortunately, the mysterious stunting confounded our results. Therefore, we weigh the 2008 results for yield much heavier.

To be conservative, using winter wheat in a minimum tillage wheat system for direct seeded onions grown in muck soil is not recommended, due to the high risk (67% probability) of stand reduction. However, if protection from wind erosion is of high importance, winter wheat did perform better for this purpose than spring oats or barley, and yields were certainly comparable to those of onions grown conventionally, because what the crop lost in bulb number was made up for in bulb size.

**For more information:** the final reports complete with data tables and photos are available at Cornell Vegetable Program website in the onion section: http://cvp.cce.cornell.edu/

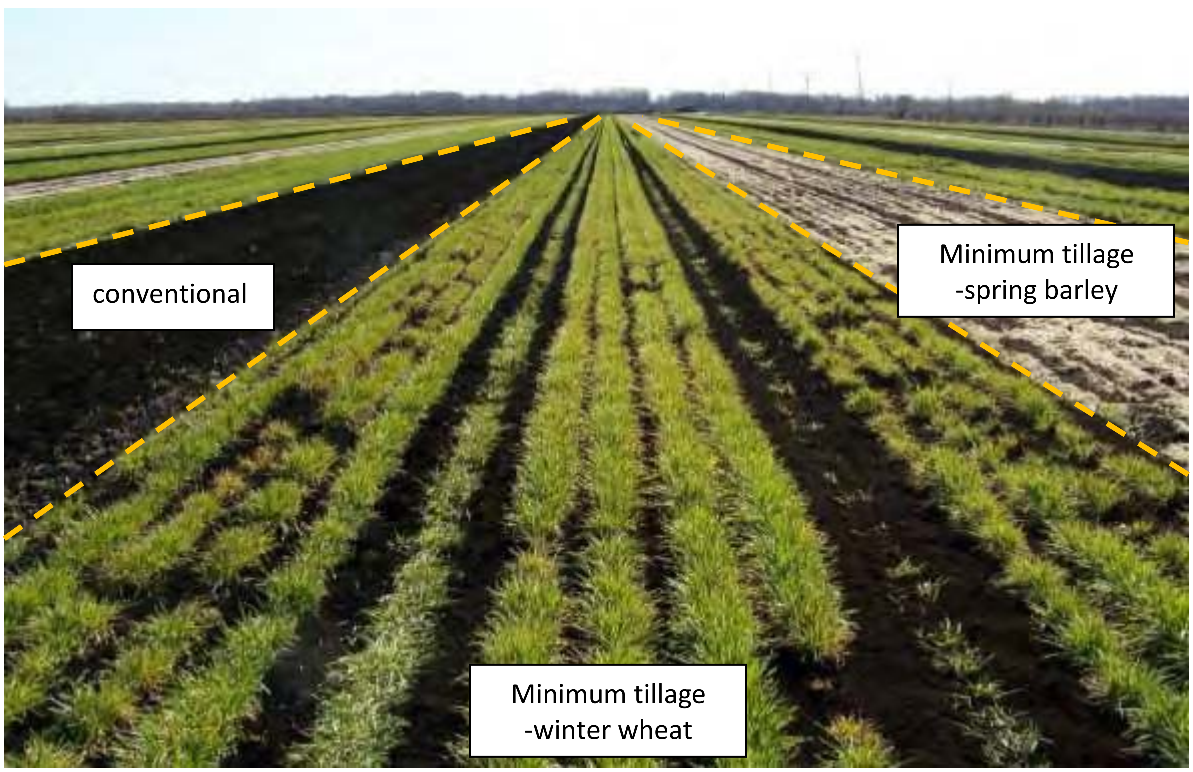


Figure 1. Minimum tillage systems in the spring prior to direct seeding onions on April 15, 2011, Elba, NY. Left – conventional strip; Center – minimum tillage with winter wheat; Right – minimum tillage with barley (winter killed).