2012 Pennsylvania Vegetable Marketing and Research Program
Pennsylvania Vegetable Growers Association Report
December 2012

Title: Evaluate the efficacy of alternative in-season management products and fertility treatments on yield and the development of onion bacterial diseases.

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Introduction:

Onions are plagued by a number of bacterial diseases that cause both foliar disease and bulb rots. In 2011, commercial fields experienced losses ranging between 0 and 50% at harvest and an additional 2 to 41% out of storage due to both neck and bulb surface rots caused primarily by the center rot pathogens, *Pantoea agglomerans*, *P. ananatis*, and the soft rot pathogens, *Pectobacterium caratovora* and *Pseudomonas marginalis*, as well as sour skin caused by *Burkholderia cepacia*. In 2012, in-field losses were reduced (0 to 15% at harvest and 6 to 64% in storage) due to less favorable weather. The primary objective of on-going research funded through the Northeast Regional IPM program, is to identify the on-farm factors most closely associated with increased bacterial disease incidence and severity, in order to further facilitate the development of disease management tools. Two years of on-farm field data have now been collected and are in the process of being analyzed. Additionally with funding from PVGA/PVMRP and NE-IPM Partnership Program, three years of data collected on the use of alternative mulches and plant spacing to reduce bacterial disease have demonstrated that the use of black biodegradable and metalized silver mulches are viable alternatives for growers to help reduce losses due to bacterial disease. Although more narrow plant spacing tends to reduce bacterial disease incidence, the reduction in marketable yield as a result of a greater proportion of small and medium sized bulbs limits its practical use commercial production in PA at this time.

In 2011, we also began conducting product efficacy trials to identify alternative in-season management tools that reduce grower reliance on copper-based products. Unfortunately, limited or highly variable disease pressure limited our ability to draw any significant conclusions from these trials in 2011. However, in preliminary greenhouse experiments conducted in late winter 2011, drench applications of Companion (*Bacillus subtilis*; Growth Products, Ltd. White Plains, NY) were effective at reducing total bacterial lesion area in onion plants inoculated with the center rot pathogen, *Pantoea agglomerans* but not *Pantoea ananatis*. In 2012, we continued these evaluations another season and expanded them to include the use of hydrogen dioxide based products to reflect current commercial production practices.

In addition, we continued to evaluate the effect of various fertility programs on onion yield and the incidence and severity of bacterial diseases. Due to the proprietary nature and complexity of commercially available fertility programs, a simple program adjusting only pre-plant and/or in-season potassium chloride (KCl) was evaluated on-farm. Chloride is becoming increasingly recognized as an important minor element required by onions only superseded by nitrogen, potassium and phosphorus. In onion, chloride is needed for stomatal regulation. Research by Schwartz and Mohan in 1995 indicated that onion plants deficient in chloride with poorly functioning stomata may have reduced photosynthesis lowering yields, and reduced transpiration, leading to increased foliar disease.

Here, we report our efforts during 2012 to address the following objectives:

1. Continue to evaluate the application of alternative in-season management products including the use hydrogen peroxide/dioxide on the incidence and severity of onion bacterial diseases in the greenhouse and field.
2. Further evaluate the effect of potassium chloride fertility on onion yield and the incidence and severity of bacterial diseases in a commercial field.

Methods and Results:

Objective 1: Continue to evaluate the application of alternative in-season management products including the use hydrogen peroxide/dioxide on the incidence and severity of onion bacterial diseases in the greenhouse and field.

To evaluate the application of alternative in-season management products on the incidence and severity of onion bacterial diseases, two replicated trials were established; one at the Plant Pathology Farm at Russell E. Larson Research and Education in Rock Springs, PA (RS) and one at the Southeast Research and Extension Center in Landisville, PA (LDV). The treatments consisted of variable rates and combinations of the following applied either as a soil drench at planting or an in-season foliar spray: copper hydroxide tank mixed with mancozeb (grower standard for bacterial diseases), hydrogen dioxide (OxiDate® BioSafe Systems, LLC.), acibenzolar-S-methyl (Actigard®, Sygenta), *Bacillus subtilis* GB03 (Companion®, Growth Products) as well as harpin αβ protein (Employ®, Plant Health Care Inc.). Actigard and Employ work by activating systemic acquired resistance which functions to increase plant defense reactions to infection (similar to the human immune system). The active ingredient in Actigard actually mimics salicylic acid (SA) in the plant while the harpin protein in Employ triggers the plant to produce SA which in turn activates plant defenses. In order to be effective, these products must be applied prior to infection by the bacteria. The specific treatments, rates and application timings are listed below:

	Fungicide(s) and rate/A (application timing[z])
1	Untreated inoculated control
2	Kocide 3000 1.5 lb/A (2,3,4,5,6,7), Manzate ProStick 3.0 lb/A (2,3,4,5,6,7) Grower standard
3	Employ 2.0 oz/A (3,6) plus Induce 0.25% v/v (3,6)
4	Actigard 0.75 oz/A (3), Actigard 1.0 oz/A (4,5), Kocide 3000 1.5 lb/A (6,7), Manzate ProStick 3.0 lb/A (6,7)
5	Oxidate (preventative) 128 fl oz/100 gal water (2,3), Oxidate 40 fl oz/100 gal water (4,5,6,7)
6	Oxidate (curative) 128 fl oz/100 gal water (2,3,4,5,6,7)
7	Companion 64 oz/100 gal water drench (1), Companion 128 fl oz/100 gal water (2,3,4,5,6,7)
8[x]	Kocide 3000 1.5 lb/A (2,4,5), Manzate ProStick 3.0 lb/A (3,4,5), Employ 2.0 oz/A (3,6), Induce 0.25% v/v (3,6)

[Z] Application dates for RS were: 1 = 30 April; 2 = 23 May; 3 = 30 May; 4 = 6 Jun; 5 = 13 Jun; 6 = 21 Jun; 7 = 27 Jun
LDV were: 1 = 2 May; 2 = 25 May, 3 = 31 May, 4 = 7 Jun, 5 = 14 Jun, 6 = 22 Jun, 7 = 28 Jun
[x] Treatment 8 was only applied at RS.

The trials were planted on standard black plastic with a double row of drip irrigation. Each plot was a 12 ft section of bed, 4 rows wide with 6 in. plant spacing within and between rows. Plots were arranged in a randomized complete block design with four or five replicates. Each plot was split into inoculated and uninoculated sub-plots in order to account for any yield reductions that may occur from use of these products. Drench treatments of Companion were applied shortly after transplanting in late-April/early May and foliar treatments were initiated in late May and continued weekly for six-weeks until late June. The inoculated plots were toothpick-inoculated on 19 and 20 June with bacterial suspension containing a mix of strains of *Pantoea agglomerans* and *P. ananatis* isolated from symptomatic onions in collected in PA. A toothpick was dipped in the bacterial suspension and the fourth and fifth or fifth and sixth leaves of the interior two rows of plants in the bed were pricked with the toothpick less than 6-in. from the onion neck.

Visual disease ratings were collected at mid-season and harvest. At harvest, treatments were evaluated for total marketable yield and the number and percent of bulbs with bacterial symptoms. Bacterial isolations were made to identify the pathogen species involved. Where appropriate, data were analyzed using analysis of variance and significant means were separated using Fisher's least significant difference test (SAS 9.2, SAS Institute, Cary, NC).

Foliar symptom development over time was similar between treatments, with the exception of a slight reduction in the foliar disease rating on the Companion treated plants on 9 July (Fig. 1). However, the subsequent rating the next week, in addition to disease incidence data collected at harvest, suggested this effect did not translate to reduced disease losses at harvest or increases in yield.

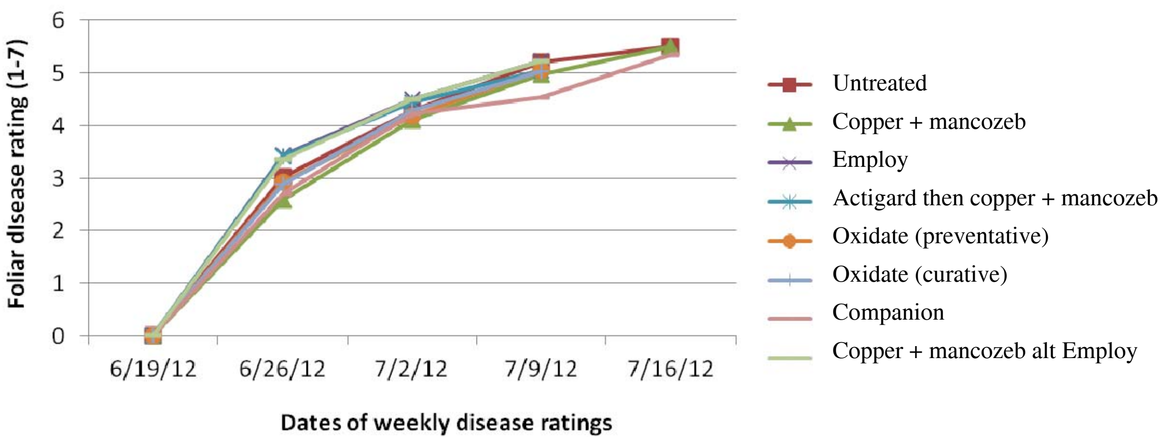

Figure 1: Leaf symptom development over time after inoculation at Rock Springs, PA during the 2012 season. Weekly disease ratings were conducted on a scale from 1-7, with 1 representing no symptoms besides inoculation injury and 7 representing total plant death.

Harvest losses due to bacterial rots in the inoculated plots ranged from 10-21% at LDV (data not shown) and 37-50% at RS (Fig.2), however, there were no statistically significant differences in losses between treatments. Harvest losses in uninoculated, treated plots ranged from 6-18% (LDV) and 9-26% (RS), while losses in treated plants adjacent to inoculated plants within the same plot ranged from 5-19% (LDV) and 18-23% (RS; data not shown). Trends pertaining to the ability of some of these products to act as protectants are indicated by the reduction in losses to bacterial disease in the two treated but uninoculated rows adjacent to the two inner inoculated rows. Though these differences are not statistically significant, the Employ and Actigard treatments in programs with copper hydroxide and mancozeb have the lowest levels of disease, while copper tank mixed with mancozeb alone (grower standard) and the preventative rate of Oxidate have the highest levels of disease in plants adjacent to inoculated plants (data not shown). No differences in marketable yields were noted between treatments, and all treatments ranged between 25.1 and 32.2 lb/12 ft of bed at LDV and 24.9 and 31.5 kg/12 ft of bed at RS (data not shown).

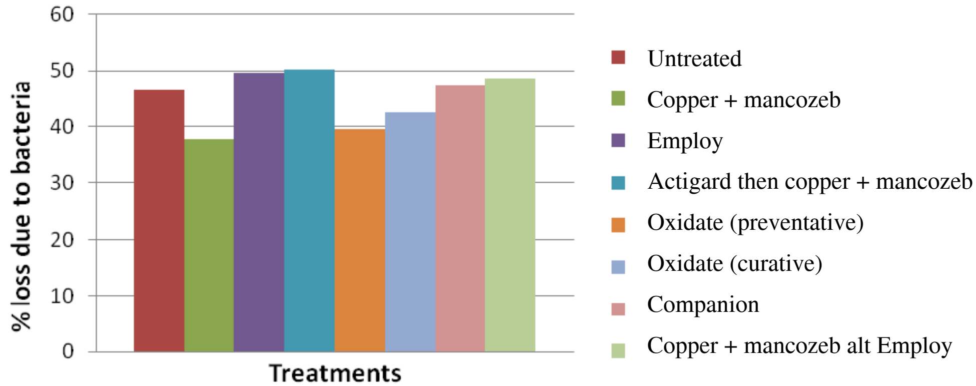

Figure 2: At-harvest losses due to bacterial rots in inoculated plots during the 2012 season at Rock Springs, PA.

In order to provide Pennsylvania growers with additional disease management tools for bacterial rots of onion, two years of product efficacy trials were undertaken at two different field sites, Rock Springs, PA (RS) and Landisville, PA (LDV). Though not statistically significant, the 2011 data suggested that fungicide programs containing Actigard, Employ, and Companion may confer some yield benefits, so those treatments were included in 2012. Interestingly, from both 2011 and 2012, Actigard and Employ treatments had among the highest yields at RS, but among the lowest yields at LDV (data not shown). This suggests there may be other environmental factors, such as soil type or temperature, interacting with the host and pathogen. Although, the Companion treatment initially showed some promise in managing foliar leaf symptoms 3 wk post-inoculation (Fig. 1), this did not translate to reduced losses at harvest (Fig. 2).

One of the challenges of evaluating product efficacy for bacterial disease is achieving uniform disease pressure within the trial. When there is a lot of variability, it is difficult so determine effects of the treatment on disease incidence and severity. In 2012, a toothpick inoculation technique was used to wound and place the bacteria into individual onion leaves. Use of this technique resulted in increased disease incidence compared to 2011 trials however, we were still not able to discern treatment differences. This may be in part due to the less favorable conditions for disease development in 2012. At this time, the standard grower practice of preventative applications on copper hydroxide tank mixed with mancozeb is still recommended for management of bacterial diseases of onion and should be used in combination with other cultural practices for managing bacterial diseases.

Objective 2: Further evaluate the effect of potassium chloride fertility programs on onion yield and the incidence and severity of bacterial diseases in a commercial field.

To evaluate the effect of potassium chloride fertility on marketable yield, an on-farm split plot trial with two replications was established with pre-plant potassium (no fertilizer or 300 lb/A 0-0-60 Muriate of potash) as the whole plot and then three fertigation treatments were overlaid as the sub-plots (none, 20-20-20, and 0-0-60) (Figure 3). Each sub-plot was 50 ft long and 30 ft wide. The entire trial was 180 ft x 100 ft. The onions were grown on standard black plastic with a double row of drip irrigation tape following standard commercial production practices. The fertigation programs were applied weekly at a rate of 5 lb of fertilizer per week for 12 weeks. Leaf tissue samples were collected mid-season and analyzed for nutrient content (Table 1). At the end of the season, total marketable yield was determined for 15 ft of row per sub-plot (Table 2) as well as at pack-out (Table 3).

In 2012, bacterial disease pressure was low in this on-farm trial. In general, it was observed that plots with higher yields had more bacterial disease losses at pack-out while, lower yielding plots had fewer onions culled due to bacterial rots. Not surprisingly, the plots that received no pre-plant fertility or fertigation had a higher proportion of smaller medium-sized bulbs as did the plots that only received a pre-plant application of 300 lb/A 0-0-60 muriate of potash.

Whole plot 0-0-60 at 300lb KCl/A Block shaded gray	**20-20-20** (gray)	**20-20-20**
	No fertigation (gray)	**No fertigation**
	0-0-60 KCl (gray)	**0-0-60 KCl**
Whole plot No pre-plant fertilizer Block no shading	**20-20-20**	**20-20-20** (gray)
	No fertigation	**No fertigation** (gray)
	0-0-60 KCl	**0-0-60 KCl** (gray)

Figure 3: Potassium fertility split plot trial design. The fertigation treatments are the sub-plots (20-20-20, none, 0-0-60).

Table 1. Mid-June onion tissue nutrient analysis (% dry weight basis and sufficiency category). Analysis conducted on a composite sample leaf sample collected from both reps.

Pre-plant Fertilizer	Fertigation Program (5 lb/weekly)		
	20-20-20	0-0-60	No Drip Fertilizer
No pre-plant fertilizer			
Nitrogen	3.98% below normal	3.77% below normal	3.57% below normal
Phosphorus	0.45% high	0.27% below normal	0.30% below normal
Potassium	3.52% low	4.21% moderate	3.51% very low
Magnesium	0.22% below normal	0.22% below normal	0.18% below normal
Calcium	1.31% below normal	1.58% low	1.39% below normal
Sulfur	0.64% low/moderate	0.64% low/moderate	0.53% low
0-0-60 300 lb/A pre-plant			
Nitrogen	4.01% below normal	3.03% below normal	2.67% below normal
Phosphorus	0.39% moderate	0.22% below normal	0.15% below normal
Potassium	3.88% low/moderate	3.88% low/moderate	2.88% below normal
Magnesium	0.26% low	0.20% below normal	0.13% below normal
Calcium	1.61% low	1.67% low/moderate	1.10% below normal
Sulfur	0.57% low	0.45% below normal	0.30% below normal

Table 2. Marketable onion yield (lb/15ft row).

Pre-plant Fertilizer	Fertigation Program (5 lb/weekly)		
	20-20-20	**0-0-60**	**No Drip Fertilizer**
No pre-plant fertilizer			
Rep 1	172.5	112.9	162.9
Rep 2	162.9	154.4	191.0
Average	167.7	133.6	176.9
0-0-60 300 lb/A pre-plant			
Rep 1	165.3	132.2	154.3
Rep 2	143.5	111.0	134.5
Average	154.4	121.6	144.4

Table 3. Onion pack-out data collected and averaged between the two plots per treatment.

	Pre-plant and fertigation fertility program					
	No pre-plant fertilizer			**300lb/A 0-0-60 pre-plant**		
	No drip fertilizer	**0-0-60**	**20-20-20**	**No drip fertilizer**	**0-0-60**	**20-20-20**
Marketable yield (lb)	210	169	192	168	179	200
# w/ Surface rot symptoms	12	4	18	12	10	10
# w/ Center rot symptoms	9	8	19	16	6	14
# w/ Black Mold	30	61	61	67	76	56
Medium-size bulbs (lb)	3.84	0.44	2.17	4.33	0.85	0