2011 Pennsylvania Vegetable Marketing and Research Program
Pennsylvania Vegetable Growers Association Report
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Title: Evaluate the role of transplants and the effect of defense-inducing, growth-promoting 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 bulb and leaf decay. This past spring locally grown and southern U.S. transplants were collected and the bacterial species present on the surface (epiphytic) and within the tissues (endophytic) of the transplants were isolated and identified with microbiological and PCR-based techniques. The bacterial species most commonly isolated (*Pantoea agglomerans*, *Pectobacterium caratovora*, and *Pseudomonas marginalis*) from these transplants were the same ones predominately isolated from symptomatic leaf and bulb tissue during 2009 and 2010. Therefore based on the 2010 data, the source of the onion transplants did not affect the epiphytic or endophytic bacterial species diversity present on the transplants. In 2011, we conducted a second year of transplant screening to validate our 2010 results by identifying the bacterial species present on and in transplants and then planted these transplants from the same lot on two research farms to monitor disease development over the course of the season under different growing conditions.

In addition to identifying potential sources of bacterial inoculum, we are interested in developing tools and techniques that can be used readily by growers as part of an integrated management program to manage onion bacterial diseases. Using results generated from PVMRP/PVGA funded research trials over the past couple of years we were able to leverage funding from the NE-IPM Partnership Grant Program to enable us to continue to evaluate the use of different mulches as well as plant spacing treatments on commercial farms in 2011 in collaboration with colleagues in New York. Thus in 2011, we expanded our research and evaluated the use of defense inducing and plant growth promoting products in combination with copper bactericides for managing bacterial diseases of onion. Currently growers are relying on frequent applications copper bactericides but losses are still considerable. Applied either directly to foliage or as a drench, defense-inducing products do not directly control bacteria; rather, they induce the plant to increase its own natural defenses against pathogens. Plant growth-promoting products' main benefit are to aid the plant in acquiring nutrients from soil, although some have been suggested to reduce susceptibility to pathogen infection as a secondary benefit. Much like our own immune systems, healthy vigorously growing plants with activated defense response systems are less susceptible to disease. Researchers in Colorado recently demonstrated the use of plant defense-inducing products to manage bacterial leaf streak on onion and in tomato they have been regularly incorporated into the management of bacterial diseases in the southeast U.S. The proposed products could easily be incorporated into conventional, integrated management, as well as organic production systems.

In recent years complex fertigation programs for applying micronutrients have become increasing used. These programs are very expensive, with some growers spending in excess of $1,000 an acre for these fertilizer programs. In addition, some of these programs include high levels of nitrogen applications, which promote bacterial diseases while others contain sulfur which increases pungency levels in sweet onions.

Here, we report our efforts during 2011 to address the following objectives.

1. Further elucidate the relationship between onion transplants as a potential inoculum source and the development of bacterial diseases in the field.
2. Evaluate the use of defense inducing and plant growth promoting products in combination with copper bactericides for managing onion bacterial diseases in replicated trials at the Russell E. Larson Research and Education in Rock Springs, PA and the Southeast Research and Extension Center in Landisville, PA.
3. Evaluate the effect several commercially available fertigation programs on onion yield and the incidence and severity of bacterial diseases in a grower field.

Methods and Results:

Objective 1: Further elucidate the relationship between onion transplants as a potential inoculum source and the development of bacterial diseases in the field.

In spring 2011, transplants cv. Candy were obtained from Dixondale Farms in Texas (bare root), Sunbelt Transplants in Arizona (bare root) and from a local producer in Lancaster Co., PA (plug). A composite sample consisting of 30 bare root transplants or 10 plug transplants were collected from each case/flat and the bacterial species isolated from the transplant surface and the internal tissues of the transplants following surface disinfesting.

The remaining transplants were planted in a randomized complete block design with three replicates at the Southeast Research and Extension Center in Landisville, PA on 29 April and four replicates at the Plant Pathology Farm at Russell E. Larson Research and Education in Rock Springs, PA on 21 April. The trials were planted on standard black plastic with a double row of drip irrigation. Each plot consisted of one 15 ft bed, 4 rows wide with 6 in. plant spacing within and between rows. Due to a limited supply of locally produced transplants, these plots at Rock Springs were only 8 ft long. Insecticides and fungicides (no bactericides) were applied according to standard grower practices. Trials were scouted regularly during the season. On 19 July at Landisville, all onions from each plot were harvested, rated for bacterial disease incidence and the marketable onions were graded based on size (small, medium, jumbo, colossal). The trial at Rock Springs was harvested on 21 July. Onions were harvested from an 8 ft section of each plot and evaluated as previously described.

Results and Discussion:

Multiple potential bacterial pathogens were isolated from both the surface and internal tissues transplants received from all three sources (Texas, Arizona, and Lancaster Co.). Both *Pantoea agglomerans*, one of the causal agents of center rot, and *Pseudomonas marginalis*, a general soft rot pathogen were isolated consistently from the surface and internal tissues of all three transplant sources however only *P. agglomerans* was isolated also from symptomatic onion bulbs at the end of the season (Table 1). *Burkholderia gladiolii* and *B. cepacia*, the causes of slippery and sour skin respectively, were isolated primarily from symptomatic onions at the end of the season. In fact, these surface rots accounted for a 21 to 31% reduction in marketable yield from these plots this season (Table 2). Both diseases are favored by warm and wet conditions. Internal neck rot symptoms caused by center rot accounted for an additional 10 to 20% loss in marketable yield in the Landisville trial. We are currently in the process of developing a method that would enable us to track specific bacterial strains and determine if the specific

strains coming in on the transplants are the same as those that were isolated from symptomatic bulbs at the end of the season. Although the plot and sample sizes were too small to make any statistical conclusions, the Texas transplants had a slightly higher marketable yield compared to those grown from Arizona or locally. At Rock Springs, where the environmental conditions were less favorable for disease development and little to no disease developed (96 to 99% marketable), the transplant sources yielded equally (Table 2). The environmental data collected from these trials is still being analyzed.

Table 1. Bacterial pathogens isolated and identified from the surface and internal tissues of transplants cv. Candy from Texas, Arizona or locally grown in Lancaster Co., PA prior to planting in the field and then from representative symptomatic bulbs collected at harvest from the onion transplant trial planted with the same lots of onions at the Southeast Research and Extension Center in Landisville, PA. Very little bacterial disease developed in the transplant trial established at the Russell E. Larson Research and Education in Rock Springs, PA.

Bacterial diseases and causal species	**Transplant Source**								
	Texas			**Arizona**			**Local**		
	Surface	**Internal**	**Bulb**	**Surface**	**Internal**	**Bulb**	**Surface**	**Internal**	**Bulb**
Center rot									
Pantoea ananatis			x		x	x			x
Pantoea agglomerans	x	x	x	x	x	x	x	x	x
Soft rots									
Pectobacterium carotovora	x		x			x			x
Pseudomonas marginalis	x	x		x	x		x	x	
Slippery skin									
Burkholderia gladiolii			x	x		x			x
Sour skin									
Burkholderia cepacia			x			x			x
Leaf streak and bulb rot									
Pseudomonas viridiflava					x			x	

Objective 2: Evaluate the use of defense inducing and plant growth promoting products in combination with copper bactericides for managing onion bacterial diseases in replicated trials at the Russell E. Larson Research and Education in Rock Springs, PA and the Southeast Research and Extension Center in Landisville, PA.

Two replicated field trials were established at the Russell E. Larson Agricultural Station in Rock Springs, PA, and at the Southeast Agricultural Research and Extension Center in Landisville, PA on 21 April and 5 May, respectively. The trials were planted with transplants cv. Candy from Texas on standard black plastic with a double row of drip irrigation. Each plot consisted of either a 15 ft (Rock Springs) or 12 ft (Landisville) 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 replicates.

Two soil treatments were administered as a drench around the base of each plant via a backpack sprayer with a concentrated spigot tip (150 ml/plant) to selected plots within two days after transplanting. *Glomus intraradices* spores (Myke Pro WG, Premier Tech Biotechnologies, Canada) were applied at a rate of 36 spores/150 mL (600g/53 gal) and *Bacillus subtilis* (Companion, Growth Products, Ltd, White Plains, NY) at a rate of 64 fl oz/100 gal. Foliar treatments were initiated on 14 June and 22 June at Rock Springs and Landisville, respectively and applied at intervals congruent with their labels (Table 3). At

Table 2. Effect of transplant source on the marketable yield of sweet onion cv. Candy and incidence of bacterial rots in two field trials conducted in 2011 at the Russell E. Larson Agricultural Station in Rock Springs, PA, and at the Southeast Agricultural Research and Extension Center in Landisville, PA.

	Marketable Yield								
	Onion grade (lb)			Total Marketable Yield		Unmarketable Yield			
						Surface bacterial rot		Bacterial neck rot	
Transplant Source	**Small (< 2.5 in.)**	**Medium (2.5 to 3 in.)**	**Jumbo (3 to 4 in.)**	**%**	**Weight (lb)**	**%**	**Weight (lb)**	**%**	**Weight (lb)**
Landisville Trial (per 15 ft of bed)									
Texas……...	2.16	9.66	21.60	62.7	33.51 a	21.3	12.43	15.9	8.84
Local…….....	0.97	7.03	19.05	60.3	28.00 ab	29.1	12.98	10.6	4.50
Arizona.....	2.51	6.59	16.42	48.6	25.57 b	31.3	16.75	20.1	12.43
P-value	0.1263	0.3188	0.2855	0.1616	0.0504	0.5957	0.6910	0.2899	0.0701
Rock Springs Trial (per 8 ft of bed)									
Texas……...	1.61	8.51	20.92	98.8	31.31				
Local……	1.41	10.58	17.72	99.2	29.94				
Arizona.....	2.49	8.07	18.10	96.2	29.21				
P-value	0.5059	0.2514	0.6328	0.1597	0.6364				

Rock Springs treatments were applied using a tractor mounted, CO2 powered side boon sprayer calibrated to deliver 22 gal/A at 24 psi through three TX-18 nozzles while at Landisville they were applied using a Solo backpack sprayer. Both trials were inoculated with a bacterial suspension containing a mix of stains of *Pantoea agglomerans* and *P. ananatis* isolated from symptomatic onions in 2009 and 2010 at a rate of 1.0 x10^8 cfu/ml. At Rock Springs, mid-season plant vigor was assessed by measuring the longest leaf of five plants per plot. At harvest 8 ft of bed was harvested from each plot, visually assessed for bacterial disease incidence and graded by size class.

Results and Discussion:

In preliminary greenhouse experiment, the application of Companion (*Bacillus subtilis*) as a drench was effective at reducing total bacterial lesion area in onion plants inoculated with the center rot pathogen, *Pantoea agglomerans* but not *P. ananatis*. In the field trial at Rock Springs, field applications of soil and foliar treatments were successful in increasing the length of the longest leaf in several treatments. The plots treated with Companion and Employ showed 21 to 23% longer leaves than the untreated/uninoculated control. Combinations of Myke Pro and Employ as well as Companion and Actigard each showed increased foliar length, each inducing 19% longer leaves. However by harvest, the observed increase in plant vigor did not translate to yield differences between treatments in either trial, nor were differences in bacterial disease severity observed in the trial in Landisville (Table 3). Very little disease developed in the trial at Rock Springs in 2011.

Table 3. Efficacy of soil and foliar products for managing bacterial diseases in sweet onion cv. Candy at the Southeast Agricultural Research and Extension Center in Landisville, PA in 2011.

Fungicide(s) and rate/A (application timing[z])	Marketable yield (8 ft of bed)		Percent bacterial rot by weight[w]
	Number bulbs	Weight (lb)	
Untreated control……..	58.8	28.7	23.6
Inoculated control……..	62.3	30.4	19.4
Myke Pro WG 600 g/53 gal (at planting).....	66.0	28.4	14.4
Companion 64 fl oz/100 gal (at planting)……..	62.5	31.7	10.6
Actigard 50WG 0.75 oz (1,2,3,4,5)..….....	50.5	28.9	17.9
Employ 2.0 oz (1,4)……..	57.5	27.5	20.9
Kocide 3000 1.5 lb + Penncozeb 75DF 1.5 lb (1,2,3,4,5)……	61.8	29.5	17.7
Myke Pro WG 600 g/53 gal (at planting) + Actigard 50WG 0.75 oz (1,2,3,4,5)..….....	57.8	27.8	21.8
Myke Pro WG 600 g/53 gal (at planting) + Employ 2.0 oz (1,4)	57.0	29.5	24.4
Companion 64 fl oz/100 gal (at planting) + Actigard 50WG 0.75 oz (1,2,3,4,5)..….....	58.0	25.6	20.7
Companion 64 fl oz/100 gal (at planting) + Employ 2.0 oz (1,4)……..	66.8	34.2	21.8
Actigard 50WG 0.75 oz (1,3,5) alt. Kocide 3000 1.5 lb + Penncozeb 75DF 1.5 lb (2,4)……	57.5	27.3	17.2
P-value	NS	NS	NS

[z] Application dates were: 1 = 22 Jun; 2 = 29 Jun; 3 = 8 Jul; 4 = 13 Jul; 5 = 20 Jul.
[w] Bacterial rot includes both bulb surface rot symptoms as well as neck rot symptoms.

Objective 3: Evaluate the effect several commercially available fertilizer programs on onion yield and the incidence and severity of bacterial diseases in a grower field.

The fertilizer trial was planted 7 April with bare root transplants cv. Candy sourced from Arizona on a commercial farm in Lancaster Co., PA. The trial was four beds wide and 400 ft long. There were eight different treatments consisting of six fertilizer programs, a no fertilizer control and a high nitrogen control (Table 4). The treatments were replicated twice due to space constraints. Each bed was broken into 4 - 100 ft plots and planted at commercial standard 6 x 6 in. spacing. Fertilizer was applied once each week either through the drip or by foliar application or both according to the recommendations of the fertilizer program. The high N control received no fertilizer until bulb initiation, it then received 6 gal/A of 35% N each week through the drip. No plow down nitrogen was applied to the trial. At harvest, 15 ft of bed per plot was harvested, weighed and the number of small bulbs was determined. In addition, enough onions were harvested from each treatment (both reps) to fill one bin. After six weeks in storage, the onions were packed and once again evaluated for marketability (% culls).

Results and Discussion:

Due to the space constraints limiting the number of replications, statistical analyses were unable to be performed, however at harvest, the Homestead, Oregon, Miller and Timac programs all yielded higher than the no fertilizer control and produced fewer small bulbs (Table 4). Following an additional 6 weeks in storage between 19 to 33% of the bin was culled depending on the fertility treatment (Table 5). Unfortunately, due to proprietary nature of the commercially available programs it is difficult to determine what nutrient components contributed to the differences in yield and losses from bacterial diseases. Additional trials are needed to determine the effect of components such as nitrogen, potassium and calcium chloride on onion yield and marketability.

Table 4. Yield of sweet onions cv. Candy grown under different fertility programs in a commercial on-farm demonstration trial.

Company (Fertilizer program)	**Yield (15 ft bed)**	
	Weight (lb)	**Number small bulbs (< 2.5 in.)**
Homestead	116.1	5.0
Oregon	115.7	3.5
Miller's	113.5	1.5
Timac	110.7	4.5
No fertilizer control	110.1	5.5
PA Supply	108.4	8.5
High Nitrogen	106.7	4.0
Keystone BioAg	104.8	2.5

Table 5. Marketability of onions grown under different fertility programs in a commercial on-farm demonstration trial after 6 weeks in storage.

Company (Fertilizer program)	Yield (lb)				
	Marketable weight		Unmarketable weight (culls)	% Medium	% Cull
	#1	Medium			
Miller's	674.7	24.4	351.1	2.3	33.4
PA Supply	742.5	30.8	313.3	2.8	28.8
No fertilizer	739.6	32.1	310.5	3.0	28.7
Oregon	693.4	33.6	305.4	3.3	29.6
Homestead	762.1	28.2	296.4	2.6	27.3
Keystone BioAg	747.2	32.5	296.0	3.0	27.5
High Nitrogen	735.6	37.1	261.2	3.6	25.3
Timac	844.8	27.2	205.9	2.5	19.1