2014 University of Georgia Vidalia Onion Extension and Research Report

UGA extension

2014 University of Georgia Onion Research and Extension Report

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Contents

UGA Variety Trial Report 2012-13 Crop Season

Cliff Riner[1], Timothy Coolong[2], Ron Gitaitis[3], Jason Edenfield[4], Chris Tyson[5], Chris Earls[6], Brooke Jeffries[7], Jennifer Miller[8], Anthony Bateman[2], Randy Hill[9], and Denny Thigpen[9]

Note

A variety trial for the 2012-13 production season was completed; however, seedbed production issues required sourcing some varieties from off-site locations. Therefore, while results were recorded, trial results for this season will not be published. The data will be available by request to any interested party. For these results, contact your local Extension office or the Vidalia Onion and Vegetable Research Center.

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UGA Variety Trial Report 2013-14 Crop Season

Cliff Riner[1], Timothy Coolong[2], Ron Gitaitis[3], Juan Carlos Diaz[2], Jason Edenfield[4], Chris Tyson[5], Chris Earls[6], Brooke Jeffries[7], Jennifer Miller[8], Anthony Bateman[2], Billy Giffin[5], Randy Hill[9], and Denny Thigpen[9]

Introduction

The University of Georgia evaluates short day onions to determine their performance characteristics in standardized growing practices. The varieties are placed in the trial by participating seed companies. These trials are conducted at the Vidalia Onion and Vegetable Research Center.

Materials and Method

There were 37 varieties entered into the 2013-14 trial. The seedbeds were grown at the Vidalia Onion and Vegetable Research Center in Lyons, Georgia. Seedbed treatment included a 75-gallon per acre fumigation treatment of metam sodium. The seedbeds were planted on September 16, 2013, and the trial was transplanted on November 18, 2013. Upon harvest and grading, one bag of jumbo onions per plot is sent to the Vidalia Onion Research Lab in Tifton, Georgia, to undergo controlled atmospheric storage conditions. The storage duration was carried out until September 15, 2014. Seedbed and trial fertility and fungicide programs are listed below.

The trial evaluated all 37 varieties in 25-foot long by 6-foot wide plots. Each variety was replicated four times and harvested based on a committee decision of maturity. The plant population for the trial was equivalent to 87,120 plants per acre.

Seedbed Fertility:

- 150 lb/A of 18-46-0 applied the day of planting
- 200 lb/A of 10-10-10 applied two weeks after planting
- 200 lb/A of 10-10-10 applied four weeks after planting
- 300 lb/A of 10-10-10 applied six weeks after planting

Note: All fertilizer applications were applied with a First Products brand drop spreader.

Trial Fertility:

- 350 lb/A of 5-10-15 applied Dec. 3
- 350 lb/A of 5-10-15 applied Jan. 9
- 400 lb/A of 5-10-15 applied Feb. 3
- 200 lb/A of CaNO3 applied Feb. 17
- 200 lb/A of CaNO3 applied Mar. 3

Total: 117 – 110 – 165 – 77
(N) (P) (K) (S)

Note: Soil sample test results called for 60 units of phosphorus, 90 units of potash, and 60 units of sulfur.

Trial Fungicide Schedule:

Date	Fungicide Applied (including rate)
Dec. 17:	Pristine 14 oz/A + MagnaBon(Copper) 12 oz/A
Jan. 16:	Chlorothalonil 1.5 pt/A + MagnaBon 12 oz/A
Feb. 3:	Pristine 14 oz/A + MagnaBon 12 oz/A
Feb. 18:	Catamaran 4 pt/A
Feb. 28:	Reason 5 oz/acre + Manzate 2 lb/A
Mar. 10:	Pristine 14 oz/acre + MagnaBon 12 oz/A
Mar. 20:	Catamaran 4 pt/A
Mar. 26:	Inspire Super 1 pt/acre + MagnaBon 12 oz/A
Mar. 31:	Catamaran 4 pt/acre
Apr. 11:	Inspire Super 1 pt/acre + MagnaBon 12 oz/A
Apr. 21:	Catamaran 4 pt/A
Apr. 28:	Fontellis 1 pt/acre + MagnaBon 12 oz/A

Harvest Timing:

Each variety was evaluated and selected for harvest based upon signs of weak tops and adequate sized bulbs. A committee of Cooperative Extension agents determined the harvest/pulling of varieties. Participating seed companies reserve the right to specify when or what characteristics determine harvest of their variety.

April 17: Isabella, Candy Kim, Candy Ann, NUN 1002, NUN 1003, GoldenBoy

April 24: Sweet Agent, Sweet Treat, DP Sweet 1407, NUN 1008

April 28: XON-109Y, Ringo, Sweet Harvest, Pirate, Emy 55455, Century, Mr. Buck, Sapelo Sweet, Caramelo, NUN 1006, 11-26

May 5: Sweet Jasper, Sweet Uno, E61S.U6253, Red Coach, J3008, Red Hunter, Emy 55102, Emy 55164, Goldeneye, Savannah Sweet, Granex Yellow PRR, SV2657NK, Miss Megan, Sweet Caroline

May 19: Inkopah, Mata Hari

Results and Discussion

Tables 1-6 show field and marketable yields as well as percent gradeout (culls removed at grading) and percent colossal, jumbo, and medium bulbs, respectively. Table 7 reports data on loss during storage. For additional information regarding the performance of a given variety in this trial please contact your local Extension agricultural and natural resources agent or the Vidalia Onion and Vegetable Research Center.

We would like to thank the participating seed companies as well as the Vidalia Onion Committee for their support of this trial.

Table 1. Field (green) weights of varieties expressed on a per plot basis.

Variety	Field/Green Weight (lb/plot)	
DP 1407	206.3	a*
Candy Kim	193.5	ab
Mata Hari	190.1	cb
Ringo	180.3	bcd
Sweet Treat	180.3	bcd
Sweet Agent	177.4	cde
Isabella	176.2	cde
J3008	172.1	def
Sweet Harvest	171.2	defg
Nun 1002	171.0	defg
Nun 1003	170.7	defg
Nun 1008	170.1	defg
Pirate	169.2	defg
E61S.U6253	168.2	defgh
Goldenboy	167.0	defghi
Sweet Caroline	163.9	defghij
Miss Megan	162.9	efghijk
Red Hunter	157.6	fghijkl
Nun 1006	156.0	fghijklm
Savannah Sweet	154.7	ghijklmn
Sapelo Sweet	154.3	ghijklmn
Xon - 109Y	152.0	hijklmn
Century	151.0	ijklmn
Candy Ann	150.1	jklmn
Granex Yellow PRR	148.7	jklmno
Emy 55102	148.1	jklmno
Sweet Jasper	146.7	klmno
Goldeneye	144.2	lmno
SV2657NK	143.7	lmno
Mr. Buck	141.1	lmno
Caramelo	140.2	mno
Red Coach	138.6	no
Emy 55455	138.4	no
Sweet Uno	137.4	no
P1126	132.6	op
Emy 55164	121.8	p
Inkopah	121.4	p

** Letters that are the same between varieties indicate that those varieties are not significantly different according to Fisher's LSD (P ≤ 0.05).*

Table 2. Total marketable yield (40 lbs boxes per acre) after curing and grading.

Variety	Company	Marketable/Graded Weight (40 lb boxes/acre)	
Mata Hari (RED)	Nunhems	1147.8	a*
Nun 1008	Nunhems	1111.5	ab
J3008	Bejo	1081.7	abc
Pirate	Bejo	1046.2	abcd
Sweet Agent	Seminis	1030.2	abcd
Nun 1006	Nunhems	1009.9	bcde
Sweet Jasper	Sakata	989.5	bcdef
E61S.U6253	Enza Zaden	984.5	bcdef
Nun 1002	Nunhems	952.5	cdefg
Sweet Caroline	Nunhems	948.2	cdefgh
Red Hunter(RED)	Bejo	941.6	defghi
Century	Seminis	924.2	defghi
Nun 1003	Nunhems	923.5	defghi
DP Sweet 1407	DP Seeds	916.9	defghi
Goldeneye	Seminis	874.8	efghij
XON-109Y	Sakata	873.4	efghij
Caramelo	Nunhems	873.4	efghij
Sapelo Sweet	DP Seeds	863.2	fghij
Miss Megan	Dp Seeds	858.9	fghij
Emy 55102	Emerald	848.7	fghijk
Emy 55455	Emerald	834.2	ghijkl
Mr. Buck	DP Seeds	833.4	ghijkl
Ringo	Sakata	820.4	ghijklm
Candy Kim	Solar	808.0	hijklmn
Sweet Harvest	Sakata	805.1	ijklmn
11-26 (Grano)	Pike Seeds	760.8	jklmno
Candy Ann	Solar	757.2	jklmno
Grnx. Yellow PRR	Seminis	745.6	jklmno
Sweet Treat	Shamrock	713.7	klmno
Emy 55164	Emerald	703.5	lmnop
Sweet Uno	Enza Zaden	700.6	lmnop
Inkopah (RED)	Emerald	686.8	mnopq
Savannah Sweet	Seminis	678.1	nopq
Red Coach (RED)	Enza Zaden	671.6	nopq
SV2657NK	Seminis	638.2	opq
Golden Boy	Shamrock	575.0	pq
Isabella	Wannamaker	553.9	q

** Letters that are the same between varieties indicate that those varieties are not significantly different according to Fisher's LSD ($P \leq 0.05$).*

Table 3. Percent culls or gradeout.

Variety	Gradeout (%)*
Sweet Jasper	93
Nun 1008	90
Nun 1006	89
Emy 55164	89
J3008	87
Goldeneye	87
Emy 55455	86
Caramelo	86
Pirate	85
Century	84
Mata Hari (RED)	83
Red Hunter(RED)	82
Mr. Buck	81
E61S.U6253	81
Sweet Agent	80
Sweet Caroline	80
XON-109Y	79
11-26 (Grano)	79
Emy 55102	79
Inkopah (RED)	78
Sapelo Sweet	77
Nun 1002	77
Nun 1003	74
Miss Megan	73
Sweet Uno	70
Candy Ann	69
Grnx. Yellow PRR	69
Red Coach (RED)	67
Sweet Harvest	65
Ringo	63
SV2657NK	61
DP Sweet 1407	61
Savannah Sweet	60
Candy Kim (Grano)	58
Sweet Treat	55
Golden Boy	47
Isabella	43

** Note: Indicates the (Graded weight/Field Weight) X 100 = % Gradeout. A variety with 75% grade out, would have discarded 25% of field weight in the grading process.*

Table 4. Percent colossal bulbs of total marketable weight.

Variety	Colossal Bulbs
E61S.U6253	20.7%
DP Sweet 1407	18.5%
Sweet Treat	14.2%
Sweet Harvest	11.0%
Ringo	10.8%
Sweet Agent	8.9%
Goldenboy	7.9%
Isabella	7.4%
Candy Ann	6.6%
Candy Kim	4.9%
Nun 1002	4.7%
Nun 1003	4.6%
Sweet Caroline	4.3%
Mr. Buck	2.6%
Emy 55102	2.5%
Miss Megan	2.5%
XON-109Y	2.1%
Mata Hari	2.0%
Goldeneye	1.9%
Nun 1008	1.8%
Savannah Sweet	1.7%
Nun 1006	1.6%
Pirate	1.5%
SV2657NK	1.2%
Red Coach	1.2%
J3008	1.1%
Sapelo Sweet	1.1%
Granx. Yellow PRR	0.8%
Red Hunter	0.7%
Inkopah	0.7%
Caramelo	0.6%
11 26	0.5%
Emy 55455	0.4%
Century	0.3%
Sweet Jasper	0.2%
Sweet Uno	0.0%
Emy 55164	0.0%

Table 5. Percent jumbo bulbs of total marketable weight.

Variety	Jumbo Bulbs
Candy Kim	88.1%
Pirate	86.4%
Goldenboy	85.8%
Savannah Sweet	85.7%
Nun 1008	85.6%
Mata Hari	85.4%
J3008	84.6%
Nun 1002	84.5%
Nun 1006	82.8%
XON-109Y	82.3%
Sweet Agent	81.9%
Isabella	81.5%
Goldeneye	81.1%
Nun 1003	80.2%
Granx. Yellow PRR	79.6%
Sweet Treat	79.3%
Sweet Caroline	78.9%
Ringo	77.7%
Century	77.5%
DP Sweet 1407	77.3%
Sapelo Sweet	76.6%
Emy 55102	76.3%
SV2657NK	76.3%
Red Hunter	76.3%
Caramelo	76.0%
Miss Megan	76.0%
Sweet Uno	75.9%
Emy 55455	75.3%
Mr. Buck	75.1%
Sweet Harvest	74.5%
Red Coach	74.5%
Sweet Jasper	74.0%
Candy Ann	72.5%
Inkopah	70.0%
11 26	69.5%
Emy 55164	64.2%
E61S.U6253	64.0%

Table 6. Percent medium bulbs of total marketable weight.

Variety	Medium Bulbs
Emy 55164	35.8%
11 26	30.0%
Inkopah	29.4%
Sweet Jasper	25.8%
Red Coach	24.4%
Emy 55455	24.3%
Sweet Uno	24.1%
Caramelo	23.5%
Red Hunter	23.1%
SV2657NK	22.4%
Sapelo Sweet	22.3%
Mr. Buck	22.3%
Century	22.1%
Miss Megan	21.6%
Emy 55102	21.1%
Candy Ann	20.9%
Granx. Yellow PRR	19.6%
Goldeneye	17.0%
Sweet Caroline	16.8%
Nun 1006	15.6%
XON-109Y	15.6%
E61S.U6253	15.3%
Nun 1003	15.2%
Sweet Harvest	14.5%
J3008	14.3%
Savannah Sweet	12.7%
Nun 1008	12.6%
Mata Hari	12.5%
Pirate	12.1%
Ringo	11.5%
Isabella	11.1%
Nun 1002	10.8%
Sweet Agent	9.2%
Candy Kim	7.1%
Sweet Treat	6.5%
Goldenboy	6.3%
DP Sweet 1407	4.2%

Table 7. Percent loss (disease/decay) during 16-20 weeks in controlled atmosphere storage.	
Cultivar	**Loss during storage (%)**
Nun 1002	68.5 a
Isabella	66.9 a
Golden Boy	63.2 ab
Ringo	61.9 ab
Candy Kim	58.7 abc
Nun 1008	58.7 abc
Nun 1003	56.0 abcd
Sapelo Sweet	54.1 abcd
Sweet Agent	53.7 abcde
Candy Ann	52.8 abcde
XON-109Y	50.2 abcdef
DP 1407	50.0 abcdefg
Inkopah	49.2 abcdefgh
11-26	48.0 abcdefgh
Sweet Treat	46.8 abcdefghi
Sweet Harvest	46.7 abcdefghi
Mata Hari	46.6 abcdefghi
Sweet Jasper	42.5 bcdefghij
Emy 55102	36.7 cdefghijk
Emy 55455	35.6 defghijk
Mr. Buck	34.6 defghijk
SV2657NK	34.0 defghijk
Sweet Uno	31.5 efghijk
Sweet Caroline	29.5 fghijk
Caramelo	29.5 fghijk
Century	28.4 fghijk
Granex Yellow PRR	28.3 fghijk
Emy 55164	27.7 ghijk
E61S.U6253	27.3 hijk
Nun 1006	24.8 ijk
Pirate	24.1 jk
Miss Megan	23.0 jk
Red Coach	21.7 jk
Savannah Sweet	20.1 k
J3008	17.2 k
Goldeneye	16.9 k
Red Hunter	16.2 k
** Letters that are the same between varieties indicate that those varieties are not significantly different according to Fisher's LSD (P ≤ 0.05).*	

[1] Vidalia Onion Area Agent; [2] University of Georgia Department of Horticulture; [3] University of Georgia Department of Plant Pathology; [4] Toombs County, ANR Agent; [5] Tattnall County, ANR Agent; [6] Candler County, ANR Agent; [7] Wheeler County, ANR Agent; [8] Montgomery and Treutlen Counties, ANR Agent; [9] Vidalia Onion and Vegetable Research Center

Impact of Fertilization Program on Yield and Quality of Vidalia Onions

Timothy Coolong[1] and Cliff Riner[2]

Introduction

Fertility and production practices have been widely studied in onion. However, the majority of studies have been conducted in isolation (only looking at a single or limited number factors) over a limited (one or two seasons) time period with a little or no genetic variation (single variety). For example previous field studies suggest that excessive nitrogen nutrition may contribute to poor storage life; while greenhouse-based trials have shown that high nitrogen levels can contribute to greater levels of methyl thiosulfinate precursors. However, no studies have been conducted evaluating both quality attributes simultaneously in field-grown crops. The lack of a systems-based evaluation makes it difficult for growers to put a value on relative risk associated with fertility and related production practices.

The objectives of this trial are to evaluate five fertilizer programs that are used by growers in some manner over five seasons. The results presented are for season one of production.

Materials and Method

Onion, 'Golden Eye,' and 'Sapelo Sweet' were transplanted November 21, 2013. Five fertilizer programs with varying amounts of nitrogen (N), sulfur (S), and calcium (Ca) were utilized (Table 1). Potassium and phosphorous were balanced with potassium chloride and mono or diammonium phosphate, respectively. Calcium was supplied with calcium chloride and calcium nitrate. Onions were harvested on May 9, 2014. Bulbs were cured and graded according to USDA standards. Ten-bulb subsamples were used for flavor analysis.

Enzymatically produced pyruvic acid (pungency) was measured using the method of Boyhan et al. (1999), while lachrymatory factor was measured using the method of Schmidt et al. (1996). Sugars were measured using HPLC.

Results and Discussion

There were significant variety by treatment interactions for total marketable, colossal, and medium bulb size yields as well as percentage of cull bulbs. Yields of jumbo bulbs were affected only by variety (Figures 1-4). There were no significant interactions present for onion flavor quality characteristics, although fertilizer treatment and variety affected lachrymatory factor and pungency levels (Table 2). Methyl thiosulfinate concentrations were not affected.

Table 1. Nutrient amounts supplied to onions during the 2014 growing season.

	Lb/acre								
	Preplant			Growth			Total Season		
Treatment	N	S	Ca	N	S	Ca	N	S	Ca
Control[z]	50	60	-	100	-	110	150	60	110
High N-S	100	120	-	120	-	130	220	120	130
Low N-S	25	35	-	70	-	72	95	35	72
High N (late)	50	60	-	190	-	185	220	60	185
High Ca	25	35	-	140	-	390	150	60	390

z Control treatment is based on University of Georgia recommended rates of N and S fertility.

Figure 1.

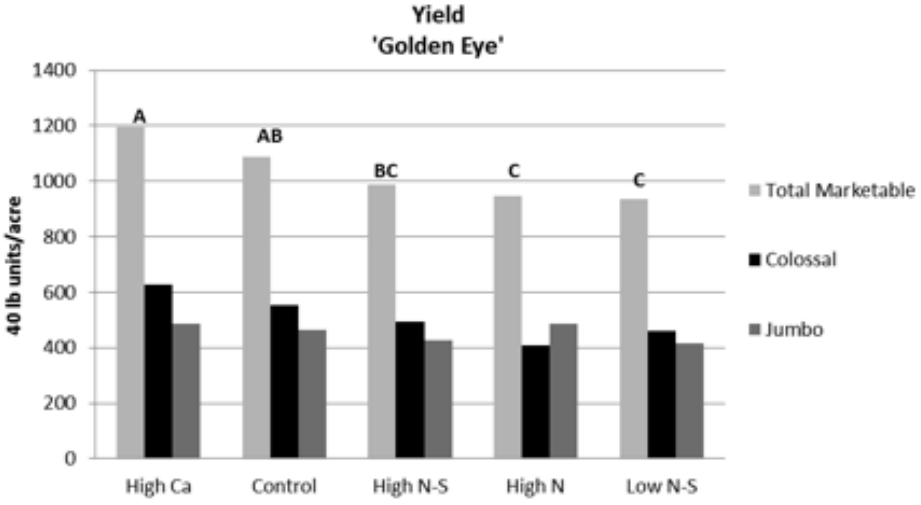

Figure 2.

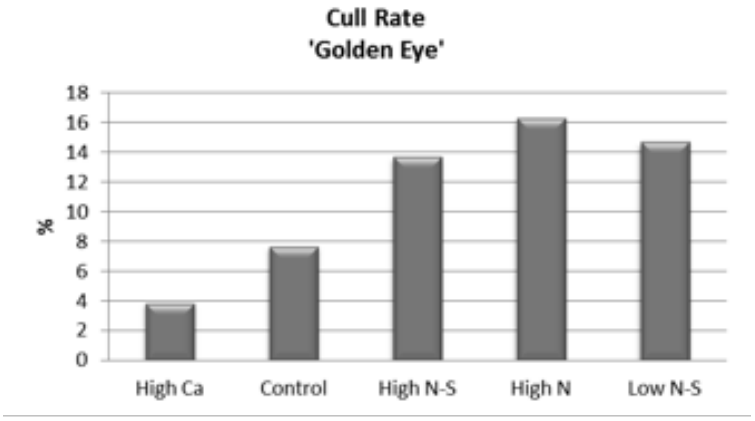

Figure 4.

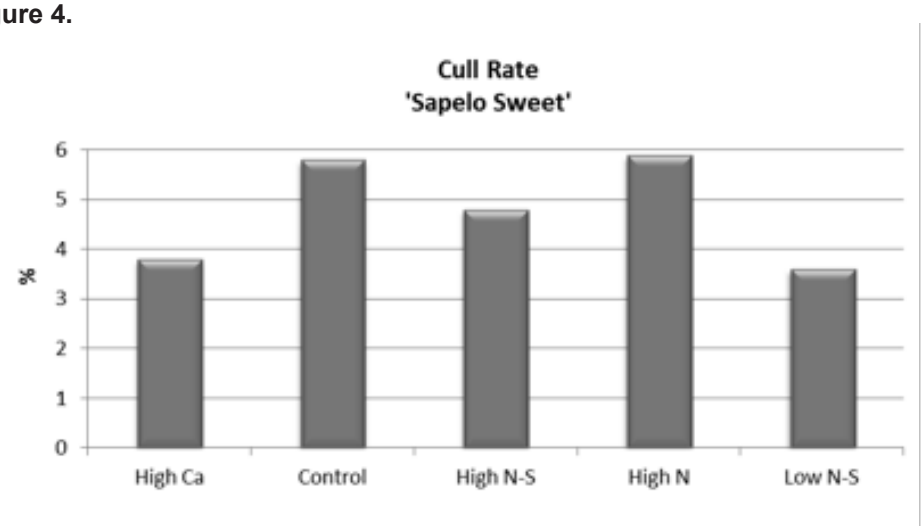

Figure 3.

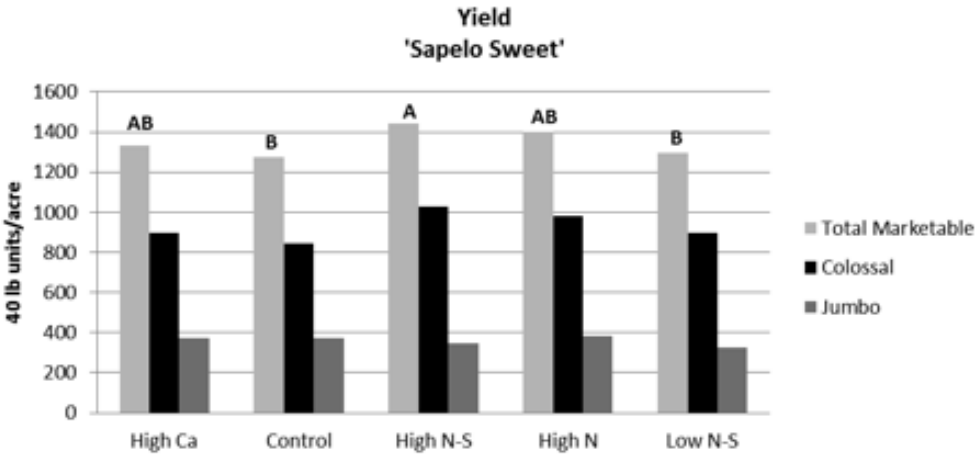

Table 2. Flavor quality for 'Golden Eye' and 'Sapelo Sweet' onion grown under five fertilizer treatments.

Treatment	Lachrymatory Factor	Methyl Thiosulfinates	Pungency
	μmol/ml juice		μmole/ g FW[z] pyruvic acid
High Ca	2.95ay	0.00047a	0.99ab
Low N-S	2.92a	0.00051a	1.24a
Control	2.57ab	0.00043a	0.74b
High N-S	1.92bc	0.00049a	0.60b
High N	1.80c	0.00046a	0.74b
Variety			
Golden Eye	2.68a	0.00042a	0.80a
Sapelo Sweet	2.18b	0.00052a	0.92a

z FW = fresh weight
y Numbers within the same column followed by the same letter are not significantly different at P < 0.05 according to Fisher's least significant difference test.

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Potassium Fertilization Effects on Sweet Onion Yield

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Introduction

After nitrogen (N), potassium (K) is the nutrient required in largest amounts by plants (Marschner, 2012). Potassium deficient plants show reduced growth and limited photosynthesis and, under severe deficiency, can present chlorosis. Fruits and tubers have a high K requirement and may develop physiological disorders when they are deficient in K. In a study in Vidalia, GA, potassium fertilizer rates from 0 to 177 kg/ha K2O were applied to sweet onion; yields showed a quadratic response with the highest yield at 84 k/ha K2O (Boyhan et al., 2007).

Materials and Method

Experiments were conducted at the Horticulture Farm, Tifton Campus, University of Georgia, in the winter of 2013 and 2014. Soil was a sandy-loam soil with a pH of about 6.5. Plants were grown on raised beds. Each bed had four rows 23-cm apart, with a plant spacing of 15 cm. Beds were covered with black plastic film mulch and there were two lines of drip tape per bed, each drip tape being located midway between rows in alternate rows. The drip tape (Ro-Drip, Roberts Irrigation Products Inc., San Marcos, Calif. [2000-01 and 2001-02]) had 10 cm emitter spacing, 0.50 $L \cdot h^{-1}$ emitter flow at 5631 $kg \cdot m^{-2}$ pressure, 0.2 mm wall thickness, and was buried 3 cm deep. Before planting, all treatments received 672 kg/ha of 10-10-10 fertilizer. Onion 'Yellow Granex PRR' plants were transplanted on December 12, 2012 and 2013.

Starting eight weeks after transplanting, N (as 28-0-0) and K (as 0-0-25 [potassium thiosulfate]) were applied through the drip tape. Total N applied was 169 kg/ha. Five total K fertilizer levels (67, 134, 202, 269, and 336 kg/ha K_2O) were evaluated in a randomized complete block design. Experimental plots consisted of a 6.1 m long bed (1.8 m centers) section.

Incidence of bolting (flower stems), sour skin (bacterial disease), and double-bulbs were determined as a percentage of plants with the symptoms. Plants were harvested when 20 percent of the necks had collapsed (tops down). Onions were hand-harvested and roots and tops were clipped; bulbs were left in the field for 48 hours for curing. After curing, bulbs were graded by size and appearance as marketable or cull (USDA, 1995), counted, and weighed. After grading, a subsample of 10 marketable bulbs per replication was used for determination of soluble solids content (SSC) and pungency. Ten wedges from each bulb group were juiced in a pneumatic press. Several drops of the juice were applied to a hand-held refractometer) to measure SSC. Pyruvic acid is used routinely to measure onion flavor intensity (Lancaster and Boland, 1990). Data were analyzed using the Mixed Procedure of SAS (SAS Institute, ver. 9.4).

Results and Discussion

Marketable and total number and weight of onion bulbs were not affected by K rate (Table 1). This indicates that a rate of 67 kg/ha K_2O was sufficient to cover the K needs of onion plants. Thus, rates higher than 84 kg/ha K_2O, as recommended by Boyhan et al. (2007), are likely unnecessary. Incidences of bolting (mean = 5 percent), sour skin (mean = 11 percent) and double-bulbs (mean = 1 percent) were also unaffected by K levels.

Bulb dry matter content, soluble solids content, and pungency were positively correlated among them, but they did not show linear relationships with K rate (data not shown). Bulbs fertilized with 240 kg/ha K_2O had greatest values of bulb dry matter content, soluble solids content, and pungency.

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Table 1. Sweet onion yields as influenced by potassium (K2O) fertilization rate. Tifton, GA, winter of 2013 and 2014.

	Marketable		Total		Bulb Weight
K2O (kg/ha)	1000/ha	t/ha	1000/ha	t/ha	(g)
67	104	29	153	39	281
134	97	28	152	42	295
202	102	31	149	42	310
269	97	29	154	42	304
336	92	28	147	40	301
P	0.342	0.658	0.324	0.583	0.491

Impact of Poly-coated Urea Products for the Production of Vidalia Onions

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Introduction

There has been an increased interest in the use of controlled release fertilizers in vegetable crops. While the uses of controlled release fertilizers, particularly poly-coated urea (PCU) products, have increased on agronomic crops, vegetable growers have been reluctant to use this technology. Some of the reasons why they have not been used are perceptions that they are too costly, release patterns are uneven, and that they may not provide adequate levels of nutrients during periods of rapid growth. To determine the suitability of two commercially available PCU products (Duration 120 and ESN) (Agrium Inc.) for Vidalia onion production, a trial was conducted during the 2014 growing season.

Materials and Method

The varieties 'Golden Eye' and 'Sapelo Sweet' were used for this trial. Fertilizer treatments were applied November 20, 2013, and transplanting took place on November 21, 2013. Fertilizer treatments were incorporated using a tiller/bedder prior to pegging. Fertilizer treatments are presented in Table 1. Plant in-row spacing was 4 inches. Plants were managed according to standard practices with the exception of fertilizer treatments. Buried mesh bags containing both ESN and Duration PCU products were placed in plots at a depth of 6 inches on November 21, 2013, and excavated throughout the growing season to determine N release patterns.

Plants were harvested on May 12, 2014, and cured at 90°F for approximately two days. Bulbs were graded according to USDA standards for Bermuda-Granex-Grano Type onions (Colossal: >3.75 inches, Jumbo: 3-3.75 inches, Medium 2-3.25 inches, [small were unmarketable and culled]).

Mesh bags containing both Duration and ESN products were buried at planting and excavated throughout the growing season to determine nitrogen release rates.

Results and Discussion

Onions receiving all N preplant via PCU grew well initially but appeared slightly yellow near maturity compared to other treatments. All other treatments, including 130 lb N PCU preplant, appeared dark green throughout growth. There was a significant freeze event in early January, 2014; however, all onions survived and suffered relatively little damage compared to other plantings in the area. 'Sapelo Sweet' bulbs appeared more vigorous than 'Golden Eye' throughout development and in general yielded more colossal bulbs.

Nitrogen release from PCU fertilizer was determined using the bag method. Evaluation dates were: November 21 (day 0), December 23, January 10, January 23, February 7, February 28, and March 18. Initial release from ESN was highest, with approximately 55-58 percent N released within the first month of growth. Release then slowed particularly

Table 1. Fertilizer treatments used in this trial.

Fertilizer Treatment	Nutrients Applied (lb/acre)
Control (UGA Recommendation)	500 lbs 10-10-10 preplant + 100 lb diammonium phosphate in Jan. + 580 lb calcium nitrate (90 lb N) in Feb.
Standard Rate 'ESN'	360 lb ESN (160 lb N) preplant + 0-0-60 & 0-18-0
Standard Rate 'Duration'	360 lb Duration (160 lb N) preplant + 0-0-60 & 0-18-0
Low Rate 'ESN'	280 lb ESN (130 lb N) preplant + 0-0-60 & 0-18-0 + 190 lb calcium nitrate (30 lb N) in Feb.
Low Rate 'Duration'	280 lb Duration (130 lb N) preplant + 0-0-60 & 0-18-0 + 190 lb calcium nitrate (30 lb N) in Feb.
Complete at planting + ESN	500 lb 10-10-10 preplant + 190 lb calcium nitrate (30 lb N) in Feb. + 175 lb ESN (80 lb N) in Feb.

between the January 10 and January 23 sampling dates. During this time period year, there was a significant cold front that moved through the area. The Duration product had a more linear release pattern with a much slower initial release than the ESN. The final sample was pulled at 117 days post application. At this time the ESN product released approximately 90 percent of N, while the Duration product had released approximately 85 percent of N.

Total N levels were recorded during rapid growth (late February) and at harvest. As might be expected, N levels were lowest in bulbs receiving all N preplant as ESN, given the relatively rapid release after planting. Bulbs grown in the control plots had the highest levels of N at harvest, though they were not significantly different than the application of 10-10-10 preplant, followed by an application of ESN later in the season. Bulbs treated with Duration had N levels that were in between other treatments. This would be expected given the release curve of Duration (Figure 1). There was more N available later in the season with Duration compared to ESN, though not as much as when using completely soluble fertilizers (control) or a combination of granular fertilizer and a late application of ESN.

Total marketable yields were higher in 'Sapelo Sweet' than 'Golden Eye' due to the higher percentage of colossal bulbs produced by 'Sapelo Sweet' (Table 3). For 'Sapelo Sweet,' applications of Duration and ESN at planting (130 lb N/acre) followed by an application of calcium nitrate later in the season yielded no differently than control or treatments receiving 10-10-10 at planting followed by a late application of ESN and calcium nitrate. In Golden Eye onion, the control treatments and those receiving 10-10-10 at planting followed by a late application of ESN yielded significantly more than most other treatments. The application of ESN at 130 lb N/acre preplant followed by a late season application of calcium nitrate was not significantly different than the control treatment.

These results suggest that PCU fertilizers can be used in the production of Vidalia onion, but they should be partnered with a soluble N-source or applications should be split over the season. Based on yield and release characteristics, an application of a complete granular fertilizer such as 10-10-10 at planting followed by a mid-season application of ESN should perform well. Because the release curve of the ESN is greater in the first few weeks, it is likely better suited for a late season application. Alternatively, an application of ESN or Duration at planting followed by a late season application of a soluble fertilizer (in this case calcium nitrate) also performed as well as the control when used in 'Sapelo Sweet' onion. Using this information, a recommendation may be to apply a PCU at planting combined with a low-N complete fertilizer to supply P and K, followed by a single late application of a soluble (calcium nitrate) fertilizer.

We would like to thank Agrium Fertilizer Inc. for funding this research.

Figure 1.

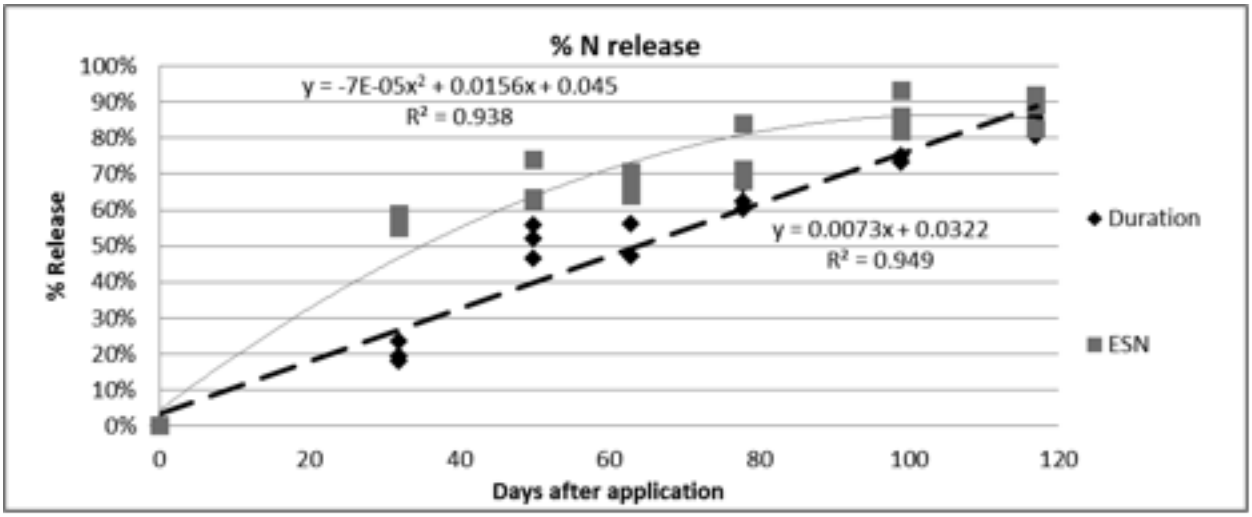

Table 2. Total nitrogen levels in leaf and bulb tissue in 'Sapelo Sweet' and 'Golden Eye' onion.

Treatment	% Nitrogen	
Sapelo Sweet	**Leaf[z]**	**Bulb**
Control	3.59a[y]	1.62a
Complete at planting + ESN	3.30a	1.59ab
Standard Rate Duration	3.25ab	1.44b
Low Rate Duration	3.17ab	1.47b
Standard Rate ESN	3.00b	1.26c
Low Rate ESN	2.76b	1.45b
Golden Eye	**Leaf**	**Bulb**
Control	3.68a	1.81a
Complete at planting + ESN	3.07b	1.67ab
Standard Rate Duration	3.27ab	1.45cd
Low Rate Duration	3.46ab	1.62bc
Standard Rate ESN	3.33ab	1.30d
Low Rate ESN	3.13b	1.54bc

z Leaf samples taken on 2/28. Bulb samples taken at harvest.
y Treatments followed by the same letter within a given variety are not significantly different according to Duncan's multiple range test P < 0.05.

Table 3. Yield data for 'Sapelo Sweet' and 'Golden Eye' onion.

	40 lb units/acre				%
Treatment	**Total Marketable**	**Colossal**	**Jumbo**	**Medium**	**Cull**
Sapelo Sweet					
Complete at planting + ESN	1367 a[z]	985 a	328 a	53 a	3.1 ab
Control	1272 ab	842 ab	375 a	55 a	5.8 a
Low Rate Duration	1245 ab	824 ab	359 a	63 a	1.8 b
Low Rate ESN	1230 ab	770 ab	420 a	40 a	3.7 ab
Standard Rate Duration	1100 bc	744 ab	302 a	54 a	4.4 ab
Standard Rate ESN	1044 c	595 b	385 a	64 a	3 ab
Golden Eye					
Complete at planting + ESN	1142 a	575 a	488 a	79 bc	3.7 a
Control	1089 ab	555 ab	466 a	69 c	7.7 a
Low Rate ESN	1004 bc	416 bc	509 a	79 bc	2.9 a
Low Rate Duration	909 c	380 c	421 a	108 ab	2.8 a
Standard Rate Duration	951 c	413 bc	418 a	120 a	2.7 a
Standard Rate ESN	946 c	428 abc	452 a	66 c	2.9 a

z Treatments followed by the same letter within a given variety are not significantly different according to Duncan's multiple range test P < 0.05.

Evaluation of Ignite S2 Transplant Dip On Vidalia Onion Yield

Chris Tyson[1], Cliff Riner[2], and Timothy Coolong[3]

Introduction

Ignite S2 is a soil and starter fertilizer product labeled for use on many crops, including Vidalia onions. It has a guaranteed analysis of 1–0–1 and also contains 0.10 percent Boron, 0.02 percent Cobalt, 0.30 percent Manganese, 0.04 percent Molybdenum, and 0.40 percent Zinc by volume. It has been marketed for use on Vidalia onions as a transplant dip just prior to being set in the soil. The purpose of this investigation is to evaluate yield of onions treated with and without the Ignite S2 transplant dip treatment.

Materials and Methods

This trial was conducted at the University of Georgia Vidalia Onion and Vegetable Research Center in Lyons, Georgia. Onion seedlings, 'Savannah Sweet' were transplanted on November 19, 2013 in a single onion bed consisting of eight plots. Plots were 25 feet long and had a total area of 150 square feet. There were 10-foot non-planted buffers between each plot. Four of the eight plots were dipped in an Ignite S2 solution prior to being transplanted. The solution consisted of a 50/50 mixture of the Ignite S2 product and water. The remaining four plots were not given any transplant dip. The onions in the trial were then grown according to UGA Extension production guidelines, including fertility, irrigation, and pesticide recommendations. The plots were harvested on May 7, 2014. Field weights were taken for each plot, and each plot was also graded. Weights were recorded for Colossal, Jumbo, and Medium grades. A total marketable weight was also given for each plot.

Results and Discussion

Data was compiled for the untreated and treated plots, and converted to a per acre yield basis. There were obvious numerical differences in comparing the treated plots to the untreated plots. Statistical interpretation was run on the data to compare the two treatments. There were some statistical differences between the treated and untreated plots (Table 1). Results from this trial indicate there may be some yield benefit to using a starter fertilizer dip treatment. More research needs to be done with this product and others over multiple years to effectively evaluate yield benefits.

Table 1. Yield Data from Ignite S2 Trial.

Treatment	Fresh	Colossal	Jumbo	Medium	Total Marketable
	Yield (40 lb units/acre)				
Treated	1270 a	23 a	784 a	101 a	908 a
Untreated	1134 a	16 a	642 b	124 a	783 b
P < 0.1	NS	NS	Sig	NS	Sig
P < 0.05	NS	NS	Sig	NS	NS

NS = Not significant.
Sig = Significant at either P < 0.1 or P < 0.05, according to Fisher's least significant difference test.

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Effect of Sulfur Dioxide on the Efficacy of Controlled Atmosphere (CA) and Ozone Storage for the Postharvest Control of Botrytis aclada *in Vidalia Sweet Onions*

Anthony Bateman[1] and Juan Carlos Díaz-Pérez[2]

Introduction

Georgia growers store Vidalia onions in controlled-atmosphere (CA) or ozone treated storage facilities for long-term storage (two months or longer). However, the storage related disorder Botrytis neck rot (BNR) (*Botrytis aclada*) may cause significant storage losses. Previous trials using sulfur dioxide (SO_2) as a postharvest fumigant to control *Botrytis aclada* showed positive results. Nonetheless, SO_2 was not evaluated then as a pretreatment for CA or ozone storage. The objectives of this study were to evaluate SO_2 as a pretreatment to CA and ozone storage to improve control of *Botrytis aclada*.

Materials and Method

Onions 'WI-129' (harvested on April 24, 2013) and 'Sweet Vidalia' (harvested on May 1, 2013) were obtained from the Vidalia Onion and Vegetable Research Farm in Lyons, Georgia, and transported to the to the University of Georgia Black Shank Research Farm for curing.

Bulbs were put on separate peanut wagons for field (48 hours, open air, in direct sun) and forced air heat (95°F for 48 hours) curing. After curing, bulbs were taken to the Vidalia Onion Research Laboratory for grading and bagging.

Onion bulbs were fumigated with SO_2 (0 ppm, 1,000 ppm, or 2,000 ppm for one hour). After SO_2 treatment, bulbs were placed in CA (3 percent O_2, 5 percent CO_2, and 92 percent N_2 at 34°F and 70 percent RH) or ozone-treated rooms (1 to 3 ppm/hour at 34°F and 70 percent RH) for two or four month storage.

Immediately after storage (day one) and after a 14-day shelf life period (70°F, ~70 percent RH), bulbs were graded, weighed and evaluated for incidence of BNR and other diseases (particularly sour skin, caused by *Burkholderia cepacia*), as well as storage disorders.

Results and Discussion

After two months of storage, the variety 'Sweet Vidalia' showed little benefit with addition of SO_2. There were no significant improvements to field cured bulbs stored in CA or ozone (Tables 1-2). Heat cured bulbs stored in CA showed an increase in sour skin during the shelf life portion of the study (Table 4). However, after four months of storage (day one), sour skin reduction was significant for field cured bulbs stored in CA (Table 5), but the 1,000 ppm rate had a significant decrease in marketable bulbs and an increase in BNR. While heat cured bulbs treated with 1,000 ppm of SO_2 had a significant increase in sour skin in CA storage (Table 7), there was a significant increase in marketable bulbs at the 2,000 ppm SO_2 with ozone in the shelf life study (Table 8).

Overall, the effects of the SO_2 treatments were more beneficial to the early variety 'WI129,' particularly the heat-cured samples. Field cured samples had a significant reduction of BNR in ozone storage at 1,000 ppm SO_2 after two months in storage (Table 1), resulting in a significant increase in the percentage of marketable bulbs immediately after storage as well as after 14 days in the shelf life study. While the percent marketable bulbs were not affected by the 2,000 ppm SO_2 rate compared to the control, this treatment results in a significant reduction in the incidence of BNR (Table 2).

While 'WI129' heat cured and ozone-stored bulbs had less sour skin at both SO_2 rates (Table 3), the 2,000 ppm SO_2 rate had significantly more BNR. In the two month shelf life study, the 1,000 ppm SO_2 treatment significantly affected heat-cured bulbs by increasing marketability and decreasing BNR in both CA and ozone storage (Table 4). For 'WI129,' there were no significant benefits of the SO_2 treatments at the four month removal for field-cured bulbs stored in CA or ozone (Table 5 and 6).

The greatest benefit of SO_2 seemed to be for heat cured bulbs at the four month removal. CA stored bulbs had significant increases in marketability and decreases in BNR at the 2,000 ppm rate for both the day one and 14 day (shelf) removal (Table 7 and 8). Ozone stored bulbs had significantly less BNR in the shelf life study (Table 8).

Also of note, after one month, CA changed from 3 percent O_2 and 5 percent CO_2 to 5 percent O_2 and 5 percent CO_2 due to equipment failure.

Utilizing SO_2 as a pretreatment to CA and ozone storage for improved control of *Botrytis aclada* showed promising results. However, rates of SO_2 use and application duration need additional evaluation to determine the best rate for short and long-term storage. Further work is also necessary on SO_2 effects on early and standard onion varieties.

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Table 1. Field cured onion bulbs after two-month storage in either controlled atmosphere or ozone; one day after removal from storage.

		Controlled Atmosphere				Ozone			
		Marketable	Botrytis	Sour skin	Other	Marketable	Botrytis	Sour skin	Other
Variety	SO2 rate	(%)							
WI129	0 ppm	87.0	11.1	0	1.9	74.1	18.5 a*	1.9	5.6
	1000 ppm	94.4	5.6	0	0	80.1	5.5 b	3.5	10.9
	2000 ppm	96.3	1.9	0	1.9	74.1	18.5 a	3.7	3.7
Sweet Vidalia	0 ppm	97.4	2.6	0	0	92.3	7.7	0	0
	1000 ppm	76.9	18.0	0	2.6	84.6	15.4	0	0
	2000 ppm	89.7	7.7	2.6	0	79.5	18.0	2.6	0

** Per variety, values followed by the same letter within a column are not significantly different (Fisher's LSD, P = 0.05). Values without letters are not significantly different from each other.*

Table 2. Field cured onion bulbs after two-month storage in either controlled atmosphere or ozone; 14 days after removal from storage.

		Controlled Atmosphere				Ozone			
		Marketable	Botrytis	Sour skin	Other	Marketable	Botrytis	Sour skin	Other
Variety	SO2 rate	(%)							
WI129	0 ppm	79.6	13.0	7.4	0	51.9 b*	33.3 a	13.0	1.9
	1000 ppm	83.3	13.0	3.7	0	75.9 a	18.5 ab	5.6	0
	2000 ppm	87.1	7.4	5.6	0	74.1 ab	13.0 b	11.1	1.9
Sweet Vidalia	0 ppm	84.6	10.3	2.6	2.6	48.7	43.6	5.1	2.6
	1000 ppm	84.6	15.4	0	0	71.8	25.6	0	2.6
	2000 ppm	89.7	2.6	5.1	2.6	79.5	15.4	2.6	2.6

** Per variety, values followed by the same letter within a column are not significantly different (Fisher's LSD, P = 0.05). Values without letters are not significantly different from each other.*

Table 3. Heat cured onion bulbs after two-month storage in either controlled atmosphere or ozone; one day after removal from storage.

		Controlled Atmosphere				Ozone			
		Marketable	Botrytis	Sour skin	Other	Marketable	Botrytis	Sour skin	Other
Variety	SO2 rate	(%)							
WI129	0 ppm	76.1	22.0	1.9	0	75.9	5.6 b*	14.2 a	3.7
	1000 ppm	87.9	8.5	1.9	1.7	85.2	13.0 ab	1.9 b	0
	2000 ppm	82.2	5.2	7.1	5.6	75.9	24.1 a	0 b	0
Sweet Vidalia	0 ppm	82.1	10.3	5.1	2.6	84.6	10.3 ab	2.6	2.6
	1000 ppm	89.7	10.4	0	0	76.9	20.5 a	2.6	0
	2000 ppm	94.9	2.6	0	2.6	87.2	2.6 b	10.3	0

** Per variety, values followed by the same letter within a column are not significantly different (Fisher's LSD, P = 0.05). Values without letters are not significantly different from each other.*

Table 4. Heat cured onion bulbs after two-month storage in either controlled atmosphere or ozone; 14 days after removal from storage.

		Controlled Atmosphere				Ozone			
		Marketable	Botrytis	Sour skin	Other	Marketable	Botrytis	Sour skin	Other
Variety	SO2 rate	(%)							
WI129	0 ppm	66.7 b*	13.0 a	20.4	0 b	53.7 b	28.2 ab	13.9	4.2
	1000 ppm	90.7 a	1.9 b	3.7	3.7 a	77.8 a	14.8 b	5.6	1.9
	2000 ppm	79.6 ab	13.0 a	20.4	0 b	42.6 b	40.7 a	11.1	5.6
Sweet Vidalia	0 ppm	84.6	15.4	0 b	0	76.9	12.8	5.13	5.1
	1000 ppm	84.6	15.4	0 b	0	76.9	23.1	0	0
	2000 ppm	76.9	15.4	5.1 a	2.6	87.2	12.8	0	0

** Per variety, values followed by the same letter within a column are not significantly different (Fisher's LSD, P = 0.05). Values without letters are not significantly different from each other.*

Table 5. Field cured onion bulbs after four-month storage in either controlled atmosphere or ozone; one day after removal from storage.

		Controlled Atmosphere				Ozone			
		Marketable	Botrytis	Sour skin	Other	Marketable	Botrytis	Sour skin	Other
Variety	SO2 rate	(%)							
WI129	0 ppm	77.8	7.4	7.4	7.4	64.8	24.1	5.6	5.6
	1000 ppm	79.6	9.3	7.4	3.7	57.4	33.3	9.3	0
	2000 ppm	81.5	7.4	3.7	7.4	77.8	18.5	1.9	1.9
Sweet Vidalia	0 ppm	82.1 a*	12.8 b	5.1 a	0	62.6	34.6	0	2.8
	1000 ppm	64.1 b	33.3 a	0 b	2.6	66.7	30.8	2.6	0
	2000 ppm	89.7 a	10.3 b	0 b	0	69.2	28.2	2.6	0

** Per variety, values followed by the same letter within a column are not significantly different (Fisher's LSD, P = 0.05). Values without letters are not significantly different from each other.*

Table 6. Field cured onion bulbs after four-month storage in either controlled atmosphere or ozone; 14 days after removal from storage.

		Controlled Atmosphere				Ozone			
Variety	SO2 rate	Marketable	Botrytis	Sour skin	Other	Marketable	Botrytis	Sour skin	Other
		(%)							
WI129	0 ppm	72.2	14.8	3.7	9.3	61.1	25.9	7.4	5.6 b*
	1000 ppm	61.1	24.1	13.0	1.9	59.3	20.4	9.3	11.1 ab
	2000 ppm	59.3	22.2	9.3	9.3	70.4	5.6	7.4	16.7 a
Sweet Vidalia	0 ppm	79.5	18.0	2.6	0	53.85	33.3	2.6	10.3
	1000 ppm	59.0	30.8	7.7	2.6	71.79	23.1	0	5.1
	2000 ppm	71.8	18.0	10.3	0	61.54	28.1	2.6	7.7

** Per variety, values followed by the same letter within a column are not significantly different (Fisher's LSD, P = 0.05). Values without letters are not significantly different from each other.*

Table 7. Heat cured onion bulbs after four-month storage in either controlled atmosphere or ozone; one day after removal from storage.

		Controlled Atmosphere				Ozone			
Variety	SO2 rate	Marketable	Botrytis	Sour skin	Other	Marketable	Botrytis	Sour skin	Other
		(%)							
WI129	0 ppm	61.1 b*	31.5 a	1.9	5.6	64.8	31.5	3.7	0 b
	1000 ppm	79.6 a	14.8 ab	3.7	1.9	59.3	20.4	11.1	9.3 a
	2000 ppm	81.5 a	7.4 b	3.7	7.4	59.3	31.5	3.7	5.6 ab
Sweet Vidalia	0 ppm	87.2	10.3	0 b	2.6	79.5	18.0	0	2.6
	1000 ppm	84.6	7.7	5.1 a	2.6	87.2	10.3	0	2.6
	2000 ppm	92.3	5.1	0 b	2.6	87.2	0	5.1	7.7

** Per variety, values followed by the same letter within a column are not significantly different (Fisher's LSD, P = 0.05). Values without letters are not significantly different from each other.*

Table 8. Heat cured onion bulbs after four-month storage in either controlled atmosphere or ozone; 14 days after removal from storage.

		Controlled Atmosphere				Ozone			
Variety	SO2 rate	Marketable	Botrytis	Sour skin	Other	Marketable	Botrytis	Sour skin	Other
		(%)							
WI129	0 ppm	42.6 b*	33.3 a	13.0	11.1 b	33.3	57.4 a	5.6	3.7 b
	1000 ppm	51.1 ab	19.8 ab	9.1	20.1 a	53.7	18.5 b	11.1	16.7 a
	2000 ppm	68.5 a	9.3 b	18.5	3.7 b	51.9	31.5 b	5.6	11.1 ab
Sweet Vidalia	0 ppm	64.1	23.1	5.1	7.7	46.2 b	35.9	7.7	10.3
	1000 ppm	53.9	41.0	2.6	2.6	59.0 ab	30.8	2.6	7.7
	2000 ppm	76.9	10.3	7.7	5.1	79.5 a	15.4	0	5.1

** Per variety, values followed by the same letter within a column are not significantly different (Fisher's LSD, P = 0.05). Values without letters are not significantly different from each other.*

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Investigation on the Spatio-temporal Spread of the Pseudomonas coronafaciens pv. morceparum in Onion Seedbeds and Production Fields

Ronald Gitaitis[1], Bhabesh Dutta[1], David Langston[1], Samuel Smith[1], Jonathon Van Keith Searcy[1], Erin Holliman[1], Cliff Riner[2], and Jason Edenfield[3]

Introduction

Yellow bud (YB) is an emerging bacterial disease of onion that has the potential to severely affect Vidalia onion production. Since first being reported in 2007, this disease has been spreading to counties within the Vidalia onion zone (VOZ). Symptoms of YB include intense chlorosis in emerging leaves and severe blight in the older leaves, leading to stand loss, reduced bulb size, and the creation of avenues of entry for secondary, soft rot organisms. The causal organism is a gram-negative bacterium and confirmed as a novel pathovar of *Pseudomonas coronafaciens*. The proposed name for this organism is *P. coronafaciens* pv. *morceparum* (Pcm).

Utilizing the previous grant award from the Vidalia Onion Commission, we surveyed and identified two weed species (Italian ryegrass and curly dock) that can harbor Pcm during the spring and summer months in the Vidalia onion zone. The bacterial strains isolated from the weeds produced YB symptoms when onions were inoculated under greenhouse conditions. We also observed that the bacterium can potentially be seedborne as onion seedlings grown from artificially inoculated seeds developed typical YB symptoms (Dutta et al., 2013, 2014).

As a continued research, we investigated the spatio-temporal spread of Pcm in the onion seedbed and in the production field. In addition, effects of time of sampling and irrigation events on the detection of Pcm as aerosols at two heights 3 feet and 6 feet were investigated. We also evaluated the potential risk of disease spread from curly dock (weed) planted along the edge of the onion field.

Materials and Method

Determining the spatial and temporal spread of the YB bacterium in onion seedbeds. Onion seeds (cv. Century) were planted at the Vidalia Onion and Vegetable Research Farm, near Reidsville, Georgia. Onion seedlings at one end of a plot (50 feet) were inoculated three weeks after planting by infiltrating leaves with a bacterial suspension containing 1×10^8 CFU/ml of Pcm. The source of inoculum was represented as a line source. Plots with seedlings inoculated with PBS served as the negative control. Onion seedlings were monitored for the presence of disease at weekly intervals until eight weeks. In addition, air samples were collected at two different heights—3 feet and 6 feet above inoculated and uninoculated plots at every 10 feet, 20 feet, 30 feet, 40 feet, and 50 feet from a line source. This was done to determine the spread of Pcm as aerosols. The air-samples were also taken at two different time periods of a day, i.e., at 9:00 a.m. and 3:00 p.m. Air samplings were done using an Andersen six-stage viable air sampler, and samples were tested for the bacterium by plating assay. Four replications of treatment were used in a single experiment, and this experiment was done two times (2013 and 2014).

Determining the potential spread of Pcm from inoculated curly dock (weed) along the edge of an onion field to healthy onion plants. Field experiments were conducted at the UGA Vidalia Onion and Vegetable Research Farm, near Reidsville, Georgia. Onion seedlings were transplanted onto raised beds with a length of 50 feet. In this study, curly dock seedlings were planted along the edges of the onion field. After one week of planting, curly dock seedlings were inoculated by spraying with a suspension of Pcm containing 1×10^8 CFU/ml. Onion plots without curly dock were used as control plots. Four replications of treatment were used in a single experiment, and this experiment was done two times (2013 and 2014). Plots were evaluated for the YB symptoms every week until eight weeks.

Results

Determining the spatial and temporal spread of the YB bacterium in onion seedbeds. In our two years of investigations, we observed the spread of Pcm through aerosols to a distance of 20 feet from line source of inoculum to healthy onion seedlings by 7 days post inoculation (dpi) (Table 1). By 14 and 21 dpi, Pcm spread to a distance of 50 feet as aerosols

with 10 percent and 40 percent of the samples tested positive for the bacterium, respectively (Table 1). In general, Pcm was detected as aerosols in plots at least two weeks prior to the YB incidence observed on seedlings. YB incidence was not observed in control plots, whereas in treated plots, symptoms appeared in inoculated plants by 7 dpi.

However, by 14 dpi, YB incidence was observed in plots (10 percent incidence) 20 feet away from the line source of inoculum. By 21 dpi, symptomatic onion seedlings (30 percent) were observed at a distance of 50 feet from the line source of inoculum (Table 1).

Once the entire plot was infected with Pcm and YB symptoms appeared at 50 feet from line source of inoculum, effects of sampling time, sampling height, and irrigation events on bacterial detection in aerosols were evaluated. Aerosols were assayed at every 10 feet, 20 feet, 30 feet, 40 feet, and 50 feet from a line source. At the sampling height of 3 feet, higher percentages of the Pcm were detected in aerosols at 9 a.m. than at 3 p.m., whereas at the height of 6 feet, higher percentages of the bacterium was detected at 3 p.m. than at 9 a.m. (Table 2). The mean percentages of Pcm detected at 9 a.m. from heights 3 feet and 6 feet were 2.54×10^2 and 1.81×10^2 CFU/m^3, respectively. In addition, after overhead irrigation, percentage of Pcm positive aerosol samples decreased at both heights, 3 feet and 6 feet for both sampling periods (Table 2).

Determining the potential spread of Pcm from inoculated curly dock (weed) along the edge of an onion field to healthy onion plants. YB symptoms were not observed from onion plots where curly dock plants were inoculated with sterile water. In contrast, onion plots where curly dock was inoculated with Pcm, YB symptoms were observed at 10 feet (15 percent) from the inoculum source by 14 dpi. By 21 and 28 dpi, YB symptoms were observed at 30 feet (52 percent) and 50 feet (64.5 percent), respectively, from the point source of inoculum (curly dock). Aerosols collected during morning hours (9 a.m.) at 3 feet of height from the ground level, were assayed for Pcm as described above. Pcm was detected in aerosols at 10 feet (24.5 percent) and 20 feet (43.8 percent) away from point source by 7 and 14 dpi, respectively. By 21 and 28 dpi, the bacterium was detected in aerosols at 40 feet (45 percent) and 50 ft (32 percent) from the point source of inoculum, respectively.

Conclusions

We demonstrated the spread of Pcm or the YB bacterium from a source of inoculum to healthy onion seedlings in seedbeds. Our finding show that the bacterium can spread through aerosols to a distance of 50 feet from a source of inoculum by 21 dpi.

We also evaluated the potential spread of Pcm through aerosols generated before and after over-head irrigation. Results from this study indicated that Pcm in aerosols were in higher percentages at 6 feet off the ground during afternoon hours (3 p.m.) than during morning hours (9 a.m.). In addition, higher percentages of aerosols with Pcm were detected before irrigation than after irrigation. This can be explained by rising air pulling bacteria off of plant surfaces and irrigation driving them out of the air back to the ground or onto plant surfaces.

Finally, we investigated the potential risk of disease spread from curly dock (weed) planted along the edge of an onion field. Results from this study indicated the spread of Pcm from weeds to healthy onion seedlings occurred within 7 dpi of the weeds. By the end of 28 dpi, YB symptoms were observed on seedlings at a distance of 50 feet from inoculated weeds. In conclusion, under favorable conditions, the YB bacterium can potentially be spread from an infected source (onion seedlings or weeds) to healthy seedlings as aerosols. The spread of this pathogen can occur rapidly, and hence, proper integrated disease management options need to be evaluated for this situation.

References

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Dutta, B., Gitaitis, R. D., Lewis, K. L., Booth, C., Langston, D. B., Webster, T. M., Riner, C. M., & Edenfield, J. D. (2013). New report of *Lolium multiflorum* L. and *Rumex crispus* L. as resident weed hosts of epiphytic populations of *Psuedomonas* sp., causal agent of yellow bud in onions in Georgia, USA. *New Disease Report, 27*(18).

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Table 1. Temporal and spatial spread of the YB in the onion seedbeds during 2013 and 2014.

Distance[a] (ft)	Time (days post inoculation)[b]							
	0		7		14		21	
	Aerosol samples with YB (%)[c]	YB incidence (%)[d]	Aerosol samples with Pcm (%)	YB incidence (%)	Aerosol samples with Pcm (%)	YB incidence (%)	Aerosol samples with Pcm (%)	YB incidence (%)
0	0	0	50	10	80	35	70	85
10	0	0	30	0	60	20	50	50
20	0	0	20	0	30	20	50	75
30	0	0	0	0	20	0	40	35
40	0	0	0	0	20	0	60	30
50	0	0	0	0	10	0	40	30

a Distance from point source of inoculum.
b Sampling time after inoculation of a line source of inoculum (onion seedlings) with Pcm.
c Percentage of aerosol samples detected positive for Pcm by diagnostic assays. Ten replicates of aerosol samples were taken at each sampling distance and assayed for the presence of Pcm. Sampling height for aerosol sample collection was 3 ft.
d Percentage of seedlings showing typical yellow bud (YB) symptoms at each sampling distance. Percentage was deduced based on calculating YB symptoms for 20 onion seedlings at each sampling distance.

Table 2. Mean population of Pcm recovered in aerosol particles during two-sampling periods in experimental onion seedbeds during a normal sunny day with an average temperature of 15 ±3°C and 65 percent RH (2013 and 2014).

Sampling time (h)	Sampling height (ft)	Sampling distance from line source of inoculum (ft)	Before overhead irrigation		After overhead irrigation	
			Percentage of aerosol samples with Pcm	Mean log^{10} CFU/m^3	Percentage of aerosol samples with Pcm	Mean log^{10} CFU/m^3
0900-1000	3	0	70.01	3.372	10.0	2.13
		10	50.0	2.18	20.0	1.42
		20	30.0	1.87	nd3	nd
		30	30.0	3.56	nd	nd
		40	15.0	2.72	nd	nd
		50	5.0	1.45	nd	nd
0900-1000	6	0	40.0	4.32	30.0	3.41
		10	20.0	3.16	10.0	2.24
		20	20.0	2.07	10.0	3.62
		30	nd	nd	nd	nd
		40	nd	nd	nd	nd
		50	nd	nd	nd	nd
1500-1600	3	0	20.0	2.12	30.0	4.32
		10	30.0	4.26	10.0	2.14
		20	nd	nd	20.0	2.65
		30	nd	nd	nd	nd
		40	nd	nd	nd	nd
		50	nd	nd	nd	nd
1500-1600	6	0	80.0	4.13	15.0	2.62
		10	65.0	4.02	12.0	1.76
		20	55.0	3.74	3.0	2.72
		30	50.0	2.87	nd	nd
		40	35.0	3.32	nd	nd
		50	15.0	2.63	nd	nd

1 Percentage of aerosol a samples assayed positive for Pcm by plating assay.
2 Mean Pcm populations recovered by plating assay from the plates upon air-sampling for 5 minutes.
3 Pcm not detected from air-samples.

Research Report on Management of Sour Skin 2013-14 Season

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Introduction

Sour skin of onion is an annual threat to onion quality and profitability of the Vidalia onion industry. Although a postharvest disease, sour skin gets its start in the field as the majority of inoculum is from a soilborne bacterium, *Burkholderia cepacia*. There are limited options available to manage bacterial diseases, and there are even fewer for those pathogens that are soilborne. Fumigants that are effective against either soilborne fungi or nematodes are ineffective against the sour skin bacterium. In fact, *B. cepacia* is often used as a bioremediation organism, meaning it can digest many chemicals and break them down into simpler compounds. In other words, it can eat fumigant chemicals. Thus there is a need for new approaches to develop a management strategy for sour skin.

Previous results indicated that there were differences in certain mineral elements in healthy onion bulbs from plots with lower levels of sour skin compared to bulbs from plots with higher levels. Furthermore, multiple regression models were developed to explain the different levels of disease observed in the different plots. Of particular interest in these models were the importance of several heavy metal cation ratios, namely, Copper:Iron, Copper:Manganese, Manganese:Zinc, and Iron:Zinc. These four elements are known cofactors of the three superoxide dismutase enzymes that help detoxify reactive oxygen species (i.e., act as antioxidants), which in turn could stimulate systemic acquired resistance mechanisms in plant metabolism. In previous years, the Copper:Iron ratio was the largest contributing factor to the model, and this same ratio has been observed as the largest contributing factor in our work with disease resistance of tobacco to tomato spotted wilt and resistance of pepper to bacterial leaf spot.

Materials and Method

Field plots for two trials were established in a randomized complete block design at the Blackshank Farm near Tifton, Georgia. In Trial 1, treatments consisted of CM, CP, CS, CZ, OM, OP, OS, and OZ; where C = carrot and O = onion, as winter crops, and M = Pearl Millet, P = peanut, S = soybean, and Z = maize as summer crops double-cropped behind either carrot or onion. In Trial 2, treatments consisted of supplements to standard N-P-K fertilizer and calcium nitrate practices where: 1 = magnesium sulfate + cupric sulfate + calcium chloride; 2 = magnesium sulfate + cupric sulfate + calcium chloride + zinc chelate; 3 = magnesium sulfate + cupric sulfate + gypsum; 4 = iron chelate + gypsum; 5 = magnesium sulfate + cupric sulfate + calcium chloride + Actigard; 6 = iron chelate + gypsum + zinc chelate; 7 = iron chelate + gypsum + zinc chelate + Actigard; and 8 = Standard N-P-K (6-12-18 with 4 percent sulfur) + calcium nitrate levels and applications as recommended by UGA Extension.

The supplements were selected for further evaluation based on earlier results from micro-plot studies and were applied. Supplements were applied five times over a course of time, beginning in mid-December and ending in early March. Weeds and insects were managed according to protocols recommended by UGA Extension. Onion bulbs were undercut on May 7 when approximately 70 percent of onion leaves were down and then allowed to dry in the field for 48 hours. Onion bulbs were rated for sour skin incidence and severity by cutting bulbs after two weeks of storage in the packinghouse.

Tissue and soil samples were sent to the UGA Plant and Soil Analysis Laboratory in Athens, Georgia, for mineral analysis. Results were compiled and all statistical analyses were performed using SAS version 9.3 (SAS Institute Inc., Cary, NC, USA). Development of PCR primers to evaluate expression of Cu-ZnSOD and MnSOD genes were developed from gene sequences of garlic and African oil palm, respectively, found in the GenBank.

Results and Discussion

The field study results were that predictive disease models (Figures 1-3, 5) could be developed for both soil and tissue data using mineral concentrations and ratios of certain minerals to one another. These models were highly significant and could explain, on average, slightly more than 37 percent of the sour skin levels observed. There were no apparent problems of co-

linearity in any of the models as indicated by all VIF values being less than 5.0 (Table 1).

In addition, all models displayed acceptable patterns when residuals were plotted against predicted values (data not shown) except for the micro-plot tissue model, which displayed a fan-shaped pattern when raw data were evaluated. This pattern occurs due to unequal (non-constant) variances and the variance of the error increases as the mean increases. A transformation of the data can help stabilize these variances. The best transformation was ASINH (inverse hyperbolic sine), which alleviated the problem and altered the model very little.

Of particular interest was the fact that manganese (Mn) levels in the soil in Trial 2 had no apparent correlation with sour skin levels (Figure 4) but different Mn levels occurred in the bulbs and significantly correlated with sour skin levels (Figure 5) despite the fact that no supplemental Mn was applied to those onions.

However, when the effects of supplemental copper and iron were evaluated (Figures 6-8), it can be seen that interactions with each other as well as Mn occurred. As expected, when supplemental copper was applied, there was an increased level of copper in the bulbs (Figure 6) in contrast to when iron was applied. However, there were actually higher levels of iron in bulbs from added copper than from the added iron (Figure 7).

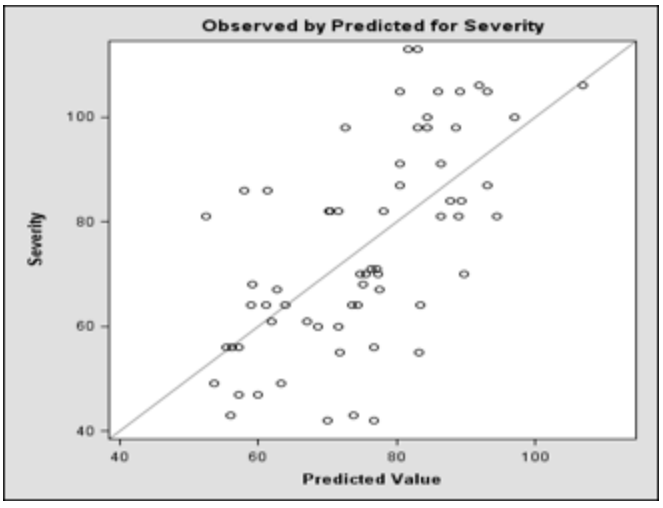
Of greater interest for disease resistance, there was a trend of higher levels of manganese in bulb tissues from adding supplemental iron (Figure 8). Furthermore, bulbs with lower levels of sour skin contained significantly higher levels of manganese (Figure 9).

The effects of supplemental iron and copper on the expression of superoxide dismutase genes and the relationship to disease can be seen in Figures 10-12. Added copper up-regulated Cu-ZnSOD more so than added iron, and in general, there were higher levels of sour skin in treatments with supplemental copper (Figure 12). In contrast, added iron not only increased Mn content in bulb tissues but also up-regulated MnSOD more so than added copper (Figure 11), and added iron correlated with lower levels of sour skin. Another trend observed and not fully understood is that lower levels of sour skin occurred with gypsum as the source of calcium when compared to calcium chloride (Figure 12).

In summary, several predictive models were developed from micronutrient levels in both the soil and plant tissues that significantly correlated (Table 1) with levels of sour skin in 2014. Furthermore, the elements Cu, Fe, Mn, and Zn appeared as components of these models displaying a trend since 2012 (Table 2). In particular, when the first three independent variables in the eight models developed from 2012-2014 are evaluated, these four elements and their combinations occur 86 percent of the time when compared to all the other elements and element combinations assessed. Furthermore, the elements Cu, Fe, Mn, and Zn occurred 94 percent of the time as the first independent variable in the nine models developed from 2012-2014.

Since these four elements are co-factors of the three main types of superoxide dismutase enzymes, namely Cu-ZnSOD, FeSOD, and MnSOD, we attempted to develop methods to assess their effect on those enzymes. Successful PCR protocols were developed to assess expression of the Cu-ZnSOD and MnSOD genes by using sequences in GenBank for genes of these two enzymes from garlic and African oil palm, respectively. Similar attempts to develop a PCR protocol for FeSOD and NPR1 protein did not meet with success. Thus, we were able to develop a protocol for only two of the four genes of interest because we were hampered by the fact that the onion genome has never been sequenced. To resolve this problem, we have submitted RNA samples for analysis using trancriptomics and hope to develop the necessary tools to also evaluate FeSOD and NPR1 protein. Understanding gene expression from these four different elements will help us to understand how minerals interact to affect disease resistance.

Figure 1. 2014 Tissue Model: Fit of observed vs. predicted values from macro plots (double-cropping/ rotation) for sour skin severity based on mineral content of bulbs. % Sour Skin = -353 CuFe + 35 NaFe + 27.8 MnZn – 1.77 Mn + 0.04 Ca + 0.003 N – 28.8; P = 0.00002; Adj. R^2 = 0.34



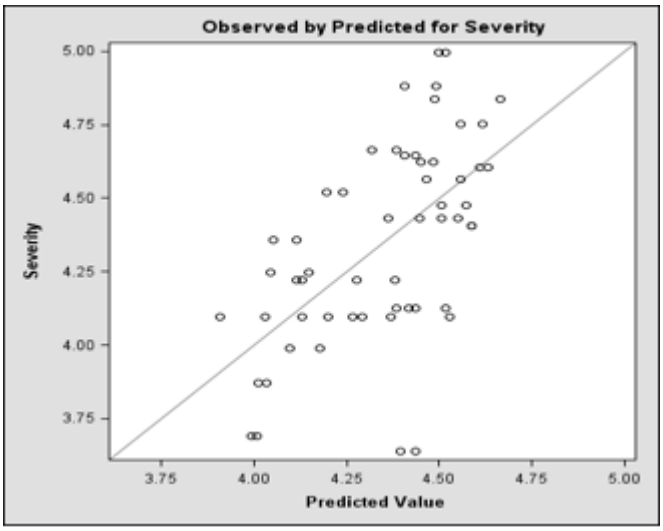


Figure 2. 2014 Tissue Model*: Fit of observed vs. predicted values from micro plots (fertility treatments) for sour skin severity based on mineral content of bulbs. % Sour Skin = -3.16 CuFe – 0.55 Mn + 6.4; *P = 0.00001; Adj. R^2 = 0.32

** Data had to be transformed (ASINH) with this model to remove problems identified by a fan shaped residual pattern using raw data. This pattern occurs due to unequal (non-constant) variances. The variance of the error increases as the mean increases. A transformation of the data can help stabilize these variances. The best transformation was ASINH.*

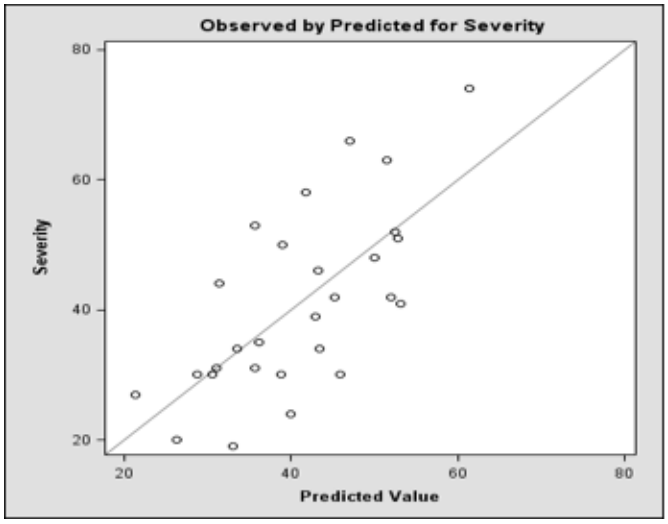


Figure 3. 2014 Soil Model: Fit of observed vs. predicted values from micro plots (fertility treatments) for sour skin severity based on mineral content of soil. % Sour Skin = -359.7 Mo – 31 CuFe + 20.5 Ni – 6.1 PMg – 0.31 FeCu + 0.13 Mg + 69.4; P = 0.02; Adj. R^2 = 0.343

Figure 4. Levels of manganese (Mn) in soil in micro-plots plotted against levels of sour skin, indicating no significant relationship between sour skin and Mn levels in the soil.

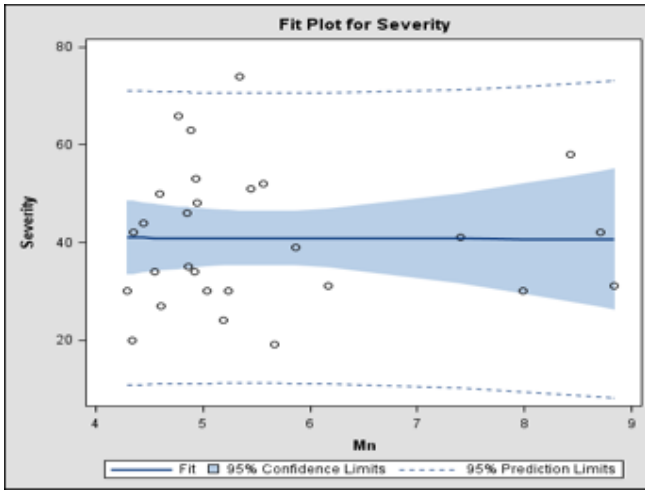


Figure 5. Levels of manganese (Mn) in onion bulbs from micro-plots plotted against levels of sour skin. Model: Sour Skin Severity = -1.03 Mn + 57.49; P = 0.00003; Adj. R2 = 0.28

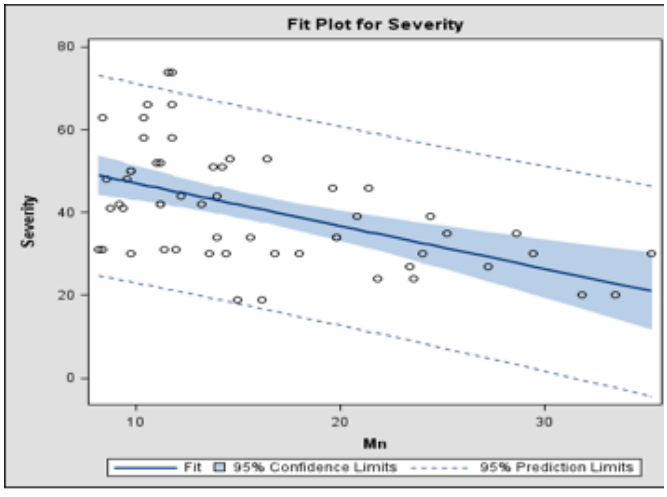


Figure 6. Copper (Cu) levels in onion bulbs selected for SOD analysis; bulbs were either supplemented with iron (low disease) or copper (high disease).

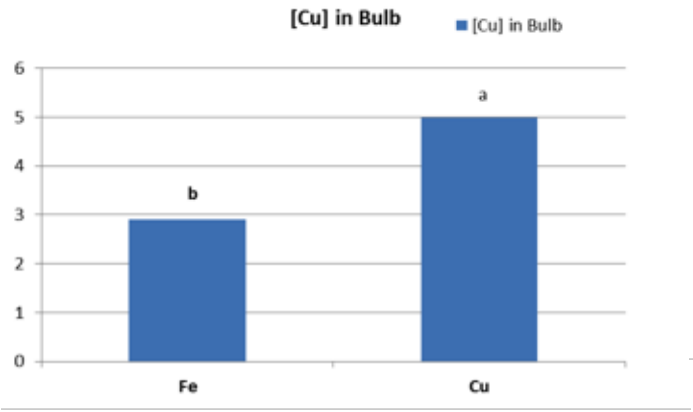


Figure 7. Iron (Fe) levels in onion bulbs selected for SOD analysis; bulbs were either supplemented with iron (low disease) or copper (high disease).

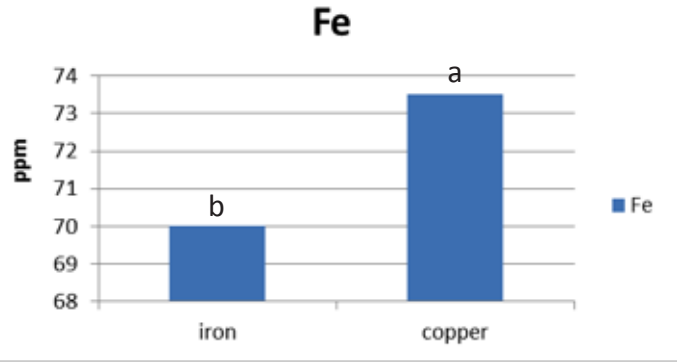


Figure 8. Trend of manganese (Mn) levels in onion bulbs supplemented with iron (low disease) or copper (high disease).

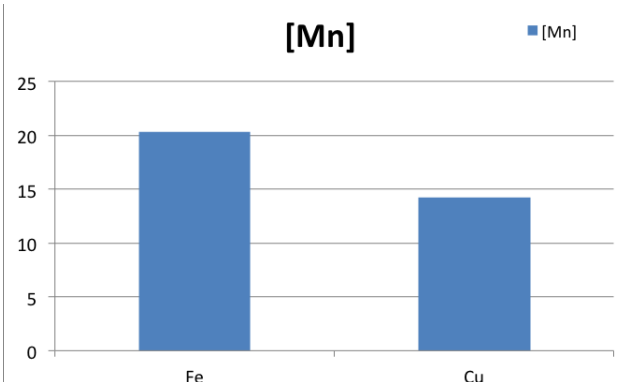


Figure 9. Manganese levels in a subset of bulbs (*n* = 6/trt) with either low levels or high levels of sour skin and then selected for superoxide dismutase analysis.

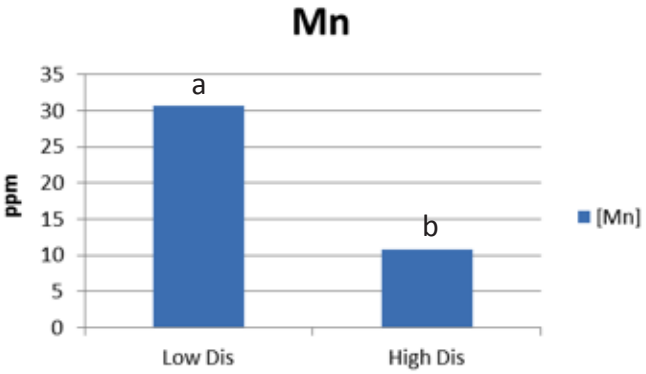


Figure 10. Relative Expression of Cu-ZnSOD gene in onion bulbs supplemented with iron (low disease) or copper (high disease).

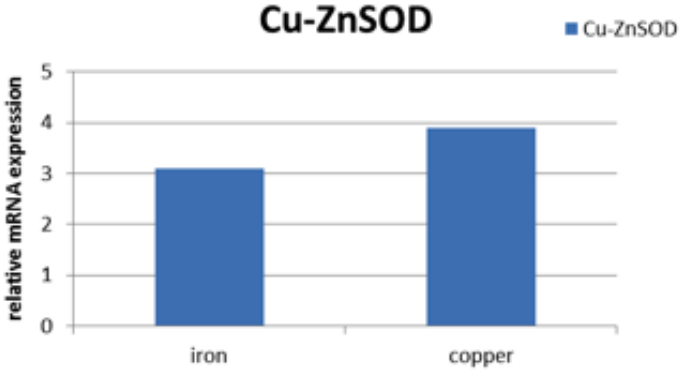


Figure 11. Relative Expression of MnSOD gene in onion bulbs supplemented with iron (low disease) or copper (high disease).

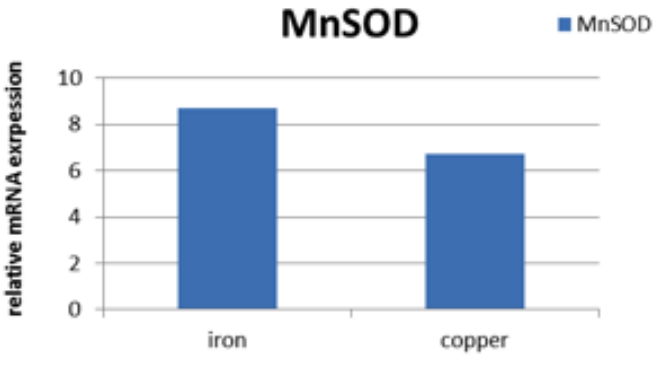
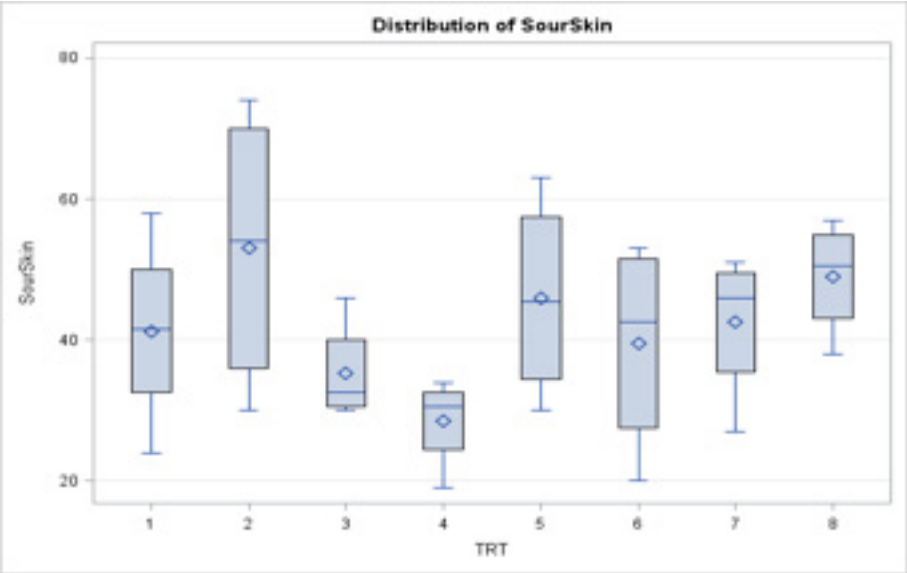


Figure 12. Effects of fertility on postharvest levels of sour skin.



Treatments:
1 = MgSO4 + Cu + CaCl2
2 = MgSO4 + Cu + CaCl2 + Zn
3 = MgSO4 + Cu + gypsum
4 = Fe + gypsum
5 = MgSO + Cu + CaCl2 +Actigard
6 = Fe + gypsum + Zn
7 = Fe + gypsum + Zn + Actigard
8 = Standard NPK

Table 1. Summary of Statistics Of Sour Skin Models 2012-2014.

Year	Source	Sample Type	*P* Value	Adj. R^2	VIF Range[a]
2014	Macro Plot	Bulb Tissue Severity	0.00004**	0.34	1.24–2.02
2014	Macro Plot	Bulb Tissue Incidence	0.00004**	0.32	1.26–3.33
2014	Micro Plot	Bulb Tissue	0.00001**	0.32	1.17–1.17
2014	Micro Plot	Soil	0.02*	0.33	1.06–3.44
2014	Micro Plot	Soil	0.00001**	0.30	NA

a VIF can be used to assess problems of co-linearity; if VIF > 5 there is some concern that co-linearity among independent variables might exist, and if VIF > 10, it should be considered that co-linearity is indeed a problem in the model.

Table 2. Summary of Sour Skin Models Listing First Three Variables 2012-2014

Year	Source	Sample Type	1st Variable	2nd Variable	3rd Variable
2012	Macro Plot	Tissue Incidence	- 139 CuFe	- 14.7 ZnFe	+ 0.7 Mn
2012	Macro Plot	Soil	- 49 ZnFe	+ 40 Cu	+ 6 MnZn
2012	Macro Plot	Tissue Incidence	- 145 CuFe		
2013	Grocery Store	Tissue Incidence	- 17.9 CuFe	- 0.34 Al	+ 0.003 K
2014	Macro Plot	Tissue Severity	- 353 CuFe	+ 35 NaFe	+ 27.8 MnZn
2014	Macro Plot	Tissue Incidence	- 49.9 CuMn	- 1.56 FeMn	- 1.06 Mn
2014	Micro Plot	Tissue Severity	- 3.16 CuFe	- 0.55 Mn	
2014	Micro Plot	Soil	- 359.7 Mo	- 31 CuFe	+ 20.5 Ni
2014	Micro Plot	Soil	- 0.46 Mn		

At Plant Applications of FRAC Group 7 Fungicides: Effect on Fungal Diseases and Yield in Vidalia Onions

F. Hunt Sanders, Jr.[1], Cliff M. Riner[2], and Michael J. Foster[3]

Introduction

FRAC (Fungicide Resistance Action Committee) Group 7 fungicides are systemic fungicides that inhibit cellular respiration. The fungicide boscalid is a group 7 fungicide, and it has been used in onion production for many years. Boscalid is an active ingredient in the fungicides Pristine (boscalid + pyraclostrobin) and Endura (boscaild). Since 2009, we have been investigating the use of at-plant applications of Endura for the control of onion diseases and have found that a single at-plant application of Endura can reduce botrytis leaf blight and pink root diseases. We also found that Endura at-plant treatments increase yields in some varieties of Vidalia onions (Sanders and Langston, 2009).

Recently, two new Group 7 fungicides, Fontelis (penthiopyrad), and Merivon (fluxapyroxad + pyraclostrobin), have been labeled for use in onion production. It was the purpose of this investigation to compare Endura to the new Group 7 fungicdes (Fontelis and Merivon) and determine if these products give similar disease suppression and yield increases as Endura.

Materials and Method

Between November 2013 and May 2014, a field trial was conducted at the Vidalia Onion and Vegetable Research and Educational Center in Lyons, Georgia. Onions were transplanted on November 19 into 6-foot beds. Each bed had four onion rows that were 11-inches apart, and onion spacing within the rows was 6 inches. The experimental design was a 2x2 factorial with six replications. Factor one was onion variety ('Pirate' or 'Sweet Jasper') and factor two was fungicide treatment. Production guidelines for growing sweet onions published by UGA Extension were followed, except for fungicide applications. Fungicides were applied the day of planting (November 19) by either dipping transplants before planting or by banding fungicides over the onions rows after planting. Banding applications were applied with a CO2 backpack sprayer with 4006E tips calibrated to deliver 47 GPA at 25-30 psi. Nozzles were 11-inches apart and lined up over each onion row. Onions were monitored for disease, and plots were rated for Botrytis leaf blight, purple blotch, and pink root during the season. Onions were harvested at maturity, and yields were recorded. Means were separated using Fisher's protected LSD $P \leq 0.05$.

Results and Discussion

Comparing the two onion varieties used in this study, there were no differences in incidence or severity of purple blotch/Stemphilium blight, Botrytis leaf blight, or pink root. However, the variety 'Pirate' did out yield the variety 'Sweet Jasper' (Table1).

At-plant fungicides applications had no effect on the diseases evaluated for the variety 'Sweet Jasper,' however, there was an increase in yield in 'Sweet Jasper' onions treated with Endura (transplant dip), Endura (banded spray), and Merivon (Table 2).

In the variety 'Pirate,' there was a difference in disease suppression between fungicide treated onions and the untreated control. Onion plots treated with Endura (transplant dip), Fontelis, or Topsin + Endura had less Botrytis leaf blight than untreated plots (Table 3). Also, plots treated with Merivon, Fontelis, or Topsin, had less purple blotch/Stemphilium blight than untreated plots (Table 3). There was no difference in yield in the variety 'Pirate' between fungicide treated plots and the untreated control plots (Table 3). Results from this trial are similar to results from previous at-plant studies with Endura, where we have seen a small amount of disease suppression in either Botrytis leaf blight and/or purple blotch/Stemphilium blight late in the growing season. But we have also seen a relatively large increase in onion yield for the amount of disease suppression that is observed. It's possible this phenomenon is due to suppression of soil borne diseases during the early part of the growing season (November to December).

In our studies, we typically do not evaluate soil-borne diseases early in the season because it requires destructive sampling. In the future, we may plant larger plots to accommodate destructive sampling during the season to determine if the soil-borne disease hypothesis is correct, and we would like to determine which soil-borne pathogens are possibly being suppressed with at plant fungicide treatments.

Another aspect of the Ggroup 7 fungicides that is worth mentioning is how long these fungicides remain in the onion plants after they are applied. The Botrytis leaf blight and purple blotch/Stemphilium disease ratings were taken on March 20 and April 28, respectively (Table 3). Even though the amount of disease suppression was small, it is incredible that the fungicides were applied in November the previous year. Results from this trial indicate that Endura, Fontelis, and Merivon are very similar in there systemicity, and that they all can suppress onion pathogens months after they were applied.

Summary and Conclusions

The trial presented here is very similar to other at-plant fungicide studies that we have conducted in the past using the Group 7 fungicide Endura (Sanders and Langston, 2009). The main difference is that we included two new Group 7 fungicides (Merivon and Fontelis). These new fungicides performed just as well as Endura in suppressing Botrytis leaf blight and purple blotch/Stemphilium blight, and Merivon was just as effective as Endura at increasing yields in the onion variety 'Sweet Jasper.'

References

Sanders, F. H., Jr., Langston, D. B., Jr., & Foster M. J. (2009). Effect of fungicides dip treatments on fungal diseases and yield of transplanted sweet onions year 2. In Dan MacLean (Ed), *Georgia onion research-Extension report 2009* (Cooperative Research-Extension Publication No. 3-2019) (pp. 8-10). Retrieved from http://www.caes.uga.edu/commodities/fruits/vidalia/publications.html.

Table 1. Effect of Vidalia onion variety on fungal diseases and yield.

Variety	PB/SB[1]	BLB[2]	Pink root[3]	Green weights[4]
'Pirate'	54.6 a[5]	2.0 a	5.0 a	49295 a
'Sweet Jasper'	60.4 a	1.8 a	2.9 a	44786 b

1 Purple blotch and Stemphyllium leaf blight severity 4/28/14, 0-100 scale where 0 = no disease and 100 = total leaf area diseased.
2 Botrytis leaf blight severity 3/20/14, 0-100 scale where 0 = no disease and 100 = total leaf area diseased.
3 Pink root incidence was rated on 5/5/14.
4 Field weights of onions in lbs/Acre.
5 Means in columns with the same letter(s) are not significantly different according to mean separation by Fisher's protected LSD at P<0.05.

Table 2. Effect of fungicide treatment on fungal diseases and yield (variety 'Sweet Jasper').

Treatments and Rates	PB/SB[1]	BLB[2]	Pink Root[3]	Green Weights[4]
Endura 2.3 oz/10 gal (dip)	53.3 a[5]	1.7 a	12.5 a	48133 a
Endura 6.8 oz/A (banded spray)	58.3 a	1.25 a	0.0 a	46563 ab
Merivon 11 fl oz/A (banded spray)	59.2 a	1.0 a	2.5 a	48061 a
Fontelis 24 fl oz/A (banded spray)	60.8 a	2.42 a	5.0 a	44358 bc
Topsin 40 fl oz/A + Endura 6.8 oz/A (banded spray)	60.8 a	1.5 a	5.0 a	43995 bc
Topsin 40 fl oz/A (banded spray)	60.0 a	1.8 a	2.5 a	42906 c
Untreated	63.3 a	3.1 a	5.0 a	42398 c

1 Purple blotch and Stemphyllium leaf blight severity 4/28/14, 0-100 scale where 0 = no disease and 100 = total leaf area diseased.
2 Botrytis leaf blight severity 3/20/14, 0-100 scale where 0 = no disease and 100 = total leaf area diseased.
3 Pink root incidence was rated on 5/5/14.
4 Field weights of onions in lbs/Acre.
5 Means in columns with the same letter(s) are not significantly different according to mean separation by Fisher's protected LSD at P<0.05.

Table 3. Effect of fungicide treatment on fungal diseases and yield (variety 'Pirate').				
Treatments and Rates	**PB/SB[1]**	**BLB[2]**	**Pink Root[3]**	**Green Weights[4]**
Endura 2.3 oz/10 gal (dip)	53.3 ab[5]	1.3 bc	12.5 a	48133 a
Endura 6.8 oz/A (banded spray)	60.0 a	2.2 a-c	7.5 a	49803 a
Merivon 11 fl oz/A (banded spray)	50.8 b	1.9 a-c	0.0 a	51183 a
Fontelis 24 fl oz/A (banded spray)	50.8 b	1.0 c	0.0 a	49005 a
Topsin 40 fl oz/A + Endura 6.8 oz/A (banded spray)	57.5 ab	1.5 bc	7.5 a	50747 a
Topsin 40 fl oz/A (banded spray)	50.8 b	2.6 ab	12.5 a	49295 a
Untreated	59.2 a	3.3 a	5.0 a	47335 a

1 Purple blotch and Stemphyllium leaf blight severity 4/28/14, 0-100 scale where 0= no disease and 100= total leaf area diseased
2 Botrytis leaf blight severity 3/20/14, 0-100 scale where 0= no disease and 100= total leaf area diseased
3 Pink root incidence, was rated on 5/5/14.
4 Field weights of onions in lbs/Acre
5 Means in columns with the same letter(s) are not significantly different according to mean separation by Fisher's protected LSD at P<0.05

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Effect of Pre-harvest Fungicide Sprays and Commercial Drying on Black Mold of Onion

F. Hunt Sanders, Jr.[1], Cliff M. Riner[2], Jason Edenfield[3], Chris Tyson[4], and Michael J. Foster[5]

Introduction

Black mold caused by the fungus *Aspergillus niger,* has become a major concern for some of the Vidalia onion producers in recent years. This may be partly due to the relatively new drying facilities used by some producers, which dry large volumes of onions in rooms heated with hot air for one to two days. *A. niger* grows readily at the temperatures used to dry onions in this manner, with optimum growth for the fungus between 82-93 degrees F. In response to some of the Vidalia onion grower's concerns, we started an investigation into the causes and possible control of black mold in stored Vidalia onions. The purpose of this investigation was to determine if pre-harvest applications of fungicides can reduce the amount of black mold in stored Vidalia onions and determine the effect of commercial driers on black mold.

Materials and Method

Three on farm trails were conducted between November 2012 and August 2014. All trials were split plot designs with fungicide treatment being the main plot and post-harvest drying or field curing being the sub plots. All treatments were replicated at least four times.

2013 Black Mold Trials:

Two trials were conducted in 2013, one in Tattnall County and one in Toombs County. Fungicide treatments in both trials were in addition to the fungicide programs that each grower used, and treatments were applied at two times during the growing season. The first applications (early season) were initiated within three days of planting and continued on a two week interval for a total of three applications. The later treatments (late season) were initiated on March 26 and continued on a two week interval for a total of four applications, with the final application applied eight days before harvest.

Onions were harvested on May 14 for both trials, and two 20 bulb sub-samples were taken from each plot. One sample was taken to each grower's drier and dried, and the other sample was taken to the Vidalia Onion Lab in Tifton, Georgia. Onions that were taken directly to Tifton were placed into cold storage on May 14, and the onions that the growers dried were taken to Tifton and placed into cold storage on May 20. Onions were taken out of cold storage on July 1 and placed under shelter in the Onion Lab for 16 days, after which the onions were evaluated for black mold incidence and severity. Means were separated using Fisher's protected LSD $P \leq 0.05$.

2014 Black Mold Trial:

One trial was conducted in 2014 in Tattnall County, Georgia. Fungicide treatments were applied in addition to the fungicide programs that the grower used. Like the 2013 trials, treatments were applied at two times during the growing season. The first applications (early season) were initiated within three days of planting and continued on a two week interval for a total of three applications. The later treatments (late season) were initiated on May 3 with follow up applications applied on May 12 and May 19, with the final application applied the day of harvest.

Onions were harvested on May 19, and two 20 bulb sub-samples were taken from each plot. Both samples were taken to the grower's packing shed, where one sample was dried and the other was placed outside the drier in the packing shed. After drying was completed, both samples were placed into cold storage at the same time. Onions were taken out of cold storage on July 17 and taken to the Vidalia Onion Lab in Tifton, where they were placed under shelter for seven days before evaluation. Onions were evaluated and data was analyzed in the same way as the 2013 trials.

Results and Discussion

Effect of Pre-harvest Fungicide Applications on Black Mold. The fungicides used in 2013 and 2014 were chosen either for their know efficacy of *A. niger* on onion or other crops or because of their efficacy on similar fungi. In the 2013 and 2014 Tattnall County trials, there was no difference in black mold suppression between any of the plots treated with pre-harvest fungicides and the untreated check. However, there was some black mold suppression in plots treated with Omega 500 (fluazinam) and Switch (fludioxinil + cyprodinil) in the 2013 Toombs County trial (Tables 1-2). Although some suppression was seen using pre-

harvest fungicides in one trial, the overall performance of the fungicides used was disappointing for all three trials, and the suppression seen in the 2013 Toombs County trial was not adequate. Part of the problem in trying to control post-harvest black mold with fungicides is that the fungus can get under one or more dry onion scales, making it difficult to target.

We thought that applying fungicides during the early growing season would help suppress latent infections of *A. niger,* which might develop later in the season or in storage. We also thought that applying fungicides late season, and as close to harvest as possible, would suppress *A. niger* from infiltrating the outer scales of onions during the harvesting process. Results from this investigation indicate that these hypotheses are incorrect, and we were unsuccessful at targeting post-harvest black mold with pre-harvest applied fungicides.

Effect of Commercial Drying on Black Mold. In all three trials in this investigation, two sub-samples were taken from each plot in order to compare onions that were field cured to those that were field cured and dried at each location.

In the 2013 Tattnall and Toombs County trials, onions that were field cured and dried had significantly more black mold incidence and severity than onions that were only field cured (Table 3). However, there was a flaw in the experimental design of the 2013 trials. Onions that were field cured were taken to the Vidalia Onion Lab and placed into cold storage six days before the onions that were dried. This discrepancy allowed for the dried onions to be subjected to potentially more *A. niger* infections while they were outside the driers before and after drying. With this in mind, the 2014 trial was designed where both the dried and field cured onions stayed in the grower's packing shed for the same amount of time, and both sets of onions were placed in the same cold room at the same time.

Results from the 2014 trial were similar to the 2013 trials where the onions that were dried had significantly more black mold than the onions that were field cured (Table 3). These results indicate that some growers are exacerbating their problem with black mold by drying their onions. However, drying is essential for long term storage of Vidalia onions because it reduces other diseases like Botrytis neck rot.

In the future, we are going to turn our attention towards the conditions that different growers use when drying onions, and hopefully provide some information about what drying conditions will not exacerbate post-harvest black mold. It is unlikely that increasing the temperature while drying is going to have an effect on black mold since the pathogen is inhibited at 116 degrees F. However, we might be able to reduce the amount of humidity in the driers by increasing the airflow around the onions. Reducing the humidity may help alleviate the problem with black mold since spore germination is inhibited at 76 percent humidity.

Summary and Conclusions

Between November 2012 and August 2014, we conducted a series of experiments designed to reduce black mold in stored Vidalia onions. These experiments had two components where we evaluated pre-harvest fungicides and post-harvest drying for control of the disease. Pre-harvest fungicide applications did not reduce black mold in stored onions in two of the three field trials conducted; however, black mold was reduced in one trial by applying Omega 500, or Switch. Black mold was increased by commercial drying in all three trials conducted. Results from this investigation indicate that applying pre-harvest fungicides is not an effective strategy for controlling post-harvest black mold infections, and that some onion growers are exacerbating their black mold problems by drying their onions.

Table 1. Effect of pre-harvest fungicide treatment on Black Mold 2013 Trials.

Treatments and Rates	2013 Tattnall County		2013 Toombs County	
	Black mold Severity[1]	Black Mold % Incidence[2]	Black mold Severity	Black Mold % Incidence
Quadris 2.08 SC 12 fl oz/A	25 a[3]	97.5 a	37 a	100 a
Switch 62.5 WG 14 oz/A	25 a	95.0 a	33 b	76.8 c
Omega 500 SC 1pt/A	38 a	92.5 a	33 b	95.6 b
Scala 5 SC 18 fl oz/A	30 a	100 a	45 a	100 a
Untreated	36 a	93.1 a	46 a	100 a

1 Black mold severity was rated on a 0-100 scale where 0 = no A. niger *present, 50 = 50% of the onion surface covered with* A. niger*, and 100 = 100% of the onion surface covered with* A. niger*. Each onion was rated and the severity was averaged for each plot (n = 20).*
2 Black Mold % incidence was rated by counting the number of onion bulbs in each plot that had visible A. niger *sporulation and dividing that number by the total number of onion bulbs in each plot (n = 20).*
3 Means followed by the same letter(s) are not significantly different according to Fisher's protected LSD test at P ≤ 0.05.

Table 2. Effect of pre-harvest fungicide treatment on Black Mold 2014 Trial in Tattnall County.

Treatments and Rates	Black mold Severity[1]	Black Mold % Incidence[2]
Quadris 2.08 SC, 12 fl oz/A	13.2 a[3]	56.7 a
Switch 62.5 WG, 14 oz/A	11.5 a	55.4 a
Omega 500 SC, 1 pt/A	13.0 a	55.8 a
Inspire Super 338 SC, 20 fl oz/A	11.4 a	54.6 a
Untreated	13.3 a	62.5 a

1 Black mold severity was rated on a 0-100 scale where 0 = no A. niger *present, 50 = 50% of the onion surface covered with* A. niger*, and 100 = 100% of the onion surface covered with* A. niger*. Each onion was rated and the severity was averaged for each plot (n = 20).*
2 Black Mold % incidence was rated by counting the number of onion bulbs in each plot that had visible A. niger *sporulation and dividing that number by the total number of onion bulbs in each plot (n = 20).*
3 Means followed by the same letter(s) are not significantly different according to Fisher's protected LSD test at P ≤ 0.05.

Table 3. Effect of commercial drying on Black Mold 2013 and 2014 Trials.

Method	2013 Tattnall County		2013 Toombs County		2014 Tattnall County	
	Black Mold Severity[1]	Black Mold % Incidence[2]	Black Mold Severity	Black Mold % Incidence	Black Mold Severity	Black Mold % Incidence
Field Cured Onions	26.0 b[3]	93.9 b	34.0 b	93.2 b	10.6 b	49.9 b
Dried Onions	41.0 a	99.1 a	44.0 a	99.7 a	12.8 a	58.7 a

1 Black mold severity was rated on a 0-100 scale where 0 = no A. niger *present, 50 = 50% of the onion surface covered with* A. niger*, and 100 = 100% of the onion surface covered with* A. niger*. Each onion was rated and the severity was averaged for each plot (n = 20).*
2 Black Mold % incidence was rated by counting the number of onion bulbs in each plot that had visible A. niger *sporulation and dividing that number by the total number of onion bulbs in each plot (n = 20).*
3 Means followed by the same letter(s) are not significantly different according to Fisher's protected LSD test at P ≤ 0.05.

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Thrips on Onions – Verimark Trial – VOVRC – 2014

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Materials and Method

Location:

Vidalia Onion and Vegetable Research Center, Lyons, Georgia.

Treatments:

Each treatment was a single drench application applied on a single date:

1) December drench
2) January 27
3) February 17
4) March 21
5) Non-treated check

Plot Size:

Three beds of onions (6-foot beds; for rows in each bed) by 24 feet.

Pesticide Application:

Verimark drench application at 13.5 oz/A applied to all three beds. On each bed, 3,000 ml of solution was applied down the row between Rows 1 and 2. Another 3,000 ml was applied between Rows 3 and 4. It was assumed each 3,000 ml treatment was treating a 2.5 feet wide area (two rows by 24 feet).

Procedure:

Thrips populations were monitored periodically by checking the non-treated check plots for thrips. Thrips were at non-detectable to very low densities through most of the season. Thrips appeared near the end of the season. Densities were checked with three minute searches of each plot, and the number of thrips found was recorded. Thrips were always monitored on the center bed of each plot.

Pant growth was also monitored periodically. On the indicated dates (Table 2), 10 plants (five adjacent plants from two location) from the outside beds of each plot were harvested. These plants were washed and weighed to evaluate potential in-season growth effects of treatments.

Bulb yields. At harvest maturity, a minimum of 60 bulbs were harvested from near the center of the center bed of each plot. These were bagged and returned to Tifton for processing. In Tifton, 50 bulbs of harvestable size were selected from each bag, sized, counted, and weighed. Size categories used were < 2 inches, 2-3 inches, 3-4 inches, and > 4 inches.

All data were analyzed with the PROC ANOVA procedure of PC-SAS. No statistically significant ($P < 0.05$) differences were detected; therefore, means separations were conducted.

Results

Thrips populations were basically non-detectable until the end of the season, with densities of 30 to 40 in a three minute search. These are low to moderate densities. Even numerical differences among treatments were minor. Weight of 10 plants also showed no significant effect of treatment.

Bulb Yields. No statistically significant differences were detected. It is worth noting that all four drench treatments did provide a numerical increase in the total weight of bulbs harvested. This appears to be from an increase in the number of large (> 4 inch) bulbs. While there is no statistical differences in yield, the consistency across all four drench treatments suggests further investigation may be warranted.

Table 1. Thrips populations during the season.

	Thrips per 3 minute search		
Drench date	**Mar 21**	**Apr 1**	**Apr 28**
Non-treated Check	11.50 a	15.75 a	29.00 a
December	11.50 a	15.50 a	28.75 a
January 27	9.75 a	13.50 a	30.75 a
February 17	8.50 a	8.75 a	28.50 a
March 21	10.50 a	15.00 a	26.75 a

Table 2. Plant growth during the season.

	Weight of 10 plants (g)				
Drench date	**Dec 17**	**Jan 13**	**Jan 27**	**Feb 17**	**Mar 10**
Non-treated Check	23.55 a	44.24 a	48.07 a	101.93 a	474.85 a
December	21.33 a	41.25 a	45.13 a	98.85 a	403.98 a
January 27	29.41 a	46.20 a	54.76 a	110.18 a	354.37 a
February 17	25.37 a	50.05 a	56.19 a	101.70 a	354.37 a
March 21	25.43 a	41.95 a	57.07 a	117.28 a	396.89 a

Table 3. Bulb grades by number at harvest.

	Number of bulbs by size			
Drench date	**2-3 in**	**3-4 in**	**> 4 in**	**Total**
Non-treated Check	7.75	31.25	11.00	50
December	3.00	28.75	18.25	50
January 27	2.75	30.25	17.00	50
February 17	5.00	26.50	18.50	50
March 21	5.75	28.75	15.50	50

Table 4. Bulb grades by weight at harvest.

	Weight of bulbs by size (lb)			
Drench date	**2-3 in**	**3-4 in**	**> 4 in**	**Total**
Non-treated Check	3.11	20.17	11.20	34.48
December	1.17	18.67	20.16	40.00
January 27	1.11	20.31	18.36	39.78
February 17	1.97	16.72	19.34	38.03
March 21	2.13	20.23	16.80	39.16

Thrips Control in Onion Spray Trial 2013

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Introduction

In 2013-2014, an insecticide efficacy trial was conducted to evaluate various chemicals for the control of thrips in onions at the Vidalia Onion and Vegetable Research Center in Tattnall County, Georgia.

Materials and Method

Onions, hyb. Nunhems 1006, were transplanted on November 13 into four rows per bed at approximately 2-3 inches between plants and maintained with standard cultural practices.

A total of 600 pounds of 10-10-10 was applied to clay loam field plots. Irrigation was applied at about 0.5-inches, weekly, with an overhead sprinkler system if there was no rainfall.

Total numbers of thrips per plant were counted on 10 plants per plot (on February 18, February 25, March 18, March 27, April 3, April 17, and April 22) and collected from onion tops during the test to determine species of thrips. Most of the thrips were collected from the plant at the time of bulb formation during March and April.

Five applications of insecticide were made on March 13, March 20, March 27, April 3, and April 17. Foliar insecticide treatments were applied with a tractor-mounted sprayer delivering 54 GPA with six TX18 hollow cone tips per bed on the second through fifth dates only. Drench applications were made with a volume of 232 gallons per acre on the first two application dates only. An unsprayed check was included.

Results and Discussion

Tobacco thrips and onion thrips were the most prevalent species in this test. The results indicated that the Verimark drench treatment alone was sufficient and even preferable for thrips control in onions (see Figure 1, Tables 1-2). However, thrips numbers were too low to adequately evaluate effects on yield (Table 3). The drench alone treatment did have significantly more culled onions, but the numbers were low over all.

The use of a Verimark chemigation for thrips control in the Vidalia onions would be a novel application method for this region. Since fungicides are the most frequently applied pesticide in this system, the combination of Verimark and fungicides compatible with chemigation needs to be evaluated before this method could be generally recommended.

Figure 1.

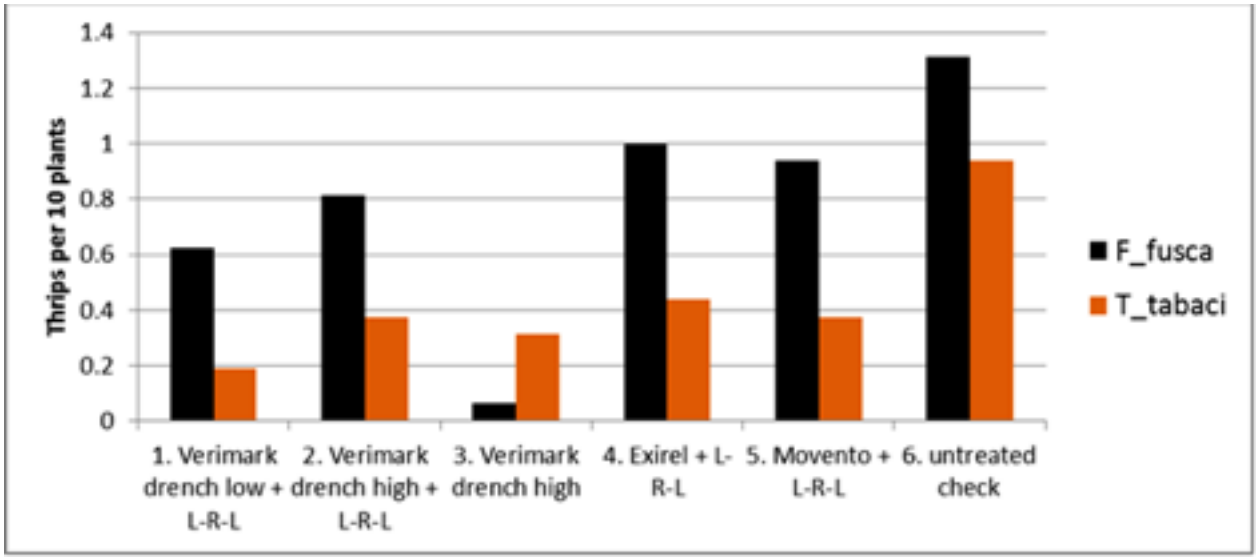

Table 1. Treatment effects on thrips collected at the VOVRC, near Reidsville, GA, per 10 plants by date in spring 2014.

Treatments (formulation) and rate	Total Thrips on Feb 18	Total Thrips on Feb 25	Total Thrips on Mar 18	Total Thrips on Mar 27	Total Thrips on Apr 3	Total Thrips on Apr 17
1. Verimark (20SC) 6.75 fl oz/A drench twice,then foliar Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A**	0.00a*	2.25a	2.25a	3.00a	2.75ba	3.50a
2. Verimark (20SC) 10.3 fl oz/A drench twice, then foliar Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A	1.00a	1.00a	3.00a	1.75a	1.50b	7.25a
3. Verimark (20SC) 10.3 fl oz/A applied as a drench twice with no follow up foliar sprays	0.25a	1.00a	0.75a	1.00a	0.25b	5.00a
4. Exirel (10SE) 13.5 fl oz/A once on 2nd spray, then Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A	0.00a	0.25a	4.25a	2.00a	2.00b	6.25a
5. Movento (2SC) 5 fl oz/A once on 2nd spray, then Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A	0.25a	0.00a	2.75a	3.00a	1.25b	2.50a
6. Untreated check	0.25a	0.25a	4.50a	5.50a	5.75a	9.25a

** Means within columns followed by the same letter not significantly (LSD, P < 0.05).*
*** All spray treatments with adjuvant MSO at 0.5% v/v*

Table 2. Treatment effects on thrips collected at the VOVRC, near Reidsville, GA, per 10 plants late season and overall in spring 2014.

Treatments (formulation) and rate	Total Immature Thrips on Apr 17	Total *F. fusca* on Apr 22	Total *F. fusca* Overall	Total *T. tabaci* Overall	Total *F. tritici* Overall	Total Thrips Overall
1. Verimark (20SC) 6.75 fl oz/A drench twice,then foliar Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A**	0.50b*	1.00b	1.11ba	0.29b	0.14b	2.21b
2. Verimark (20SC) 10.3 fl oz/A drench twice, then foliar Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A	1.00b	2.00b	1.57ba	0.54b	0.11b	2.82ba
3. Verimark (20SC) 10.3 fl oz/A applied as a drench twice with no follow up foliar sprays	1.25b	1.00b	0.61b	0.39b	0.04b	1.54b
4. Exirel (10SE) 13.5 fl oz/A once on 2nd spray, then Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A	1.25b	5.75a	2.07a	0.64b	0.14b	3.25ba
5. Movento (2SC) 5 fl oz/A once on 2nd spray, then Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A	0.25b	0.25b	0.86b	0.50b	0.04b	1.64b
6. Untreated check	5.75a	1.50b	1.29ba	1.71a	0.36a	4.61a

** Means within columns followed by the same letter not significantly (LSD, P < 0.05).*
*** All spray treatments with adjuvant MSO at 0.5% v/v*

Table 3. Treatment effects on onion yield at the VOVRC, near Reidsville, GA, per 30 feet of bed, spring 2014.

Treatments (formulation) and rate	Weight of Colossal Size Bulbs	Weight of Jumbo Size Bulbs	Cull Bulb Count	Total Weight of Bulbs per Plot
1. Verimark (20SC) 6.75 fl oz/A drench twice,then foliar Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A**	30.1a*	137a	12.3b	174a
2. Verimark (20SC) 10.3 fl oz/A drench twice, then foliar Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A	45.5a	153a	11.8b	204a
3. Verimark (20SC) 10.3 fl oz/A applied as a drench twice with no follow up foliar sprays	49.1a	141a	19.0a	193a
4. Exirel (10SE) 13.5 fl oz/A once on 2nd spray, then Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A	41.2a	147a	7.0b	196a
5. Movento (2SC) 5 fl oz/A once on 2nd spray, then Lannate (2.4SL) 3 pt/A alternated with Radiant (1SC) 8 fl oz/A	42.0a	152a	12.3b	201a
6. Untreated check	34.4a	146a	11.3b	186a

** Means within columns followed by the same letter not significantly (LSD, P < 0.05).*
*** All spray treatments with adjuvant MSO at 0.5%*

Annual Report of the Vidalia Onion Research Laboratory University of Georgia – Tifton Campus

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Introduction

The Vidalia Onion Research Laboratory facilitates many post-harvest activities. Be it shelter, equipment, or cold or controlled atmospheric storage, the Onion Lab supports a wide array of vegetable and fruit research. This report lists the users and their usage of this facility for the 2012-2013 season.

Table 1. Experiments requiring CA storage.

Researcher(s)	Crop(s)	Experiment	Number Rooms	Storage specifications	Duration (months)
Gitaitis, Torrance, Riner, Diaz	Onion	Variety Trial	4	34°F + 70% RH 3% O2 + 5% CO2 + 92% N2	4
Diaz	Onion	Storage	4	34°F + 70% RH CA 3% O2 + 5% CO2 + 92% N2 Ozone @ 2-3.0 ppm/hr Pre-storage fumigation SO2 (1hr trt @ 1000 and 2000 ppm)	2
Diaz	Onion	Storage	1	34°F + 70% RH 3% O2 + 5% CO2 + 92% N2	2
Picha, Diaz	Sweet Potato	Storage	8	38°F + ambient conditions Regular air 45°F + ambient conditions Regular air 58°F + ambient conditions Regular air CA 45°F + 90% RH 5% O2 + 10% CO2 + 85% N2 58°F + 90% RH 5% O2 + 10% CO2 + 85% N2 38°F + 90% RH 5% O2 + 95% N2 45°F + 90% RH 5% O2 + 95% N2 58°F + 90% RH 5% O2 + 95% N2	0.75

Table 2. Cold storage users and usage.				
Researcher(s)	**Crop(s)**	**Temperature (°F)**	**% RH**	**Duration (months)**
Diaz	Onion	70	70	2
	Pomegranate	42	85	2, 3
	Corn	36	≥ 80	< 1
Langston, Sanders	Cucumber	50	70	< 1
	Onion	34	70	4
Johnson	Onion	34	70	4
Riley	Onion	36	≥ 80	5
	Squash	36	≥ 80	< 1
Diaz	Various seed	46	50	12
Conner	Muscadine	34	85	1
	Seed	36	70	12
	Pecan	42,34	70, 70	7, 4
Abney, Smith	Blueberry	34	85	1
Riner	Onion	34	≥ 80	1
Gitaitis	Onion	34	≥ 80	3
Li	Onion	34	70	1
Dutta	Onion	34	≥ 80	< 1
Coolong	Cucumber	50	70	< 1

Table 3. Facilities and equipment users.		
Facility or equipment	**Researcher(s)**	**Crop(s)**
Warehouse	Diaz	Onion, pomegranate, tomato, Hot pepper
	Langston	Onion
	Gitaitis	Onion
	Riner	Onion
	Conner	Pecan
	Coolong	Cucumbers, broccoli
	Sanders	Onion
	Ruter	Camellia
	Sidhu	Pomegranate
	Johnson	Onion
Lab	Smith	Blueberry, pomegranate
	Diaz	Tomato, pomegranate, onion, watermelon
	Conner	Muscadine
	Abney	Blueberry
	Sidhu	Pomegranate
Grader and sizer	Diaz	Onion
	Sanders	Onion
Dryers	Diaz	Onion, soil samples, pepper
	Coolong	Onion
	Conner	Pecan
Growth chamber	Duhta	Onion
	Gitaitis	Onion, peanut

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