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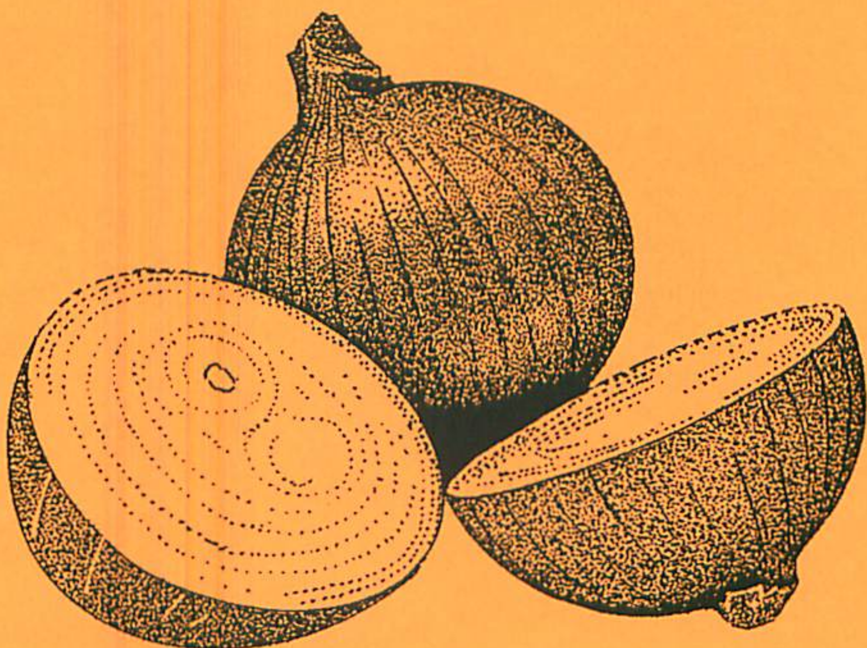
Georgia ONION



1999

Research-Extension Report

U.S. Department of Agriculture Cooperating

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1999 GEORGIA ONION RESEARCH - EXTENSION REPORT

(Summary Report of 1999 Data)

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THE 1999 ONION RESEARCH-EXTENSION REPORT

Georgia's onion industry is primarily based upon the production of sweet onions, so called because of a mild pungency level of the varieties grown. Georgia's sweet onion industry is said to have originated on the farm of Mose Coleman, two miles East of Vidalia, more than 60 years ago. Mr. Coleman is given the credit of having observed the mild taste of some onions he had grown. It is reported that he sold a 50 pound bag for as much as $3:50. During 1999, growers in Georgia harvested over 14,500 acres of onions with an on farm value in excess of $74 million.

The University of Georgia and USDA/ARS, through Research and Extension programs, provide information on the production and handling of onions. The Onion Research-Extension Report is an official University of Georgia publication for conveying current information, either in the form of progress reports of research underway or reports of conditions in the field. Since the Onion Research-Extension Report is intended to convey current information, it should not be considered as a final authority containing peer reviewed manuscripts. The Onion Research-Extension Report may serve as a means of accountability to those who have supported the described programs.

EVALUATION OF NITROGEN RATES IN VIDALIA ONION PRODUCTION

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Introduction

An experiment was established at the Vidalia Onion and Vegetable Research Center in Toombs County to investigate the effect of different nitrogen rates on Vidalia onion performance.

Materials and Methods

The experiment was a randomized complete block design with three treatments and five replications. Each plot consisted of a 50-foot section of panel. The three treatments were 102 pounds per acre, 129 pounds per acre, and 156 pounds per acre of nitrogen. 'Sweet Vidalia' transplants were set to their final spacing on 11/19/98. All treatments received 1000 pounds of dolomitic lime per acre applied preplant. In addition, 200 pounds per acre of 18-46-0, 370 pounds per acre of 6-12-18, and an additional 280 pounds per acre of 6-18-18 were applied on 12/15/98, 1/11/99, and 1/27/99, respectively.

Treatment application began on 2/12/99 with the application of 170 pounds per acre of $CaNO_3$ to all three treatments. On 3/1/99 180 pounds per acre of $CaNO_3$ was applied to treatments two and three and finally on 3/16/99 180 pounds per acre of $CaNO_3$ was applied to treatment three. All treatments received the equivalent of 187 pounds of phosphorus per acre, 117 pounds of potassium per acre, and 35 pounds per acre sulfur.

Foliar nitrogen analysis was conducted on 3/23/99, 3/31/99, 4/16/99, and 4/29/99. A ten-foot section of each plot was harvested on 4/29/99. Yields are reported as 60-pound field bags per acre to reflect fresh weights without grading or curing.

Results and Discussion

There were no differences in yields among the different rates of nitrogen (Table 1). This suggests that lower rates of nitrogen may be used in onion production compared to our current recommendations of 130-150 pounds nitrogen per acre on Coastal Plain soils. This may be particularly true on heavier soils found in the onion-growing region. The site of the Vidalia farm does have a heavier soil than is found at many locations in the onion belt, which may be an important factor in the performance of the low nitrogen treatments. In addition, this site has not had a history of onion production, which may also contribute to the relatively high yields at the lower nitrogen levels. There has not been an opportunity for the build up of soil borne pathogens that could reduce yields. As we continue to produce onions at this site, the effects of continuous onion cultivation will become more apparent.

Foliar nitrogen levels (Table 1) did not differ on any of the measured dates with the exception of measurements take on 3/23/99 where the treatment with 129 pounds of nitrogen per acre had a significantly higher foliar nitrogen level compared to the foliar nitrogen level with 102 pounds per acre of nitrogen. In any case, all of the foliar nitrogen levels were above 2.0%, which is the critical level for deficiency (Maynard and Hochmuth, 1997). Neither pungency nor sugar content differed between the different treatment regimens.

References

Maynard, D.N. and G.J. Hochmuth. 1997. Knott's Handbook for Vegetable Growers 4th Edition. John Wiley & Sons, Inc. New York.

Table 1. Nitrogen rate effect on yield, foliar nitrogen, pungency, and sugar[z].

Nitrogen (lbs./A)	Yield (60 lb. bags/Acre)	Foliar Nitrogen (%)				Pungency (um/gfw)	Sugar (%)
		3/23/1999	3/31/1999	4/16/1999	4/29/1999		
102	781	2.53	3.11	2.35	2.66	5.4	7.8
129	759	2.84	3.12	2.61	3.04	5.5	8.1
156	754	2.64	3.40	2.63	2.85	6.4	7.8
R^2	0.46	0.72	0.31	0.52	0.86	0.65	0.44
CV	13	11	9	10	10	17	5
LSD	NS	0.29	NS	NS	NS	NS	NS

[z]NS-not significant, R^2-component of measured value accountable by treatments, 0-1 scale; CV-coefficient of variation; LSD-least significant difference.

VIDALIA ONION VARIETY TRIALS -1998-99 SEASON

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Introduction

Three Vidalia onion variety trials were held during the 1998-99 growing season. The locations of these trials were the Bamboo Farm and Coastal Garden in Savannah, the Vidalia Onion and Vegetable Research Farm in Toombs County, and an on-farm location in Tattnall County.

Transplants for the Bamboo Farm trial were produced on-site in a high density planting according to current Extension recommendations for plantbed onion production. Transplants used at the Vidalia Farm and at the on-farm location were produced on-farm according to current Extension recommendations. Data on yield, quality, and storability were collected from these trials.

Materials and Methods

The trial at the Bamboo Farm consisted of 20 entries while the Vidalia Farm trial consisted of 11 entries. There were 15 entries in the on-farm trial. The trial designs were a randomized complete block design with three replications at each location. Plot size at the Bamboo Farm consisted of four rows of onions with an in-row spacing of four inches and a between-row spacing of 14 inches. Each plot was 20 feet long.

The trial at the Vidalia farm originally consisted of 15 entries, however, four of these entries were left out due to poor stands. The plants were grown from seed by a local grower and transplanted to final spacing on 11/18/98 at the Vidalia Farm. Each plot was 40 feet long and consisted of four rows of onions with an in-row spacing of four inches and a between-row spacing of 18 inches.

The on-farm trial consisted of 50 foot plots with an in-row spacing of four inches and a between row spacing of 18 inches.

Onion transplants were set at their final spacing on 11/13/98 at the on-farm location and on 11/18/98 at the Vidalia Farm. At the Bamboo Farm they were set at the final spacing on 12/17-18/98.

The entire plot at the Bamboo Farm was harvested, while only a ten-foot section from each plot was harvested at the Vidalia Farm. Plots at the Bamboo Farm and Vidalia Farm were harvested when varieties reached maturity (50% of tops down) while at the on-farm location a 10-foot section from each plot was harvested on 4/27/99, 5/4/99, and 5/11/99 regardless of variety maturity. At the Bamboo Farm, onions were harvested beginning on 4/15/99 as they matured. Additional harvests were conducted on 4/26/99 and 5/17/99. Harvested onions had their tops and roots clipped and weights were taken immediately. Yields are reported as 60-pound field bags to reflect the fact the onions were not cured or graded before weighing.

A five-gallon bucket of onions was selected at random from each plot and graded as to size for those onions harvested on 5/17/99. The grading sizes consisted of small: less than two inches, medium: greater than two inches and less than three inches, jumbo: greater than three inches and less than four inches, and colossus: greater than four inches.

Pungency numbers are a measure of pyruvate, which is produced in conjunction with pungency producing compounds from macerated onions. The higher the value the more pungent the onions. Values below 5 generally indicate a mild onion.

Onions were harvested at the Vidalia Farm on 4/19/99, 4/22/99, and 4/29/99 as the onions matured. A ten-bulb sample from each plot was weighed and measured for bulb width.

Results and Discussion

At the Bamboo Farm (Table 1), yields ranged from 825 to 321 field bags per acre. The lowest yielding varieties were also the earliest. This is a reflection of the late planting date, 12/17-18/98, rather than variety performance. Early varieties reach maturity (tops go down) regardless of the size of the bulbs. For best performance with early varieties, they should be planted to their final spacing by mid-November. Varieties 'Sunex 1519' and 'SRO 1519' are the same variety, they were inadvertently entered twice in the trial. Pungencies ranged from a high of 6.2 for 'Sweet Advantage' to a low of 3.8 for RCS 1938. Overall, the pungency values were higher than in past years due to the relatively dry winter.

Of the 14 varieties that were graded by size at the Bamboo Farm, six had combined percentages of jumbo and colossus sizes below 80%. Typically, growers expect to see 80% or more of their onions in these classes.

The trial at the Vidalia Farm (Table 2), showed no significant difference between yields forthe varieties evaluated. There were, however, differences for bulb weight and size.

Post cure yields in the on-farm trial (Table 3) were highest among those varieties that were harvested on 5/11/99 with average yields of 718 bags/acre compared to 608 and 445 bags/acre for onions harvested on 5/4/99 and 4/27/99, respectively. After five months of storage the highest yields were among the early harvests. Until now it has been accepted that fully mature onions will perform the best in CA storage. These results did not necessarily support that statement. It should be noted, however, that during the last harvest on 5/11/99 it began to rain, which may explain the poor performance of these onions in storage. The last harvested onions had a higher incidence of Botrytis neck rot, which was the direct cause of the lower yield after storage. Clearly, further work is required to clarify the relationship between onion maturity and storability.

Table 1. Bamboo Farm Onion Variety Trial 1998-1999[z]

Savannah, GA

Variety	Company	Yield/Acre (60 lb. field bags)	Harvest Date	Soluble Solids	Pungency	Percent of Harvest[y] Small	Medium	Jumbo	Colossus
Sweet Success (1514)	Sunseeds	639	5/17/1999	6.7	5.7	3	16	70	11
Granex 33	Asgrow Seed	566	5/17/1999	6.5	4.5	7	32	58	4
XP 6712	Asgrow Seed	688	5/17/1999	6.1	4.5	2	14	77	7
Sunex 1519	Sunseeds	695	5/17/1999	6.5	4.7	2	16	73	8
Pegasus	Asgrow Seed	816	5/17/1999	6.6	5.5	1	8	69	21
Savannah Sweet	Petoseed	693	5/17/1999	5.8	5.1	6	25	65	4
PS 7092	Petoseed	646	5/17/1999	6.5	4.5	4	21	60	15
1032	D. Palmer Seed	501	4/26/1999	7.1	5.3				
1058-Sweet Advantage	D. Palmer Seed	506	4/26/1999	7.6	6.2				
DPSX 1035	D. Palmer Seed	591	5/17/1999	7.1	4.2	7	33	58	3
Southern Honey	D. Palmer Seed	644	5/17/1999	6.3	4.4	4	20	66	10
Equanex	Petoseed	703	5/17/1999	6.5	5.6	3	12	72	13
SRO 1519	Sunseeds	820	5/17/1999	6.3	5.2	1	14	64	21
SSC 6389	Shamrock	321	4/15/1999	7.1	5.1				
RCS 1919	Rio Colorado	340	4/15/1999	7.4	4.6				
RCS 1938	Rio Colorado	746	5/17/1999	6.2	3.8	1	18	73	8
XP 6846	Asgrow Seed	825	5/17/1999	6.2	5.8	1	22	69	8
XP 6995	Asgrow Seed	736	5/17/1999	6.3	5.0	2	16	69	13
WI-3115	Wannamaker	374	4/15/1999	7.9	5.3				
WI-609	Wannamaker	406	4/15/1999	7.3	4.5				
	R^2	0.79		0.88	0.36				
	CV	55		9	20				
	LSD	140		0.4	1.7				

[z] R^2-component of measured value accountable by treatments, 0-1 scale; CV-coefficient of variation; LSD-least significant difference.

[y] As an oversight, the early varieties were not graded by size.

Table 2. Vidalia Onion and Vegetable Research Farm Variety Trial 1998-1999

Reidsville, GA

Entry	Company	Harvest Date	Yield (Bags/Acre) (60 lb. field bag)	Weight/Bulb (oz.)	Size/Bulb (in.)
RCS 1027	Rio Colorado	4/22/1999	796	12	3.7
1032	D. Palmer Seed	4/22/1999	646	11	3.5
Sweet Advantage (1058)	D. Palmer Seed	4/19/1999	630	9	3.3
RCS 1063	Rio Colorado	4/19/1999	672	12	3.5
2012	Global Seed	4/29/1999	788	12	3.7
XP 6712	Asgrow Seed	4/29/1999	787	12	3.7
Sweet Success (1514)	Sunseed	4/22/1999	643	12	3.8
Mr. Max	Rio Colorado	4/29/1999	696	11	3.6
RCS 1919	Rio Colorado	4/19/1999	786	11	3.5
Sweet Melody	Rio Colorado	4/29/1999	671	12	3.7
Sweet Vidalia	Rio Colorado	4/22/1999	695	11	3.6
		R^2	0.51	0.63	0.66
		CV	15	13	5
		LSD	NS	1.9	0.2

[z]NS-not significant, R^2-component of measured value accountable by treatments, 0-1 scale; CV-coefficient of variation; LSD-least significant difference.

Table 3. On-Farm Variety Trial, Tattnall County, 1998-99.

Variety	Post Cure Yield 50 lb bags/acre[z]	Percent Large & Jumbo[z]	After 5 months Storage 50 lb bags/acre[z]	After 5 months Storage Percent Botrytis[z]
RCS 1027	760 a	88 a	255 ab	18.1
RCS 1919	752 a	81 a	319 a	13.1
1032	711 ab	76 ab	203 ab	27.7
RCS 1063	695 ab	75 ab	270 ab	19.3
1514-Sweet Success	690 ab	78 ab	214 ab	27.9
1058-Sweet Advantage	681 ab	76 ab	217 ab	21.9
Sweet Vidalia	653 ab	76 ab	200 ab	18.1
Sweet Melody	606 bc	66 bc	175 ab	19.8
2012	576 bcd	65 bc	199 ab	19.1
Sunseed F1	497 cde	59 cde	205 ab	16.4
Mr. Max	494 cde	54 cde	173 ab	17.1
Granex 33	444 de	48 ef	148 b	23.5
Asgrow 6712	444 e	50 e	147 b	19.7
Pegasus	443 e	52 de	129 b	23.3
Evita	411 e	36 f	141 b	20.4
Harvest				
4/27/1999	445 b	43 b	219 a	11.8 b
5/4/1999	608 ab	72 a	214 a	17.4 b
5/11/1999	718 a	81 a	166 b	31.8 a
Probabilities				
Variety	0.000	0.000	0.000	0.853
Harvest	0.000	0.000	0.019	0.016
Variety x Harvest	0.895	0.002	0.546	0.344

[z]Values followed by the same letter within a column for either variety or harvest are not different by Duncan's Multiple Range Test ($p \leq 0.05$)

SWEET ONION PRODUCTION WITH DRIP IRRIGATION AND SOIL MULCHES: EFFECTS ON INCIDENCE OF BACTERIAL DISEASES, YIELD AND BULB QUALITY

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Introduction

Dry onions represent the leading vegetable crop by value ($75 million) in Georgia. During 1998, onions in Georgia were planted to over 15,000 acres. Onions are typically grown on bare soil and irrigated with high-pressure systems such as sprinklers or center-pivots. These irrigation methods apply water to the whole field, even though onion plants occupy a fraction of the field. Besides, in most onion-producing areas of Georgia, soils are sandy-loam with a low water-holding capacity. In this kind of soils, frequent irrigation is necessary during periods of high evaporative demand in order to maintain adequate soil moisture content.

Soil moisture levels may significantly affect the quality and yield of onions. Low moisture conditions in the soil are conducive to poor yields. However, excessive moisture conditions result in irrigation water waste, nutrient leaching, and often lead to rots and poor bulb quality. In drip irrigation, water is applied only next to the plants, saving water that otherwise would be applied to the aisles between the beds. This saving is particularly significant in crops with a shallow roots such as onion. Additionally, drip irrigation allows for frequent water applications, which result in less fluctuation in soil moisture content compared to sprinkler or center-pivot irrigation. Another advantage of drip irrigation allows for the delivery of fertilizers and pesticides in the irrigation water, resulting in the placement of these chemicals close to the root zone.

Drip irrigation alone or in combination with plastic mulches is widely used for vegetable production, particularly for tomatoes, peppers and melons. However, drip irrigation and plastic mulches are not utilized for onion production in Georgia, and they are used only in a small scale in other parts of the USA. The benefits associated with the use of plastic mulche for vegetable production include higher yields, earlier harvests, improved weed control, cleaner fruit and increased efficiency in the use of water and fertilizers.

Current and Future Research Plans

During the period 1999-2001, we shall conduct studies with the objective of measuring plant growth, yield, bulb quality and the incidence of bacterial diseases, as affected by mulch (black plastic film or wheat straw) and irrigation method (drip or sprinkler). The experiments will be conducted at the Blackshank Farm (Tifton) and at the Vidalia Onion and Vegetable Research Farm (Reidsville). The experimental design will be a split plot, where the main plot will be the irrigation system (sprinkler or drip) and the sub-plot will be the type of mulch (bare soil, black plastic or wheat straw). Each sub-plot will consist of three 60-ft long beds and each bed will have four rows nine inches apart, with a plant spacing of six inches. In drip-irrigated plots, there will be two lines of drip tape per bed. Fertilization of sprinkler-irrigated plants will be according to UGA extension recommendations. Pre-plant fertilizer (1000 lb 5-10-15 per acre) will be applied to the soil for all treatments. After transplanting drip-irrigated plants, N and K will be supplied weekly through the drip tape.

BACTERIOLOGY REPORT, 1999

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Introduction

Bacterial diseases continue to be highly destructive and responsible for reduction in yield, and ruin the quality of onions in storage or on the shelf. The latter is most important since it tarnishes the reputation and may affect future sales of the Vidalia onion.

Bacterial Streak and Rot: Since bacterial streak and rot was reported as an onion pathogen in Georgia 10 years ago, it has been found in Florida, Colorado, and Venezuela. It has been particularly devastating in Venezuela and has become a limiting factor in their production of sweet onions.

It is interesting to note that the disease occurred on pungent, dry onions in Colorado. Both in Colorado and Venezuela, the disease is associated with periods experiencing warmer temperatures. In Georgia, on the other hand, the disease occurs under milder conditions that usually occur during the month of March. Generally, lesions develop as dark, water-soaked streaks that traverse the length of the leaf. Under favorable conditions the entire plant can be blighted and killed. Once infection has occurred, lesions rapidly develop and streak downwards to the neck of the bulb. Infected leaves may appear wet or soft, are dark green or black in color, and collapse with the veins being prominent.

Symptoms of this type often are associated with a soft rot of the base of the leaf and when gently pulled, such leaves easily break off from the plant. However, under some conditions, blighted leaves are dry, tan to a light brown in color, and tend to curl backwards from the leaf tip. It is not clear if tip dieback symptoms are a result of the disease, or simply provide a temporary survival site.

Bulb symptoms can occur both in the field and during storage. When weather conditions are favorable for disease development, it is common for them to rot in the field. Bulbs of severely infected plants are impossible to harvest as the leaves tear from the bulb when it is lifted. However, in plants with less severe infections, bulbs can appear normal. In such cases, the rot may have progressed into the neck of the bulb by means of only one infected leaf and into the inner scales before bulbs are harvested or cured. In other instances, if the bulbs are not yet infected at time of harvest and are properly cured, the bacterium may be prevented from migrating into the bulb. The bacterium can be mechanically transmitted by tractors and farm equipment that make contact with weeds along field perimeters and by field workers during harvest. A possible source of spread at harvest is by contaminated clipping sheers..

Center Rot: Another bacterial disease that is equally destructive and was first observed in 1997 is center rot, caused by the bacterium, *Pantoea ananaits*. A year later it was observed in dry bulb, pungent onions in Colorado. As the name suggests, the disease commonly affects, but is not restricted to, the center leaves of the plant. Affected leaves become water-soaked, soft, and bleached white as the rot progresses. Surrounding tissues may appear tan to a darker brown. Advanced stages of the disease result in complete wilting and bleaching of all leaves. Bulb interiors may become soft, watery, and produce a foul odor.

As with bacterial streak and rot, attempts to lift plants afflicted with center rot result in leaves tearing away from the plant. Unlike most other bacterial diseases of onion, center rot also infects seed stalks in a similar manner to the leaves, which results in plant lodging. An almost identical disease was reported in South Africa and some seed used in Georgia in 1997 was produced in South Africa. Thus it was a possibility that the disease could have been introduced by means of infected seed.

Although no specific insect relationship is known for *P. ananatis* so far, other members of this genus, most notably *P. stewartii* and *P. tracheiphila*, survive in association with and are vectored by corn flea beetles and cucumber leaf beetles, respectively. In Japan, they found that *P. ananatis* will inhabit the gut of mulberry pyralid larvae and they even suggested the use of the bacterium as a biocontrol agent for that insect.

P. ananatis was originally reported as a pathogen of pineapple but the host range includes cantaloupe, honeydew melon, onion and sugarcane. The geographical distribution includes Brazil, British Guiana, Guatemala, Haiti, Malaysia, Mexico, Nigeria, Philippines, Puerto Rico, Queensland, Taiwan, and the United States.

Controlling these diseases is difficult. Use of bactericidal sprays with fixed coppers have been successful in some years and ineffective in others. As is the case with most bacterial pathogens, copper-tolerant strains can develop; but these typically are sensitive to a copper - maneb mixture. However, in the 1999 - 2000 season, the combination of copper and maneb apparently failed to control either bacterial streak or center rot. It is not yet known, but it is possible that "super-tolerant" strains have developed to the mixture of these products. Because of the difficulty in controlling bacterial plant diseases, man has usually relied on a coordinated or integrated approach using all available methods at his disposal. This means the use of the most tolerant varieties (not always available), management practices such as proper fertilization, weed control, insect control, irrigation management, avoiding entry into the field when plants are wet, and proper harvesting, curing, handling and storage of onions.

It was the purpose of this research to examine the effect that management practices may have on these two bacterial diseases, Bacterial Streak and Rot and Center Rot. In addition, we wanted to ascertain the source of inoculum for the Center Rot pathogen.

Materials and methods

Bacterial Streak & Rot: Onions were harvested at three different times within a single season and categorized as immature, optimum and over-mature. Half of the onions were undercut and allowed to dry on the surface of the soil (field curing) for 48 hours. The remaining half were immediately trimmed with shears to remove roots and foliage and placed in storage in a cold room. Treatments consisted of shears contaminated with a suspension of the bacterial streak organism, *Pseudomonas viridiflava* , or sterile water. The test was replicated four times and repeated for two seasons.

A second test was conducted to evaluate the benefit of CA storage. Onions produced in Tifton, were either stabbed with a dissecting needle contaminated with the bacterial streak organism or with a sterile needle. The onions then were placed into either refrigerated storage at approxiamtely 4 ^{0}C or CA storage at approximately 1-2 ^{0}C and $\leq$ 3% oxygen. After 16 weeks, the bulbs were removed and evaluated for rot. The test was replicated four times and repeated for two seasons.

A third test was done to determine if secondary spread could occur during storage. Eighteen or 20 onions that had been brushed, cured, and graded as healthy were stored in standard onion bags. The treatment, receiving 18 bulbs, had two bulbs with a moderate degree of bacterial streak rot placed in the center of the bag prior to storage, i.e. 10% disease. The second treatment was a control in which all 20 onions were graded as healthy, i.e. 0% disease. Both treatments were placed into CA storage for 16 weeks. After removal from storage, bulbs were split and evaluated for rot. The test was replicated four times and repeated for two seasons.

Center Rot: Two tests were conducted to investigate the effect that management practices have on the development of center rot and one test was completed to determine the source of inoculum for the causal organism, *P. ananatis*. In the first test, field plots were established at the Vidalia Onion and Vegetable Research Farm near Reidsville and at the Blackshank Farm near Tifton. The design was a split plot with the main plots being overhead or trickle irrigation and the subplots were black plastic mulch, straw mulch or bare ground. Mulch treatments were replicated four times in a randomized block design. The treatment of overhead irrigation and bare ground was used as the standard. Disease levels were recorded over time, mapped, and colored flags were placed adjacent to the infected plant in the field. Different colors represented the time period when the symptoms first were observed.

The second test was to determine if plants with "young" infections posed a threat to onion quality after harvest. Plots were scouted at time of harvest and plants with only a single infected leaf were used for the trial. Onions were undercut, field-cured, and harvested using typical methods. After removal of roots and leaves, bulbs were bagged and stored at room temperature on shelves at the Vidalia Onion Lab in Tifton. After 2 wk, bulbs were split and rated for rot.

Finally, a PCR technique was developed as a tool to detect the center rot organism in the environment. The DNA of the intergenic transcribed spacer region [ITS] between the 16S and 23S RNA genes was amplified and sequenced. A DNA primer, PanITS, specific for *P. ananatis* was developed from that area. When paired with the primer EC5 [*E. coli* universal primer], PCR was sensitive, specific and reproducible. Seeds from growers, weeds from 13 sites in six counties, and thrips were from onions in Tifton were collected and processed for PCR. Weed sites were within the Vidalia onion-growing zone and up to 150 miles outside the zone. Leaves and stems (5 g) were shaken in 50 ml of PBS + Tween 20 (0.02%). An aliquot of 1.5 ml was centrifuged 10 min at 14,000 rpm. The pellet was washed in 1.5 ml HPLC water and agitated for 1 min on a vortex mixer. This was centrifuged 10 min at 14,000 rpm. The liquid phase was discarded. The pellet was suspended in 100 *u*l of sterile HPLC water, boiled 15 min and cooled. Aliquots of 4 *u*l were collected for PCR. Amplification products were detected by gel electrophoresis. Aliquots from the original leaf washings from samples giving a positive PCR were plated on to tryptic soy broth agar (TSBA). Suspect colonies were harvested, identified and inoculated onto onion seedlings.

Results & discussion

Field-curing of onions effectively reduced the secondary spread of bacterial streak by contaminated shears in onions harvested at optimum maturity or when over-mature but not in onions that were harvested at an immature stage (Figure 1). Contaminated shears were an effective means of infecting onions of all three maturity stages if onions were not field-cured prior to the clipping of stems and roots. It is interesting to note that onions harvested at the immature stage and immediately clipped (i.e. no field-curing) with "sterile" shears had more bulbs with rot than the control. However, onions harvested later were fairly resistant to rot, if "clean" shears were used. The best disease control should be obtained by harvesting plants when they are properly mature and allow them to field-cure for at least 48 hours prior to trimming the leaves and roots.

CA storage was quite effective in retarding the development of bacterial streak rot (Figure 2) and inhibiting the secondary spread of the disease (Figure 3). Previous work had already established that this disease continues to rot onions and spread in normal cold-room storage. Therefore, CA storage should be an effective means of storing onions to control this particular disease. The development of sourskin and neck rot, however, appear to continue to develop in CA storage and more research is being conducted on those diseases.

In the mulch-irrigation tests, virtually identical results were obtained at Tifton and Reidsville. Significantly more center rot occurred on onions grown on black plastic and the least amount of disease occurred in the straw mulch treatment (Figure 4). The epidemic started 7-10 days earlier in the black plastic plots than it did in the bare ground plots, which started 7-10 days earlier than in the straw mulch plots. Disease ratings from all dates were fit to a mathematical model, values transformed, and regression equations were calculated. The slopes of the equation are an indication of the rate of disease development and spread. Slope values from the logistic model were as follows: Overhead/black plastic = 0.15, Trickle/black plastic = 0.13, Overhead/bare ground = 0.12, Trickle/bare ground = 0.10, Overhead/straw = 0.06, and Trickle/straw = 0.05. By definition, the steeper the slope, i.e. the larger the value, then the faster is the rate of disease development and spread. Consequently, black plastic accounted for the disease starting earlier and developing at a faster rate and the straw mulch was able to delay the onset of the epidemic and slow it down. Unfortunately, there are significant disadvantages to using straw mulch. Yields were considerably lower, the difficulty of application, the extra expense, and competition from the grass as a result of the seed in the straw. However, if we can determine what factor(s) is/are responsible for the disease control, we may be able to "isolate" it and use it for our benefit. One possibility is that the straw affected the makeup of the soil microflora which in turn influenced physical and/or physiological resistance factors in the plant. In other words a biological control or systemic acquired resistance.

Although mulch treatments significantly affected disease, irrigation had no significant effect in the 1999-2000 season. Approximately the same level of disease occurred in the overhead sprinkler plots as it did in the trickle plots. It is most likely that rain events occurred at critical times in the epidemic, and masked any differences between trickle and overhead irrigation in terms of disease control. However, it is logical to assume that less disease should develop using trickle irrigation in years when rain events are on a different schedule than disease development.

At Reidsville, approximately 28-33 % of the onions harvested from plants without symptoms developed postharvest rots after 2 and 4 wks compared to 80% of the onions that had a single leaf with center rot symptoms (Figure 5). At Tifton, similar results were obtained, although there was less disease in the symptomless plants, approximately 20% after 2 and 4 wks. However, there was a dramatic increase in the amount of rot in single-leaf-infected plants from approximately 40 % after 2 wks to almost 90 % after 4 wks.

Finally, in developing a PCR protocol, we found that the 16S genes of *P. ananatis* and *P. agglomerans* were 99% identical. Consequently we had to amplify and sequence the ITS region to develop a PCR technique that would distinguish the pathogen from the saprophyte (Figure 6). The primers Pan_ITS_1 and EC5 were highly sensitive as we could detect as few as 4 bacterial cells / PCR mix. Furthermore, Pan_ITS_1 was specific. When paired with EC5 it did not amplify any other bacteria except for *P. ananatis* (all strains) and one strain of *P. stewartii*. Also, in a computer search on the internet, there were no matches with any other organism in the GenBank Library at the National Institute of Health.

Results from PCR indicated that two strains in the University of Georgia culture collection, originallylabeled as *P. agglomerans*, were actually *P. ananatis*. Their identity was confirmed by other tests. One strain was from peach in 1986 and the other was from onion in 1992. PCR reactions from all seed samples were negative. One thrips sample produced a positive PCR result, but it could not be repeated. Some problems with PCR inhibition occurred with thrips samples, thus further research is being conducted to determine if that insect can vector the center rot pathogen. However, positive PCR reactions occurred from at least one weed species collected at all 13 sites (Figure 7). Weeds that supported populations of *P. ananatis* are listed (Table 1). The bacterium was recovered on TSBA medium from 50% of the samples giving a positive PCR reaction and all strains recovered were pathogenic to onion, thus confirming the PCR results.

TABLE 1. Weeds or crops collected at 13 sample sites in six Georgia counties which were found to harbor populations of *Pantoea ananatis*, the causal agent of center rot of onion.

Common Name	Latin Bionomial
Bermuda grass	*Cynodon dactylon*
bristly starbur	*Acanthospermum hispidum*
broadleaf signalgrass	*Brachiaria platyphylla*
Carolina geranium	*Geranium carolinianum*
carpetweed	*Mollugo verticillata*
crabgrass	*Digitaria sanguinalis*
common chickweed	*Stellaria media*
common cocklebur	*Xanthium pensylvanicum*
common ragweed	*Ambrosia artemisiifolia*
cudweed	*Gnaphalium* spp.
curly dock	*Rumex crispus*
Florida beggarweed	*Desmodium tortuosum*
Florida pusley	*Richardia scabra*
rescue grass	*Bromus catharticus*
sickelepod	*Cassia obtusifolia*
smallflower morningglory	*Jaquemontia tamnifolia*
soybean	*Glycine max*
spiny amaranth	*Amaranthus spinosus*
stinkweed	*Thlaspi arvense*
tall verbena	*Verbena bonariensis*
Texas panicum	*Panicum texanum*
vaseygrass	*Paspalum urvillei*
wild radish	*Brassica* spp.
yellow nutsedge	*Cyperus esculentus*

Fig. 1. Benefits of harvesting onions at optimum maturity and field curing (fc) for minimum of 48 hours for controlling bacterial streak and rot.

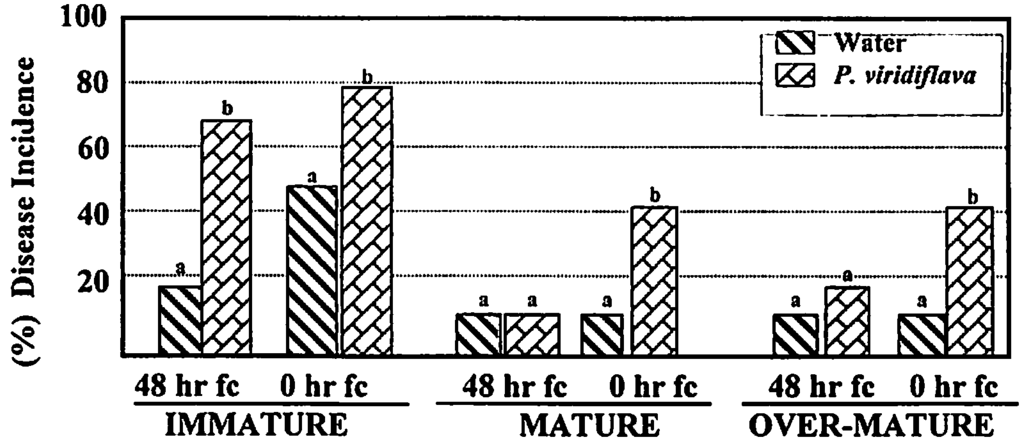


Fig. 2. The effects of 16 weeks of refrigerated or controlled-atmosphere [CA] storage on the postharvest phase of bacterial streak & rot [*Pseudomonas viridiflava* (Pv)] in inoculated onions compared to non-inoculated controls [NIC].

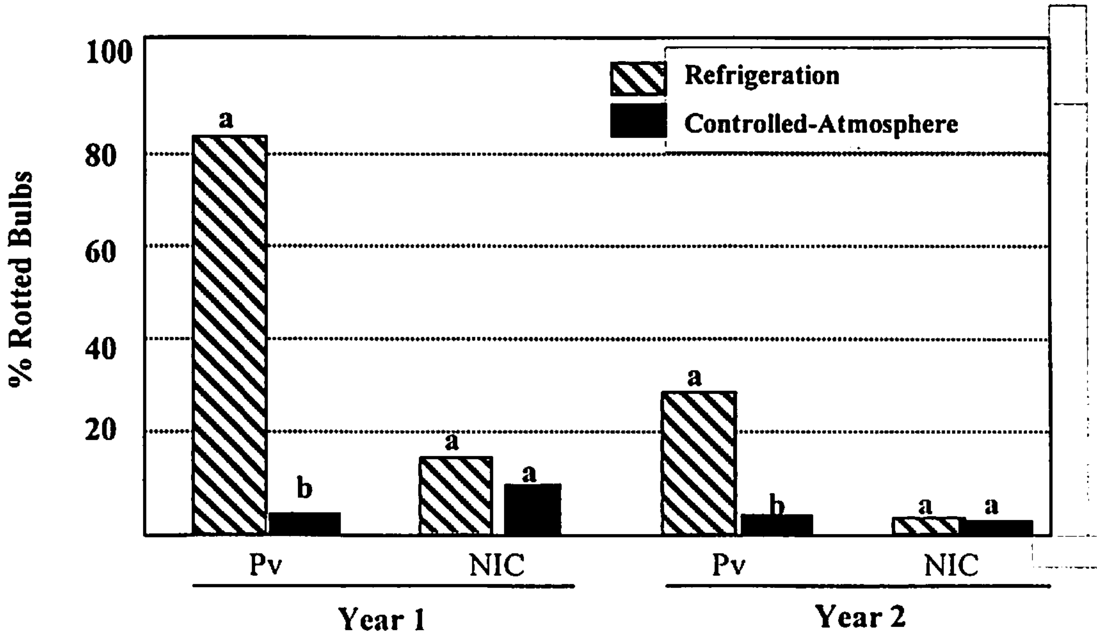


Fig. 3. Amount of rot in CA-stored onions when bulbs were graded at 0 or 10% rot prior to storage demonstrates the lack of both bacterial streak development and secondary spread of *Pseudomonas viridiflava*.

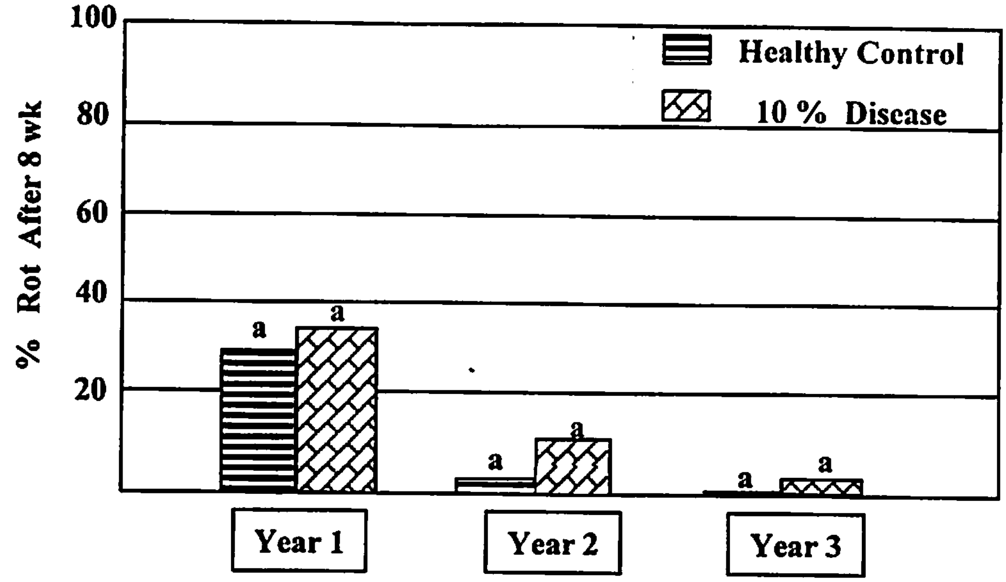


Fig. 4. Effect of black plastic, straw mulch, or bare ground paired with either overhead or trickle irrigation on incidence of center rot, caused by the bacterium *Pantoea ananatis*.

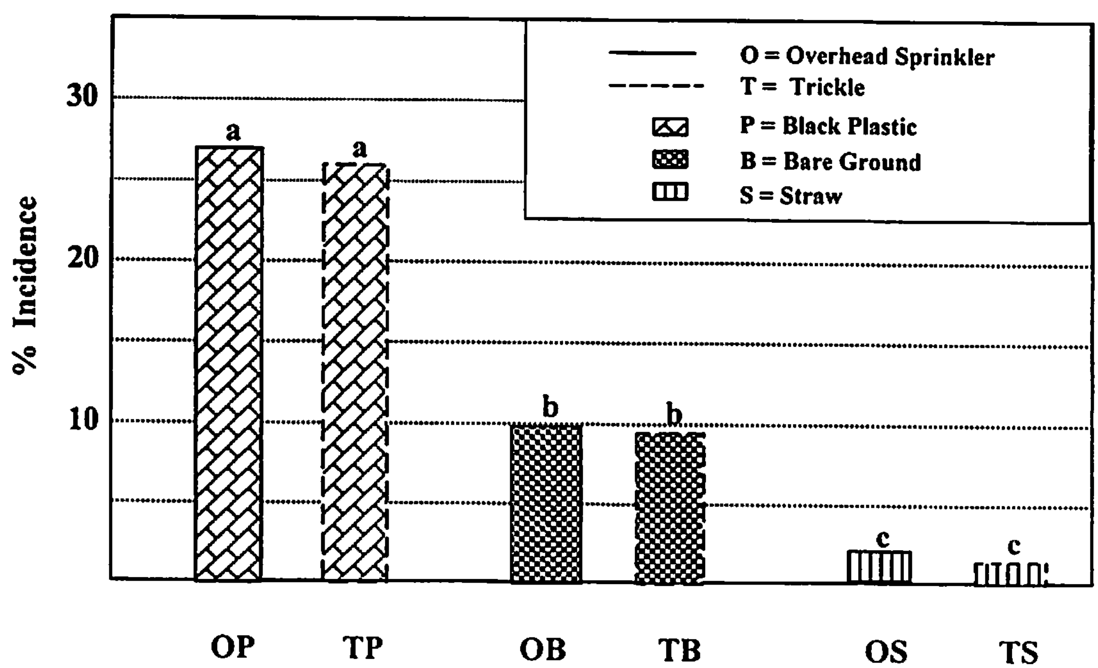


Fig. 5. Quality of bulbs from healthy plants or plants with one leaf with center rot [*Pantoea ananatis*] symptoms at time of harvest at the Vidalia Onion and Vegetable Research Farm after being stored on the shelf for two or four weeks.

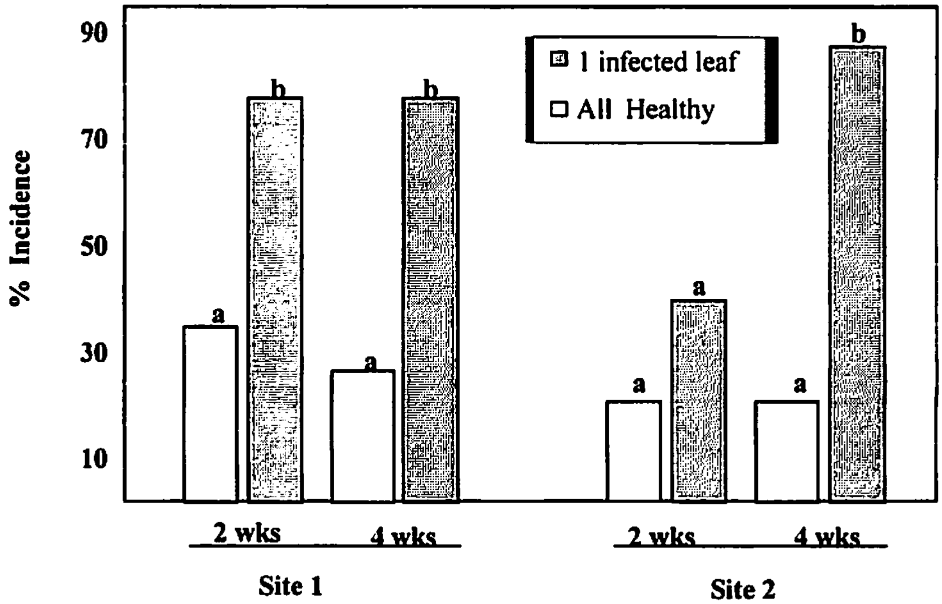


Fig. 6. Primers Pan_ITS_1 (specific for the ITS region in *Pantoea ananatis*) and EC5 (a universal primer from *Escherchia coli*) used in epidemiologic studies for PCR detection and identification of *P. ananatis*, the causal agent of center rot of onion.

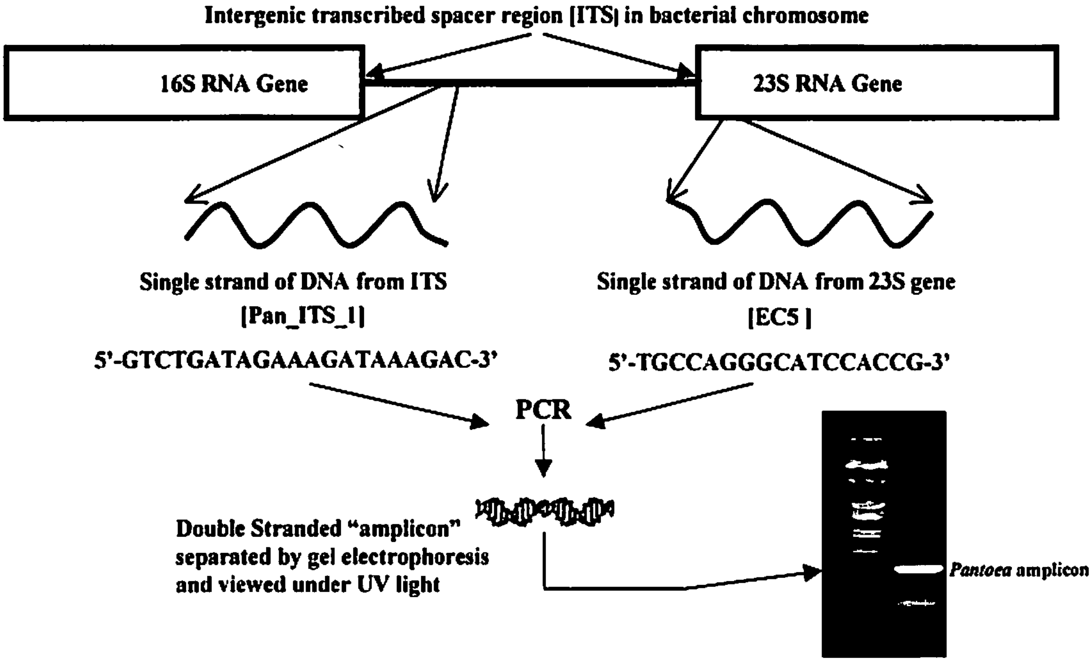
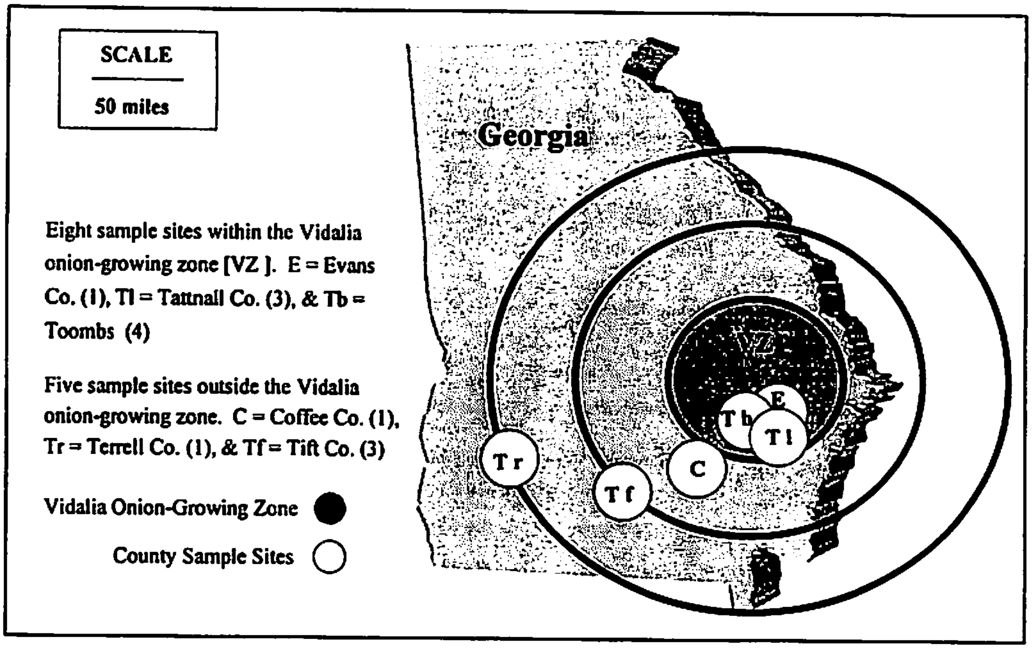


Fig. 7. Sample sites surveyed for the center rot bacterium [*Pantoea ananatis*] on weeds using PCR with the specific primer Pan_ITS_1 and the universal primer EC5.



EVALUATION OF VIDALIA ONION CULTIVARS FOR RESISTANCE TO CENTER ROT, 1999

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Introduction

Cultivars of Vidalia sweet onions grown on seedbeds were transplanted to fields at the Horticulture Farm at the University of Georgia Coastal Plain Experiment Station, Tifton, GA, a commercial farm in Chula, GA, and a commercial farm in Tattnall Co., GA.

Materials and Methods

Transplanting dates were 12, 18, and 19 Nov 98 for the Tattnall Co. farm, the Chula farm, and the Horticulture Farm, respectively. Onions were planted on four rows per 6 ft bed with 12 in. between adjacent rows and 5 in. between plants in the same row. Plots were 50 ft in length (480 onions/plot) and were arranged in a completely randomized design with three replications. Standard productions practices as recommended by the University of Georgia Cooperative Extension service were followed in regard to fertility, insect, weed and disease management. The incidence of center rot was assessed by counting the total number of diseased plants per plot prior to harvest.

Results and Discussion

Results from variety trials are shown in Table 1. All three locations experienced unusually warm and dry conditions in Feb and Mar 99 and center rot was not observed at any test site until early Apr. At each location, significant differences in the incidence of center rot were noted among the cultivars being evaluated. Onion cultivars Pegasus and Asgrow 6712 exhibited the highest levels of disease incidence at the Chula and Tattnall locations while Evita contained the highest level of disease at the Horticulture Farm. The lowest levels of disease incidence were observed in the cultivar RCS 1027 at Chula and the Horticulture Farm while Sweet Advantage had the lowest level of disease at the Tattnall location.

Table 1. Variety trials of Vidalia onion cultivars showing resistance to center rot, 1999.

Cultivar	Source	Incidence of Center Rot/plot[1]					
		Chula		Hort. Farm		Tattnall	
Pegasus	Asgrow	25.3	a[2]	15.7	ab	44.0	b
Asgrow 6712	Asgrow	15.3	b	15.0	b	64.3	a
Granex 33	Asgrow	9.3	b-e	12.0	b	28.7	c-f
Evita	Shamrock	13.7	bc	25.0	a	24.3	d-f
Sweet Vidalia	Rio Colorado	7.7	c-e	7.7	b	25.3	d-f
RCS 1027	Rio Colorado	4.0	e	7.7	b	18.3	d-f
RCS 1063	Rio Colorado	6.7	de	11.0	b	25.3	e-h
Mr. Max	Rio Colorado	13.3	b-d	11.3	b	13.0	bc
Sweet Melody	Rio Colorado	-[3]		-		33.0	b-d
RCS 1919	Rio Colorado	-		-		10.3	gh
Global 2012	Global	-		-		31.3	b-e
Sweet Success	Sunseeds	8.7	b-e	8.3	b	10.3	gh
Sunseed F1	Sunseeds	8.3	c-e	11.3	b	20.0	d-g
DP 1032	D. Palmer	7.7	c-e	13.3	b	15.0	f-h
Sweet Advantage	D. Palmer	-		-		4.0	h

[1]Data are counts of diseased plants in each plot that exhibit symptoms of center rot.
[2]Means in a column followed by the same letter(s) are not significantly different according to the Waller-Duncan *k*-ratio t test, k=100.
[3]Global 2012 and Sweet Melody were not included in tests at the Horticulture farm and Chula locations. RCS 1919 and Sweet Advantage are early maturing varieties and were harvested prior to disease ratings.

EVALUATION OF BACTERICIDAL AND FUNGICIDAL COMPOUNDS AND THEIR USE PATTERNS FOR MANAGING FOLIAR AND POST-HARVEST PATHOGENS OF ONIONS

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Introduction

The evaluation of bactericidal and fungicidal compounds and their use patterns for managing foliar and post-harvest pathogens of onions was studied.

Materials and Methods

Four rows of the onion variety "Sweet Vidalia" were transplanted to 6-ft beds (panels) on 1 Dec 1998. The fertility program for these onions was consistent with University of Georgia Extension Service recommendations. The experimental design consisted of a randomized complete block with four replications. Fungicide/bactericide treatment plots were 25 ft. long and were separated by non-treated border panels. Fungicides were applied using a CO_2 pressurized backpack sprayer calibrated to deliver 40 gallons per acre at 65 psi using TX-18 hollow cone nozzles. Onions were harvested on 22 Apr by digging the two center rows of each panel and allowing them to field dry until bagged on 26 Apr. Onions were cured at approximately 98° F for 72 hours before weighing and grading. Ten onions from each treatment were tested in the lab for the presence of post-harvest internal bulb pathogens while twenty onions from each treatment were placed in controlled atmosphereic (CA) storage for 6 months then removed and tested for post-harvest internal bulb pathogens.

Overall, the 1999 onion season was warm and dry with rainfall accumulations 9.24 inches below the fifty year average. These conditions were not favorable for the development of high levels of foliar disease. Botrytis leaf blight was first observed on 1 Feb while Purple blotch was not identified until 1 Mar (Table 1a). Plants infected with *Pantoea ananatis* were not observed until 22 Apr.

Results and Discussion

All fungicides and spray programs (Table 1 a-d) significantly reduced the percentage of Botrytis leaf blight compared with the non-treated check on the 2 Feb rating date, although ManKocide applied alone was less effective than other spray programs. ManKocide applied alone did not significantly suppress Botrytis leaf blight below the non-treated check by the 1 Mar rating. No significant differences in Botrytis leaf blight were detected between treatments on 22 Apr. Significant differences in Purple blotch were only detected on 22 Apr with Bravo Ultrex + ManKocide alternated with Quadris + ManKocide and Bravo Utrex + Actiguard alternated with Switch + Actiguard demonstrating the greatest disease suppression compared to the non-treated check.

The incidence of *Pantoea ananatis* was not significantly reduced by any fungicide/bactericide spray program. Yield as well as weight and number of jumbo onions was significantly reduced below the non-treated check in spray programs containing Actiguard. Only traces of Botrytis neck rot were detected when onions were biopsied for the presence of pathogens prior to CA storage, however, several onions were found to be diseased after six months of storage. No significant differences in post-harvest diseases were detected between fungicide programs.

Table 1a. Effect of selected fungicide spray programs on foliar and post-harvest diseases of onion.

Treatment and spray dates[1]	% Botrytis Leaf Blight[3]			%Purple Blotch[4]	
	2 Feb	1 Mar	22 Apr	1 Mar	22 Apr
ManKocide DF, 3.0 lb/A (1 - 9)	4.8 b[2]	7.8 a	13.8 a	13.8 a	5.0 bc
Bravo WeatherStik 6F, 1.5 pt/A + Mankocide DF, 3.0 lb/A (1 - 9)	1.0 c	1.8 b	13.8 a	16.3 a	3.3 bc
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1 - 9)	1.0 c	1.8 b	13.8 a	17.5 a	3.3 bc
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1 - 9) Trilogy 90E, 1 qt/A (4 - 8)	1.0 c	1.5 b	13.0 a	17.5 a	5.8 b
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1, 3, 5, 7, 9) Quadris 2.08F, 12.0 oz/A + ManKocide DF, 3.0 lb/A (2, 4, 6, 8)	1.0 c	3.5 b	11.3 a	22.5 a	2.3 c
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50WG, 1 oz/A (1 - 9)	1.0 c	1.3 b	12.8 a	17.5 a	3.8 bc
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50WG, 1 oz/A (1, 2, 3, 4, 9) Switch 62.5WG. 068 lb/A + Actiguard 50WG, 1 oz/A(demand - 5, 6, 7, 8)	1.0 c	1.8 b	10.0 a	18.8 a	4.3 bc
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF, 3.0 lb/A (1, 2, 4, 6, 8) Switch 62.5WG, 0.68 lb/A + ManKocide DF, 3.0/A (3, 5, 7, 9)	1.0 c	1.8 b	15.5 a	17.5 a	3.0 bc
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50 WG, 1.0 oz/A (1, 2, 4, 6, 8) Switch 62.5WG, 0.68 lb/A + Actiguard 50WG, 1.0 oz/A (3, 5, 7, 9)	1.0 c	1.8 b	10.0 a	18.8 a	2.5 c
Non-treated check	15.0 a	8.0 a	13.0 a	23.8 a	18.0 a

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Table 1b. Effect of selected fungicide spray programs on foliar and post-harvest diseases of onion (continued).

Treatment and spray dates[1]	*Pantoea ananatis*[5]	Yield lb/plot[6]
	22 Apr	
ManKocide DF, 3.0 lb/A (1 - 9)	1.8 a[2]	42.1 ab
Bravo WeatherStik 6F, 1.5 pt/A + Mankocide DF, 3.0 lb/A (1 - 9)	2.0 a	41.3 ab
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1 - 9)	2.3 a	41.4 ab
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1 - 9) Trilogy 90E, 1 qt/A (4 - 8)	4.8 a	39.7 ab
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1, 3, 5, 7, 9) Quadris 2.08F, 12.0 oz/A + ManKocide DF, 3.0 lb/A (2, 4, 6, 8)	3.0 a	42.1 ab
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50WG, 1 oz/A (1 - 9)	4.0 a	38.4 b
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50WG, 1 oz/A (1, 2, 3, 4, 9) Switch 62.5WG. 068 lb/A + Actiguard 50WG, 1 oz/A(demand - 5, 6, 7, 8)	3.3 a	37.0 b
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF, 3.0 lb/A (1, 2, 4, 6, 8) Switch 62.5WG, 0.68 lb/A + ManKocide DF, 3.0/A (3, 5, 7, 9)	3.8 a	41.0 ab
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50 WG, 1.0 oz/A (1, 2, 4, 6, 8) Switch 62.5WG, 0.68 lb/A + Actiguard 50WG, 1.0 oz/A (3, 5, 7, 9)	4.3 a	35.5 b
Non-treated check	2.3 a	47.0 a

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Table 1c. Effect of selected fungicide spray programs on foliar and post-harvest diseases of onion (continued).

Treatment and spray dates[1]	Botrytis Basal Rot[7]	Botrytis Neck Rot[8]
ManKocide DF, 3.0 lb/A (1 - 9)	0.8 a[2]	1.3 a
Bravo WeatherStik 6F, 1.5 pt/A + Mankocide DF, 3.0 lb/A (1 - 9)	0.5 a	1.0 a
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1 - 9)	0.5 a	2.3 a
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1 - 9) Trilogy 90E, 1 qt/A (4 - 8)	0.8 a	1.3 a
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1, 3, 5, 7, 9) Quadris 2.08F, 12.0 oz/A + ManKocide DF, 3.0 lb/A (2, 4, 6, 8)	0.0 a	1.0 a
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50WG, 1 oz/A (1 - 9)	0.5 a	0.8 a
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50WG, 1 oz/A (1, 2, 3, 4, 9) Switch 62.5WG. 068 lb/A + Actiguard 50WG, 1 oz/A(demand - 5, 6, 7, 8)	0.3 a	0.3 a
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF, 3.0 lb/A (1, 2, 4, 6, 8) Switch 62.5WG, 0.68 lb/A + ManKocide DF, 3.0/A (3, 5, 7, 9)	1.8 a	0.0 a
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50 WG, 1.0 oz/A (1, 2, 4, 6, 8) Switch 62.5WG, 0.68 lb/A + Actiguard 50WG, 1.0 oz/A (3, 5, 7, 9)	1.0 a	0.8 a
Non-treated check	1.5 a	1.0 a

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Table 1d. Effect of selected fungicide spray programs on foliar and post-harvest diseases of onion (continued).

Treatment and spray dates[1]	Tan Discoloration[9]	Ext. Rot[10]	Int. Rot[11]
ManKocide DF, 3.0 lb/A (1 - 9)	2.8 b-d[2]	1.8 a	4.8 a
Bravo WeatherStik 6F, 1.5 pt/A + Mankocide DF, 3.0 lb/A (1 - 9)	1.5 d	1.8 a	3.3 a
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1 - 9)	2.3 cd	2.3 a	6.0 a
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1 - 9) Trilogy 90E, 1 qt/A (4 - 8)	3.3 a-d	1.8 a	6.0 a
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF 3.0 lb/A (1, 3, 5, 7, 9) Quadris 2.08F, 12.0 oz/A + ManKocide DF, 3.0 lb/A (2, 4, 6, 8)	5.3 ab	0.5 a	5.8 a
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50WG, 1 oz/A (1 - 9)	6.0 a	1.3 a	7.3 a
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50WG, 1 oz/A (1, 2, 3, 4, 9) Switch 62.5WG. 068 lb/A + Actiguard 50WG, 1 oz/A(demand - 5, 6, 7, 8)	4.3 a-d	0.5 a	5.3 a
Bravo Ultrex 82.5WG, 1.5 lb/A + ManKocide DF, 3.0 lb/A (1, 2, 4, 6, 8) Switch 62.5WG, 0.68 lb/A + ManKocide DF, 3.0/A (3, 5, 7, 9)	3.3 a-d	1.5 a	6.3 a
Bravo Ultrex 82.5WG, 1.5 lb/A + Actiguard 50 WG, 1.0 oz/A (1, 2, 4, 6, 8) Switch 62.5WG, 0.68 lb/A + Actiguard 50WG, 1.0 oz/A (3, 5, 7, 9)	5.0 a-c	1.8 a	6.8 a
Non-treated check	2.0 d	2.0 a	4.8 a

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Footnotes for Table 1

[1]Spray dates are as follows: 1st=12/14, 2nd=1/4, 3rd=1/19, 4th=2/2, 5th=2/15, 6th=3/1, 7th=3/16, 8th=3/29, 9th=4/12).

[2]Means followed by the same letter(s) are not significantly different at according to the Waller-Duncan *k*-ratio t-test at $k = 100$.

[3]Botrytis leaf blight ratings were conducted by visually assessing 10 plants in the two center rows of each plot and recording the total percentage of the leaf area affected by Botrytis.

[4]Purple blotch ratings were conducted by visually assessing 10 plants in the two center rows of each plot and recording the percentage of the leaf area affected by Purple blotch.

[5]Values represent the total incidence of *Pantoea ananatis* per plot.

[6]Weight of cured onions harvested from 15-ft of the two center rows of each plot.

[7]Average number of onion bulbs infected with *Botrytis allii* at the basal region from a bag of twenty onions.

[8]Average number of onion bulbs infected with *Botrytis allii* at the neck region from a bag of twenty onions.

[9]Average number of onion bulbs showing tan discoloration (mostly from *Pantoea ananatis*) from a bag of twenty onions.

[10]Average number of onion bulbs showing some type of exterior decay from a bag of twenty onions.

[11]Average number of onion bulbs showing some type of interior decay from a bag of twenty onions.

RESISTANCE OF SWEET ONIONS TO AIRFLOW

Bryan W. Maw, Research Engineer
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Benjamin G. Mullinix, Statistician

Introduction

Curing is an essential step in the preservation of sweet onions. Curing is one of the processes by which the interior of an onion is sealed from the intrusion of disease that may take place post-harvest and by which an onion may receive some mechanical protection. Through curing: the outer scales are dried; both the neck and the roots are dried and sealed; and wounds on the surface may be sealed. Throughout this procedure, maintenance of the internal moisture content of the onion must be assured, for that reason the term "curing" rather than "drying" is used to describe this process.

Onions receive some curing whenever they are in an environment that has the capacity to absorb moisture. Curing may take place under natural sunshine and wind while onions are in the field, either undercut and laying on the ground or held in bags. Artificial curing may take place when the onions are purposely placed in curing bins or may even take place while they are in storage. Curing in the field is the least expensive of all methods, yet, suitable climatical conditions for this to occur in the field can not be guaranteed (Smittle and Williamson, 1978). Artificial curing, while being an added expense of onion production, provides a controlled environment within which a regulated amount of curing may take place.

Smittle and Williamson (1978) reported supplementing natural field curing with artificial curing using peanut drying wagons, having warm air passing from a plenum under the perforated floor of each wagon up and around the onions stacked in the wagon. Artificially curing onion bulbs for three days with air at 40 °C produced bulbs with better storability than field cured bulbs. Yet an air temperature of 46 °C caused severe bulb deterioration. Boyette et al. (1992) described demonstrations whereby sweet onions, held in pallet boxes, were dried in bulk tobacco barns. He advocated re-circulated air with a wet bulb temperature of 29-32 °C and a dry bulb temperature of 38 °C. A reduction in bulk onion weight of 5-8 % was noted.

During artificial curing, air is usually forced around the onions by means of a fan. The extent to which a commodity resists airflow is an influencing factor when selecting the capacity of fans to force air through or around the commodity. Based upon numerous studies, a standard has been established to aid in the selection of fans. ASAE standard D272.3 (ASAE, 1996) "Resistance to airflow of grains, seeds, other agricultural products and perforated metal sheets" includes the relationship between pressure drop per unit depth and volumetric airflow. While most of the commodities reported are small in diameter as for example in the form of grains and seeds, there is reference to data collected for bell pepper (Gaffney, 1975), for sweet potatoes (Abrams, 1982) and for potatoes (Staley, 1961).

There has been found only limited reference to studies of airflow in relation to onions. Glaser (1993) suggested that sliced onions may be dried by airflow in a fluidized bed and Rapusas et al. (1995) found the resistance to airflow of sliced onions may be described by the modified Ergun equation (Ergun, 1952). However, reference to airflow resistance while drying whole onions has not been found and is needed as an addition to the ASAE standard D272.3. During curing and storage, settling of the onions may cause an increase in bulk density even though the airflow may continue to be uniform. Continued settling may cause a less than uniform airflow, with air taking the path of least resistance through established channels, leaving some onions with out air flowing over them. Without air movement, onions are likely to become infested with surface and then secondary diseases.

Objectives

An experiment was designed to establish the relationship between airflow and static pressure at depths above the plenum within a column of onions. This report covers a preliminary study.

Materials and methods

The arrangement of apparatus for the study was similar in concept though not necessarily in dimensions, to that used by Abrams and Fish, 1982, and Suggs et al, 1986.

Column and plenum: Granex 33 sweet onions (*Allium cepa*) used for the test originated from the Vidalia onion growing region. During the test they were placed into a column constructed of 15.8 mm (0.625 in.) plywood box sections, each of 58.42 x 57.15 cm (23 x 22.5 in.) internal dimensions and of height 30.5 cm (12 in.). The internal cross sectional area was calculated as 3338.7 cm^2 (517.49 in^2). Each section fitted snugly onto the one below, forming an airtight seal. Strips of plastic sheet were placed at each joint, acting as a gasket between the sections and protruded 2.5 cm (1 in.) into the interior of the box to baffle air movement up the interior of the walls and thus simulate the conditions within a box of a larger cross sectional area. The bottom section was provided with an expanded mesh floor of open space 67%. It is not known to what height sweet onions may be piled without there being a detrimental effect on onions at the lower levels. However, curing bins having onions as deep as 3 m (10 ft) in depth have been observed by the authors and so a column of onions 1.8 m (6 ft) high was used according to the availability of onions and the feasibility of data collection. Box sections of onions were added one at a time with the onions being carefully placed inside each section as it was added.

The box sections, containing onions, were mounted over a lower plenum of 71.12 x 50.16 cm (28 x 19.75 in.) external elevation cross section, made of 15 mm (0.5 in.) plywood. A steel frame of 51 x 8 mm (2in. x 0.3125 in.) angle was placed over the plenum to support the box sections of onions in order to avoid crushing the lower plenum. As much as half a tonne of onions were expected to be supported by each frame. A tight seal was established between the plenum and the first section, just as between successive sections. The inlet to the plenum was connected to a large plywood box, 1.2 x 0.7 x 1.3 m (48 x 29 x 53 in.) to which was connected, by way of a flexible canvas hose, the fan used to supply air for the study. An additional box section was added, above those containing onions, to act as an upper plenum.

Fan: A Peerless Whisper Jet fan (Anonymous, 1994) was used to provide airflow. This fan had the capacity to blow air through the column of onions as needed for the study. The backward inclined blade squirrel cage fan had a 3.7 kW (5 hp) 3 phase electric motor. For static pressures of 1.3 to 7.6 cm (0.5 to 3.0 in.) of water pressure the volumetric air flow was rated as 241 to 320 m^3 /min (8520 to 11300 ft^3 / min). Attached to the power supply of the fan was an AC inverter (E.Trac WFC ^{HT} 2005-0CHT,T.B. Woods, 440 North Fifth Avenue, Chambersburg, Pennsylvania) capable of varying the speed of the fan from 10 - 60 hz or 16 % to 100 % full speed. A digital strobescope (Digistrobe III, model 1965, Ametek, Mansfield and Green Division, 8600 Somerset Drive, Largo, FL 33773) was used to measure the fan motor speeds as observed at different inverter settings (Table 1). During the test, consideration was given to a range of linear airflow rates through the onions of 20 - 60 m/min, representative of practical onion curing conditions (Maw et al., 1997), as provided by inverter settings of 10 - 50 hz.

Measurement of static air pressure: Static air pressure was measured with a manometer (Dwyer model 400 or Microtector model 23-206, Dwyer Instruments Inc., Michigan City, Indiana). Connected to the manometer by a rubber pipe was a brass probe used to penetrate through the wooden column wall via 6.25 mm (0.25 in.) ports. The probe was constructed of a 40 cm (16 in.) length of hollow brass pipe of 6.35 mm (0.25 in.) O.D. with a solid pointed end and with fourteen 2.3 mm (0.093 in.) diam holes into the center, along the first 15.24 cm (6 inches) from the point. By means of this probe attached to the manometer, the static pressure in the lower and upper plenum was obtained. The probe protruded 25.4 (10 in.) inside the plenums, to take static pressure readings away from the inside surface. The probe ports were closed when not being used for the probe.

Measurement of air velocity: Because of the variability in readings taken using other types of linear air velocity meters, the static pressure differential across an orifice was used to measure air velocity through the column of onions. This method is reported (Henderson and Perry,1976, pg 63) to be convenient for measuring discharges into the atmosphere out of large bodies where a hole would act as an orifice.

An airflow meter using the principles of a sharp orifice was attached, by a flexible duct, to the closed top section of the upper plenum. Immediately prior to or upstream from the orifice, a 1.5 m (5 ft) section of straight p.v.c. pipe of internal dimensions 6.00 in. established uniform airflow. Immediately following or downstream from the orifice, a 0.75 m (2.5 ft) section of p.v.c. pipe ensured a uniform airflow before the air was exhausted into the atmosphere. The orifice (Oripac model 4150-P, Lambda Square, P.O. Box 1119-M, Bayshore, NY 11706) was of 9.243 cm. (3.639 in.) in diameter of thickness 3.55 mm (0.14 in.)with corner taps for measurement of the upstream and downstream static pressure differential. Along with the airflow meter orifice came a calibrated chart from which the flow in standard volumetric airflow at

68 ^{0}F was derived. The same manometer was used to measure the pressure differential across the orifice as was used to measure the static pressure in the plenums.

A probe port was positioned in the lower plenum 15 cm (6 in.) below the floor of the onions, for measuring the static pressure of the air before it passed through the onions. Likewise in the upper plenum there was a ports at each corner of the section 15 cm (6 in.) above the onions. The pressure differential between that of the lower and upper plenums was the net pressure difference responsible for airflow through the onions and the pressure difference between upstream and downstream of the orifice was responsible for flow through the orifice. Since leakage in the system was negligible, flow through the orifice was considered to be flow through the onions.

Data collection: Beginning with one box section of onions placed over the lower plenum and capped with the upper plenum, air was provided to the column of onions at different fan speeds from 10 hz through to 50 hz in increments of 5 hz. At each fan speed the static pressure was measured inside both the lower and upper plenums and the static pressure differential was measured across the orifice measuring the airflow. An additional box section of onions was then added to the first and the procedure repeated for two box sections of onions as for the previous single section. This same procedure was repeated as successive box sections of onions were added until six box sections of onions were in place.

Presentation of results: For each depth of onions in the column, the static pressure gradient across the onions was calculated in correspondence with the airflow through the column of onions. Air velocity through the stack was slightly higher than the superficial velocity because part of the column cross section was occupied by onions and the air must increase in speed to pass around the onions within the stack. Both airflow and static pressure were plotted and a straight line fitted to the data by simple non linear regression (PROC NLIN, SAS, 1998).

Air flow through containers of certain commodities has been shown to increase with pressure according to the Shedd equation (Suggs, 1986), a straight line on a $\log_e$-$\log_e$ graph.

$$Q = a P^b \text{ (Shedd, 1953)} \quad (1)$$

$$\text{or } \mathrm{Log}_e Q = \log_e a + b \log_e P \quad (2)$$

where Q = air flow velocity per unit cross-sectional area (superficial velocity), m/s (ft/s).

P = pressure gradient, Pa/m (in.water/ft).

a = intercept value of Q for the line when P = 1, in consistent units.

b = slope of the line, in consistent units.

With the flow being divided by the cross sectional area of the bin or column and division of the pressure by the depth of the material in the bin or column, the results become independent of system size. The velocity is then known as the superficial velocity.

Results and discussion

The overall static pressure gradient variation across a stack of onions according to air velocity passing through the onions was found as given in Figure 1. The intercept, a, was 264 ft / min as taken from Figure 1 and the slope, b of the line was 0.8908 ft / min / in. H_20 / ft. as taken from the regression analysis. Equation (2) of the line then becomes:-

$$\mathrm{Log}_e Q = \log_e 5.5765 + 0.89085 \log_e P \quad (3)$$

where 264 is the antilog of 5.5765 and 235 is the instantaneous slope on the real line at P = 1. The closeness of fit of the line to the data points was 0.92.

From this preliminary study the resistance to airflow for onions has been found to be in association with that for peppers, sweet potatoes, potatoes and peanuts in the shell as shown in Figure 2 by the broken line. Further study may reveal a variation of the position of the line in relation to those commodities.

Acknowledgements

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Table 1. Fan motor speeds according to the AC inverter settings.

AC inverter setting hz	Fan motor speed revolutions / min
10	296.8
15	446.3
20	594.7
25	743.0
30	891.4
35	1038.9
40	1186.1
45	1332.8
50	1477.8
55	1623.7
60	1766.4

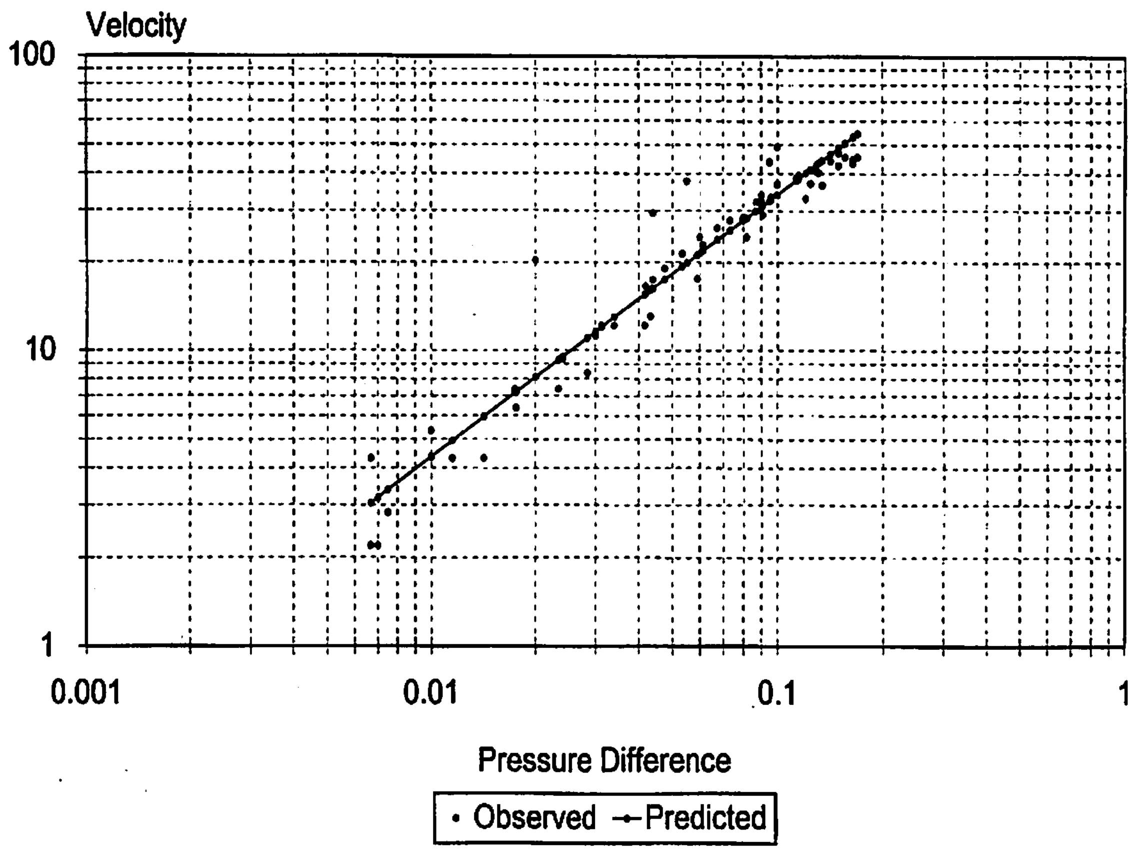
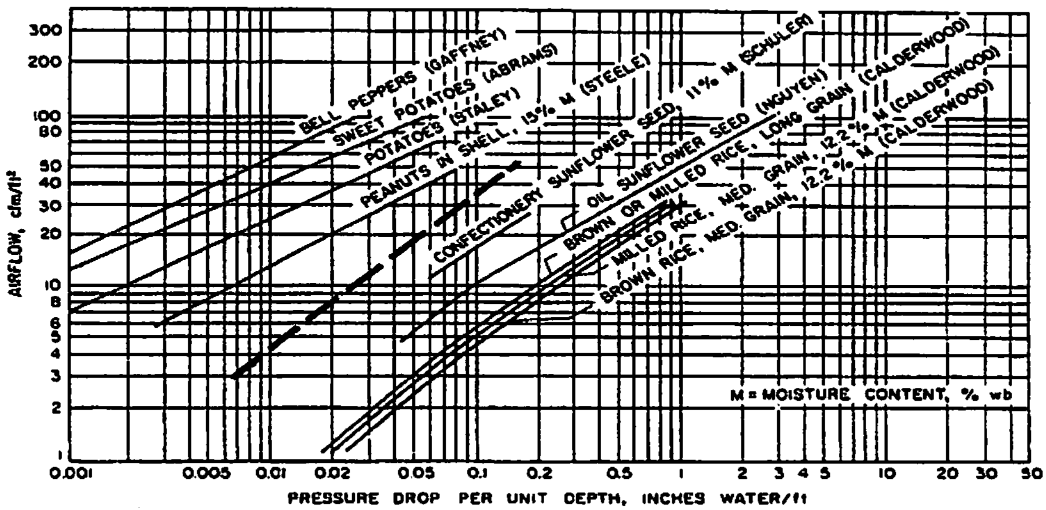


Figure 1. Overall static pressure gradient versus superficial air velocity for onions.



NOTES: Rice: Clean, loose-fill. A packing operation which raised the bulk density by 14 to 17 percent resulted in pressures 3.3 to 3.4 times those for loose fill.

Figure 4 – Resistance to airflow of other agricultural products (inch-pound units)

ASAE STANDARDS 1997

Figure 2. Resistance to airflow of onions (– – –) compared with that of other commodities.

Harvesting and Curing Vidalia Onions in plastic pallet bins

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Introduction

Sweet onions are soft and succulent. They are easily damaged, opening a way for disease to enter the bulb. A satisfactory harvesting program enables sweet onions to be harvested and handled as gently as possible, even through curing, storage and shipping.

Curing is an essential part of harvesting as it prepares onions for an extended shelf life, be it for the fresh market or for later markets after storage. Onions are cured in order to enhance dormancy and to dry the outer scales, roots and neck. By drying the scales, a bulb is sealed against internal water loss and the bulb is provided with an armor which enhances its durability. Drying the scales, roots and neck reduces the likelihood of disease entering the bulb by removing a requirement for most diseases to both travel and grow, that of moisture. Drying the outer flesh can also aid in the healing of scarred tissue.

Traditionally, Vidalia onions have been harvested and handled in units of bags (40 lb). Bags are convenient in size for a person to handle, but they do not provide protection to the onions inside them from impact during handling. Pallet bins are an alternative to bags in that onions may be harvested straight into the bins in the field either by hand or by machine. Once in the bins the onions may be gently moved in bulk, reducing the likelihood of impact damage.

Coupled with subsequent curing, while they are still in pallet bins, the number of times an onion is exposed to impact may be reduced by at least six events, compared with hand harvesting into bags, loading onto trucks, tipping into hoppers and curing bins. Pallet bins fit well as part of a bulk handling procedure when harvesting by hand or by machine. Wooden pallet bins are satisfactory, however, plastic pallet bins are durable, long lasting, easily washed, not abrasive to produce, smooth to handle by hand and convenient for forklift trucks.

This preliminary study was designed to examine the feasibility of using plastic pallet bins as a container for holding sweet onions during harvesting, hauling, curing and later storing in fresh air, AC, Cold or CA rooms.

Material and Methods

Plastic pallet bins, model TM 34 of capacity 32 ft^3, manufactured by Macro Plastics, Fairfield, CA, were filled with onions either by a harvester or by hand. For the harvester, pallet bins one at a time were mounted on the CPES onion harvester and, once filled with onions, were handled with a forklift truck. When filled by hand the pallet bins were either gently poured in loose from a bucket or placed in bags inside the pallet bin. Curing was conducted by forcing warm air up through vents in the bottom of the pallet bin.

The pallet bins were delivered with vents in the sides as well as the bottom. In order to direct airflow up through the onions from the base the side vents were covered with plywood, each section bolted in place and sealed with tape. The remaining open vented area was 7.4 % of the total base area. If the onions were left in bags inside the pallet bin, the bags were placed in the bin over each other so as to reduce the likelihood of tunnels forming between the bags through which air could circumvent the onions.

A digital AC inverter, developed by T.B. Woods, Chambersburg, PA, was coupled with a Pearless Whisperjet Dryer (Peerless Manufacturing Co., Shellman, GA) to provide a controlled variable airflow. The dryer had a backwards curved squirrel caged 25 in. diameter by 15 in. wide fan, driven by a 5 hp three phase electric motor. Curing at a standard temperature of 100 °F, volumetric airflow was variable between 0 and 11,300 ft^3 at the fan, depending upon the static back pressure.

The dryer was coupled to a plenum over which the bins were placed. Each bin was supported on a metal frame to carry the weight of the bin and onions, a weight which could be in excess of 1000 lbs per bin.

The warm air from the dryer passed through the plenum then by way of the vents in the base of the pallet bin, up through the onions, exhausting to the atmosphere. Up to seven bins (> 3 tonnes) could be serviced at once. The variable fan speed control allowed the same back pressure of 0.75 in. water gage and thus a similar airflow in the plenum to be established, regardless of the number of bins being serviced by the dryer fan. When several bins were mounted over the plenum, onions in the pallet bins were evenly distributed amongst the bins in order to encourage an even airflow through each bin.

Results and Discussion

From this preliminary study under the conditions described, the pallet bins, dryer and plenum performed quite adequately in all aspects. The open vented area in the base of the pallet bin was large enough to enable sufficient curing air flow through the onions according to guidelines used during curing research (Maw and Sumner, 1998, Maw et al., 1998a and Maw et. al, 1998b.)

Acknowledgements

Appreciation is extended to Steven M. Bisesi of Macro Plastics Inc., for making available the plastic pallet bins used during this preliminary study.

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COMPARISON OF THE SHELF LIFE OF VIDALIA ONIONS FOLLOWING HARVEST BY HAND AND BY MACHINE

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Introduction

Sweet onions, having a low level of pungency, do not possess the natural disease inhibitor of more pungent onions. Instead, extra care must be taken to avoid those onions during harvest and subsequent handling from being damaged. Damaged areas of the bulb of a sweet onion provide access for disease organisms to enter the bulb. A study continues of the variation in suitability of different varieties of sweet onions for mechanical harvesting.

Materials and Methods

Sweet onions were collected after having been harvested either by hand, by machine without being machine topped or by machine after having been machine topped, from Bland's Farms, Tattnall County, GA. The variety Sweet Vidalia were undercut on Friday May 14th and harvested on Tuesday May 18th, 1999. The variety Nikita was undercut on May 5th, 1999 and harvested on Monday May 31st, 1999. Onions of both varieties were considered to be mature at the time of harvesting.

The onion harvester used was a self propelled Schuknecht SP-160. Lifting two beds of onions at once, the harvester required the onions to be undercut and laying on top of the ground. While traveling and lifting onions from the bed, the onions were delivered via a side elevator into the side tip dump body of a six - wheel - drive truck, traveling beside the harvester. The SP-160 harvester had a topping mechanism to reduce the length of tops but not close trim the tops. At the grading line a stationary topper was included to further trim the tops of the machine harvested onions to an acceptable length before the onions were cured.

Hand harvested onions were harvested by and collected from regular labor crews harvesting onions into burlap sacks in the same field of onions as the machine (Table 1). Untopped machine harvested onions were taken from the top of a loaded truck of onions. Topped machine harvested onions were collected from the onion shed after they had been harvested by machine, carried on a truck to the shed, dumped into a hopper, elevated into a mechanical topper and unloaded onto a conveyor.

Following collection from Bland Farms all onions were artificially cured for 48 h. The temperature of the air as it passed through the onions during artificial curing was maintained at 100 ^{0}F. Airflow was sufficient to maintain a back pressure of between 0.75 and 1.00 in. of water pressure. Following curing, the onions were sorted and any decaying onions were removed from the sample.

Once sorted the onions were stored as mixed grades, held in boxes of 25 lb capacity (Table 1) and placed in a room serviced by a window-type air conditioner set at 72 ^{0}F. The onions were placed in storage, the variety Sweet Vidalia on Wednesday, May 26th, 1999, and Nikita on Friday June 4th, 1999.

While in storage, the onions were inspected at biweekly intervals. Onions showing signs of decay or sprouting were weighed and then discarded. The remaining onions in each box were weighed before the box of onions was returned to the shelf for further storage. The data was analyzed using Proc MIXED (SAS 1998).

Results and Discussion of Results

A graph of the percentage of good onions remaining after time in storage, is given in Figure 1. The 100 % level, on the graph, is after the onions had been cured and after any decayed onions had been removed before the commencement of storage. Week 0 is when either variety went into storage even though they were placed in storage on different dates.

The data in Figure 1 has been analyzed for weeks 0 through 19. Regression coefficients were determined at week 10 , half way through the storage period (Table 2). Overall, regardless of harvest method, Sweet Vidalia (SV) had greater storability in storage than Nikita (N). Overall, between harvest methods, onions harvested by hand (HH) had significantly ($P < 0.01$) greater storability.

For Sweet Vidalia (Table 2), although hand harvest (SV - HH) was significantly greater in storability than the machine harvest methods (SV - MU or SV - MT) the fact that > 75 % if the onions were still good > 100 weeks suggests that machine harvesting may be a viable option for harvesting Sweet

Vidalia. For Nikita (N), machine harvesting (SV - MU or SV - MT) was found to be a less than acceptable option, since approximately only 50 % were in storage > 10 weeks compared with > 70 % of the hand harvested onions. It remains to be determined if being undercut in the field from May 5th - May 31st had anything to do with deterioration which took place after the onions had been machine harvested because hand harvested onions (N - HH) acceptably performed in storage.

Even though the slope (Table 2) of the lines for Sweet Vidalia showed that the rate of loss of storability for the machine harvested onions was greater than for hand harvested onions, the lines on the graph (Figure 1) seem to indicate that the slopes were nearly the same. The significant of curvature component for Sweet Vidalia indicates that rate of loss of storability dramatically increased > week 11. For Nikita, the rate of loss of the machine harvested onions was generally the same for the 19 weeks of storage. The hand harvested onions behaved similarly to the SV onions.

Summary and Conclusions

* Sweet onions of varieties Sweet Vidalia and Nikita were harvested either by hand, by machine and untopped or by machine and topped.
* Following harvest the onions were placed in air conditioned storage and biweekly inspected, with decaying onions being discarded at that time. Storability, measured by the number of good onions remaining after a given length of time in storage, was taken as an indication of the suitability of a harvesting method for a given onion variety.
* Regardless of harvest method, Sweet Vidalia (SV) had greater storability than Nikita.
* For Sweet Vidalia (SV), machine harvesting was considered to be a viable option.
* For Nikita (N), machine harvesting found to be less than a viable option.
* Onions harvested by hand had significantly ($P<0.01$) greater storability.

Acknowledgment

The authors wish to thank Mr. Ben Mullinix for assistance with analysis of the data.

Reference

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Table 1. Treatments of machine harvested versus hand harvested onions on the onions samples.

Variety	Harvest Technique	Inline Topper	No of 25 lb boxes	Graphical Code
Sweet Vidalia				
	Hand Harvested		20	(SV-HH)
	Machine Harvested	Untopped	20	(SV-MU)
	Machine Harvested	Topped	20	(SV-MT)
Nikita				
	Hand Harvested		20	(N-HH)
	Machine Harvested	Untopped	20	(N-MU)
	Machine Harvested	Topped	20	(N-MT)

Table 2. Regression coefficients determined at 10 weeks of storage in percentage of good onions.

Variety	Good Onions (%)		
	Intercept	Slope (% / week)	Curvature (% / week^2)
Sweet Vidalia			
Hand Harvest	81.19 a	- 4.72 b	- 0.336 a
Machine Untopped	77.08 b	- 4.99 a	- 0.318 a
Machine Topped	77.08 b	- 5.08 a	- 0.323 a
Nikita			
Hand Harvest	72.44 a	- 3.79 b	- 0.136 a
Machine Untopped	47.84 c	- 5.00 a	- 0.003 b
Machine Topped	52.89 b	- 3.86 b	0.004 b
S.E.	1.07	0.089	0.0162

Note; intercept and slope determined at week 10 using the model, $y = a + b(x - 10) + c(x - 10)^2$, where x = the actual week data was collected and 10 is the mean of the weeks (Draper and Smith, 1981, Applied Regression Analysis, second edition, New York, Wiley, 706p).
Coefficients determined from data shown in Figure 1.

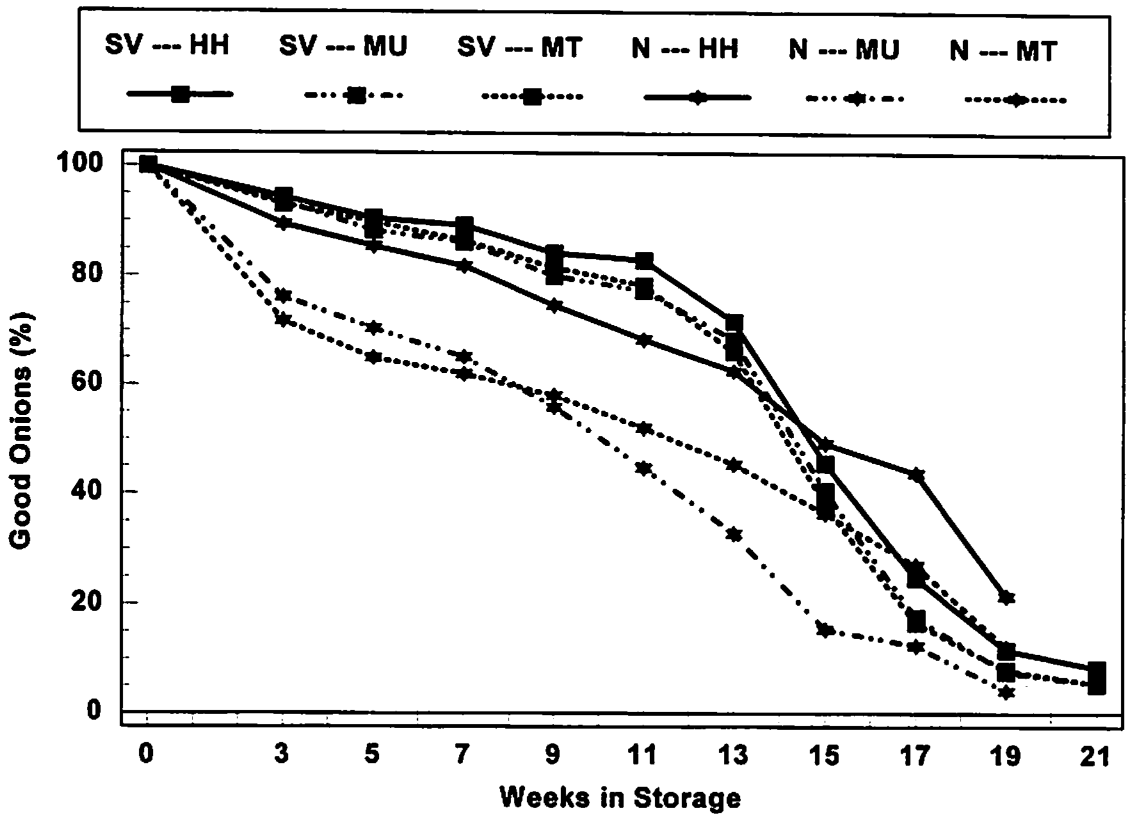

Figure 1. Mean storability of Sweet Vidalia (SV) and Nikita (N) sweet onions following harvest by hand (HH), harvest by machine but untopped (MU),or harvest by machine and topped (MT).

LASER PUFF FIRMNESS EVALUATION OF ONIONS,

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<u>Introduction</u>

The harvesting and handling of produce invariably has the potential to cause mechanical injury to that produce. The durability of produce may be described as its ability to withstand mechanical injury. The relationship of durability with physical properties of the produce both varies with the produce in question and may not be clearly known. Firmness is one such physical property and even this may be measured in different ways, such as resistance to puncturing the skin and successive flesh with a probe or the resistance to compression from a non destructive source.

ASAE standard S 368.3, March 1995, was developed for use in determining: mechanical attributes of food texture; resistance to mechanical injury as a result of static loading; and quasi - static force - deformation behavior of food materials of convex shapes such as fruit and vegetables, seeds and grains and manufactured food materials. The standard has been developed around compression tests that may be conducted using an Instron Universal Testing apparatus. Determination of compressive properties requires the production of complete force - deformation curves, from which stiffness; apparent modulus of elasticity; toughness; force and deformation to points of inflection, to bio - yield and to rupture; work to point of inflection, to bio - yield and to rupture and maximum normal contact stress at low levels of deformation, can be obtained. Any number of these mechanical properties can, by agreement, be chosen for the purpose of evaluation and control of quality. Firmness evaluation by the force - deformation curve method depending upon the force applied, may result in the deformation or destruction of produce. Samples of produce are used and then discarded.

Nondestructive techniques of measuring firmness have been conducted by various people. Sugiyama et al., 1998, measured the transmission velocity of an impulse waveform induced by an impact of a plunger on a melon. Two microphone sensors were the receivers, transmitting acoustic signals to a computer through a PC card-type A/D converter. Physiological changes taking place during melon ripening could be observed. Stone, et al., 1998, measured the energy content of a response signal between 150 and 200 Hz compared with the total energy transmission between 0 - 500 Hz as received at four locations of a peach. A solenoid hammer provided the impulse and piezoelectric ceramic/brass discs detected the response signal. Armstrong et al., 1995, developed a firmness tester for soft fruit with cups on a turntable that sequentially brought fruit under a load cell attached to a flat plate. A rack and pinion stepping motor gently lowered the plate onto the fruit while the force at each step was detected by the load cell. Firmness was calculated from the force deformation curve. All of the aforementioned techniques involve impacting the produce by some mechanical means.

Prussia et al., 1994, have developed a not only nondestructive but non-contact firmness detector which uses a short puff of pressurized air to deflect the food surface and a laser displacement sensor that calculates the amount of deflection as a measurement of firmness. Firm items in each category of product that was tested had less deformation than soft items. Sorting peaches with the laser-puff detector resulted in accuracies equal to that of a USDA inspector (Hung and Prussia, 1995). Laser - puff values for peaches also correlated well with destructive measurements of firmness (R^2=0.78).

Because of the unique construction of sweet onions the relationship between their durability and firmness is still in question. The real test is in a sweet onion's shelf life after it has received mechanical injury. Furthermore, only limited data is available for the measurement of firmness of onions. Hung et al., 1996, measured firmness using a 3.2 mm diameter flat ended puncture probe to penetrate the first and second rings from the shoulder, using an Instron Universal Testing machine. Little or no difference was observed in firmness between fresh onions and those having been stored in refrigeration or controlled atmosphere. Maw et al., 1996, used a similar technique to establish the puncture resistance of sweet onions for all rings (Figure 1) and established that the puncture resistance was highest for the first or outside ring. For subsequent rings the puncture resistance was similar until the center where the ring membrane was less developed. Some change in resistance was experienced over time when onions had been stored in an air conditioned room. There occurred a decrease in puncture resistance with time but the outside ring had still the most resistance.

The mechanical harvesting of sweet onions is taking its place along side hand harvesting. In an attempt to help farmers select varieties of onions that may be more suitable for mechanical harvesting, there is a need to evaluate the different varieties being grown. Assuming that firmness is one of the components of durability, this report describes a project to evaluate the firmness of sweet onions using the laser puff firmness tester.

Objectives

To evaluate the firmness of onions as an indication of their suitability for mechanical harvesting.

Materials and methods

Following harvest the onions were stored in cold storage at 34 ^{0}F until they were tested. During testing onions, one at a time, were placed on a support, gently held in place with putty. Adjustments were then made to the position of the onion to cause the laser beam and air jet to coincide at the surface of the produce. When a puff (0.2 s) of air, was focused on the surface of the onion, the indentation was dependent upon the pressure selected and used. A suitable air pressure was chosen by experiment to be 20 lbf/in.^{2}, whereby a reading of deformation could be received without breaking the skin of the onion. The same pressure was maintained throughout the study.

Since, in the study, comparisons were being made between onions, absolute units of firmness were not accumulated but rather units of measurement pertinent to the equipment. The readings were first of all taken in terms of volts read from a digital oscilloscope, representing the depth of indentation made by each puff of air. At the conversion of 1 volt = 1 mm deflection, the results were then noted in -mm, in order to indicate a reverse relationship between depth of indentation and firmness. An increase of indentation implied a reduction in firmness.

The onion varieties examined were as in Table 1, a short day group of onions.

Contessa, by Asgrow, is a hard pungent fresh market, short day, white, deep globe, early maturing onion tolerant to bolting. It is grown in Mexico.

Granex 33 by Asgrow, is a short day, sweet, oval, fairly early onion, typical of the Vidalia name.

IPA-3 by the ministry of Agriculture in Brazil is a long day, purple, flat globe, pungent, purple, known for its waxy leaves and resistance to thrips damage.

Nikita is a short day, sweet, globe onion suitable for processing , such as for onion rings.

Sweet Vidalia is a Granex type, short day, sweet onion.

Texas Grano 502 by Asgrow, is a short day, sweet, fresh market, mid maturing onion having a spinning top shape.

Texas Grano 1015 by Asgrow, is a short day, sweet, fresh market, late maturing onion having a spinning top shape, perhaps sweeter than 502 and resistant to pink root.

The indentation data was analyzed using PROC MIXED (Littell et al., 1996).

Results and discussion

Since only one reading was taken for each onion in the sample and the means generated of all values within the same cultivar so a bar graph has been used to display the data (Figure 2). the values of indentation have been presented as -mm since firmness has a reverse relationship to indentation. For purposes of discussion the remainder of the bar to -1 has been shaded to give the idea of relative firmness one cultivar with another even though the values do not have meaning. Contessa had the highest firmness or the smallest indentation. Granex 33, IPA-3, Sweet Vidalia and Texas Grano 502 had a lower firmness or greater indentation than Contessa and were similar to each other. Nikita and Texas Grano 1015 had the lowest firmness and were similar to each other. The mean values for indentation are given in Table 1 and clearly fall into three groups according to their significant differences.

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Table 1. Varieties of onions examined for firmness.

Cultivar	Mean indentation (mm)	
Contessa	0.4076	c
Granex 33	0.5633	b
IPA-3	0.5118	b
Nikita	0.6790	a
Sweet Vidalia	0.5359	b
Texas 502	0.5536	b
Texas 1015	0.6750	a
	LSD = 0.10215	

Note: Means with the same letter are not significantly different according to Fisher's LSD test (Steel and Torrie, 1960)(P = 0.05).

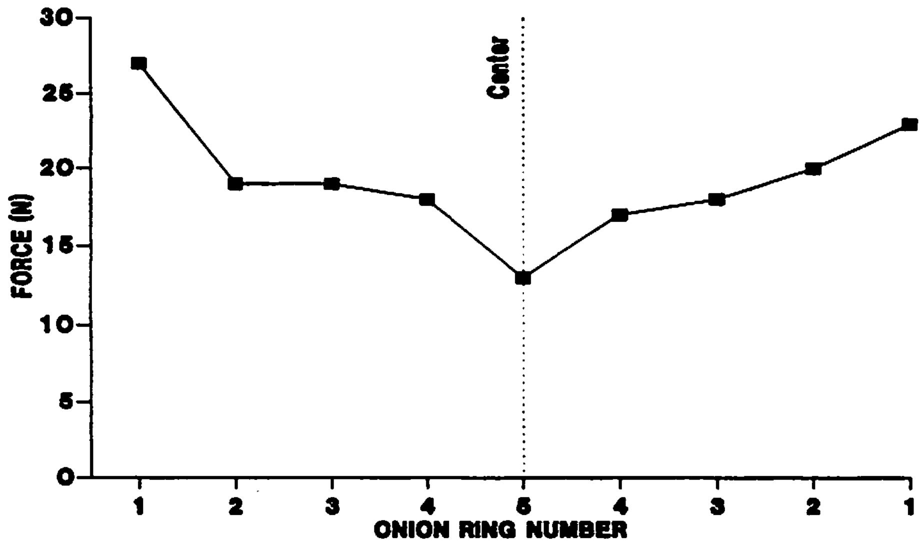


Figure 1. Puncture force distribution through successive onion rings, for fresh onions (Maw, et al., 1996).

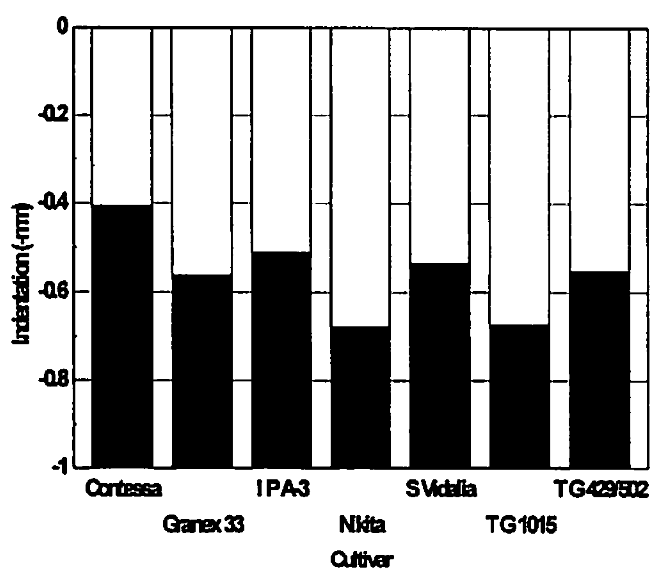


Figure 2. Laser puff firmness tests on onions.

ONION CULTIVAR RESPONSE TO THRIPS INFESTATION, 1999

David G. Riley, Research Entomologist
Dean Batal, Research Horticulturalist

Introduction

Work was continued in 1999, repeating the experiment that was done in 1998. The main focus of this research was to document how thrips affected bulb size and dollar value of the onion crop in various cultivars of onions. Based on previously published results, a seasonal average of 5 thrips per plant could result in a 8% decrease in jumbo-size onions. Last year's onion trial at the Coastal Plain Experiment Station averaged approximately 5 thrips per plant in the untreated plots and we observed a 18% decrease in dollar value across all onion cultivars in the untreated plots. Therefore, it appears that thrips can have a large effect on onion bulb size and value even at moderate thrips numbers that can occur in Georgia.

Thrips cause damage to onions by feeding on the leaf surface by rasping plant cells and feeding on plant sap. If thrips average over 5 per plant or occur in high enough numbers to noticeably injury leaf tissue prior to bulb formation, a significant reduction in onion bulb size can result. Also there have been reports of increased disease incidence, such as purple blotch, with high numbers of thrips. Based on observations in 1999, thrips in onions in Tift county occur in low numbers in January to February (<0.1-1 per plant), begin to increase in early March (1-5 per plant), and continues increase in late March and early April (15-50 per plant in 1999). Based on recent studies at Tifton, onion thrips, *Thrips tabaci* Lindeman, do occur, but in our test plots they have been in very low, nonsignificant numbers. Most of the thrips that have been found to reproduce on onions in the last few years in Tift County were western flower thrips, *Frankliniella occidentalis* (Pergande) and tobacco thrips, *F. fusca* (Figure 1). Thresholds for controlling thrips with insecticides vary with onion varieties, but a general rule of thumb is that action can be initiated when thrips occur at 1-5 thrips per plant in susceptible varieties. We conducted a cultivar response study in 1998 and 1999 to more accurately describe this relationship.

Materials and Method

In the spring of 1999, an experiment was conducted to evaluate five cultivars of onions, Granex 33, IPA-3, Contessa, Texas Grano 502, and Texas Grano 1015, under different levels of thrips pest pressure. Onions were seeded on October 12, 1998 with a Stanhay precision seeder. The experiment was arranged in a split plot design with main plots being insecticide treated and non-treated for thrips, and subplots consisting of the five cultivars. An insecticide application of Ammo plus Lannate was made on December 18, but efficacy against thrips was low. We then switched to Karate/Warrior 3.75 oz/acre plus Malathion 3 pt/acre in the treated plots beginning from January 11 to March 12 in 9 sprays. Thrips were counted in treated and untreated plots (Figure 2) and by cultivar (Figure 3). Thrips were counted on the plant, using a sample of 5 plants per plot per date. Onions were harvested from May 5 to May 26 depending on cultivar, dried, and graded by size categories. Dollar value was estimated using jumbo+large=$15/50lb bag, medium+small=$11/50lb bag, and all other categories culled.

Results

Thrips populations did not begin to increase until the middle of February, but by early March thrips were averaging over 5 per plant in most untreated plots (Figure 3). There was significantly fewer thrips on IPA-3 than other onion cultivars on February 16 and 23, suggesting that you can alter thrips pest pressure with this onion cultivar. IPA-3, a thrips-resistant red onions, had relatively low thrips through much of the season until near harvest (Figure 3). On onion foliage the species collected was 33% F. fusca, 57% F. occidentalis, and 13% immatures.

Yield was negatively impacted by the presence of thrips in onions based on reduced bulb size in the untreated plots (Table 1) and reduced dollar value (Table 2). Cultivar differences were significant in terms of bulb size, total weight of marketable bulbs, and dollar value. The dollar value was calculated based on a 28 ft section of 4 rows on a 6-ft bed so the $13.70 difference between treated and untreated Granex 33 represented a >$3,000 difference per acre. Even with the 10 applications of insecticide costing approximately $20-30 per acre, this represented a more than 10 fold return on the money spent. Examining the effect of thrips control on individual cultivars (Figure 4), revealed large effects on dollar value. Exceptions were the thrips-resistant cultivar, IPA-3, which produced as well with no insecticide treatment as expected, and Contessa, which also held up under this level of thrips pressure.

Discussion

This preliminary study demonstrated several important points relative to thrips management in onions in Georgia. First, if thrips occur in high enough numbers, >5 thrips per plant on the average, yields can be affected, particularly in terms of bulb size. Secondly, not all onion cultivars react the same to thrips infestation. Indeed, where there are cultivars with documented resistance to thrips, as is the case with IPA-3, any reduction of yield with moderately low thrips population levels may not be evident. The only quality factor measured in this preliminary test relative to insecticide treatments was bulb size which has a direct impact on the dollar value of the crop. The main treatment (insecticide vs. no-insecticide) did produce significant effects at the $P<0.05$ level in this test and the trend toward smaller bulb size in the untreated plots was clear. The effects of bulb size on quality, and the incidence of disease need to be further evaluated. Published reports indicate that increased thrips pressure can increase the incidence of certain disease, e.g., purple blotch.

The impact of thrips on onion production has been extensively reported in scientific literature, however, it is not well documented in Georgia. It is hoped the this research project will lead to a better understanding of the role of thrips in the pest complex in Georgia onion production systems. In 2000 we shall evaluate thresholds for thrips and insecticide efficacy to develop an efficient control program for this pest complex of onions in Georgia.

Table 1. The effects of insecticide treatment and onion cultivar on size of bulbs harvested in an onion trial at Tifton, GA in the spring of 1999.

Treatment	Jumbo bulbs	Large bulbs	Medium bulbs	Small bulbs
Treated	96a	41a	20.9a	9.1a
Untreated	74.3b	32.9a	21a	9.9a
Granex 33	125a	45a	27a	15a
Tx.Grano 502	116a	22b	12a	6b
Tx. Grano 1015	91b	36a	17a	14a
Contessa	84b	38a	19a	6b
IPA-3	10c	43a	29a	6b

* Means followed by the same letter are not significantly different (P>0.05, LSD test) and no letter indicates no significant treatment effect or too variable to detect.

Table 2. Damage, quality, and overall bulb yield results of an onion trial at Tifton, GA in the spring of 1999.

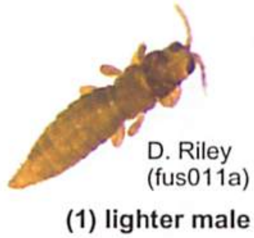
Treatment	Damaged bulbs	Marketable weight/25 ft.	Dollar value**
Treated	18a	137a	40a
Untreated	26a	112b	33b
tx. Grano 502	27a	173a	51a
Granex 33	9b	131b	39b
Tx. Grano 1015	27a	147ab	43ab
Contessa	39a	124b	37b
IPA-3	7b	48c	13c

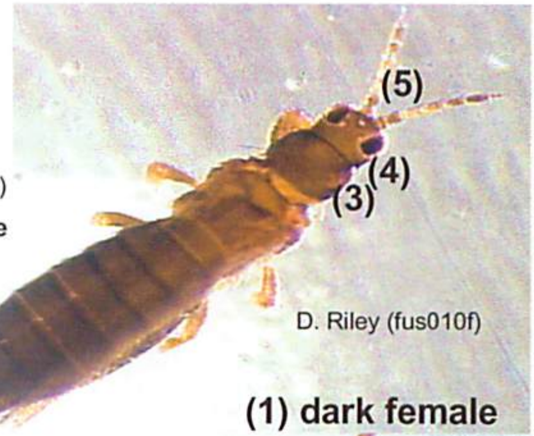
* Means followed by the same letter are not significantly different (P>0.05, LSD test) and no letter indicates no significant treatment effect or too variable to detect. ** Value based on jumbo+large=$15/50lb bag, medium+small=$11/50lb bag, and all other categories culled.

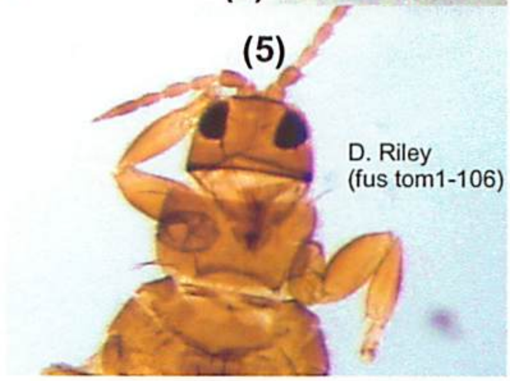
Tobacco Thrips

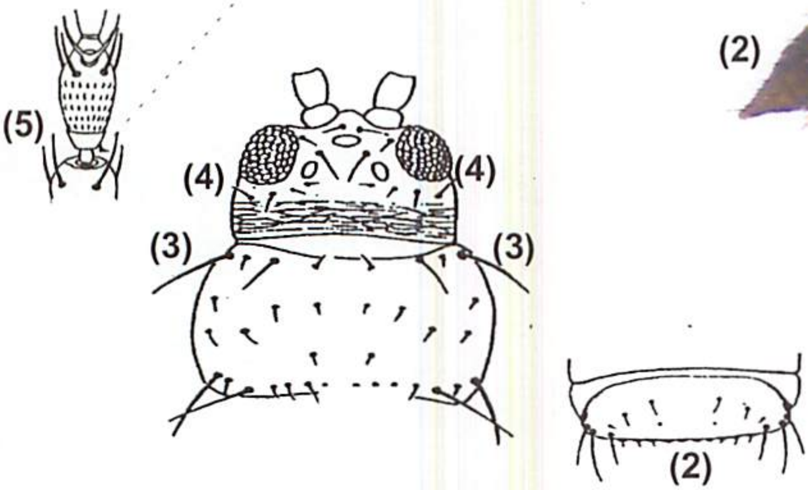
Frankliniella fusca (Hinds)

(1) mostly dark brown, males are lighter
(2) setal comb on posterior margin of 8th abdominal segment incomplete
(3) inside setae much shorter than outside setae on the front margin of the pronotum
(4) setae behind eyes not pronounced
(5) 8 antennal segments with pedicel of 3rd segment straight







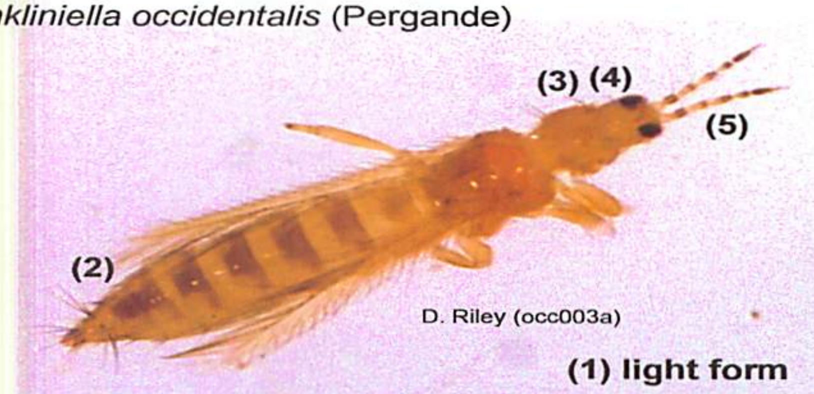


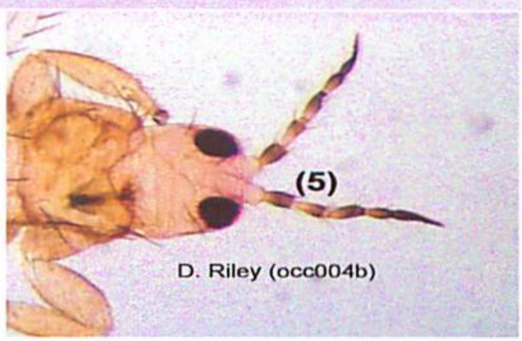
D. Riley (2000) CPES - Tifton, figures from Oetting et al. 1993

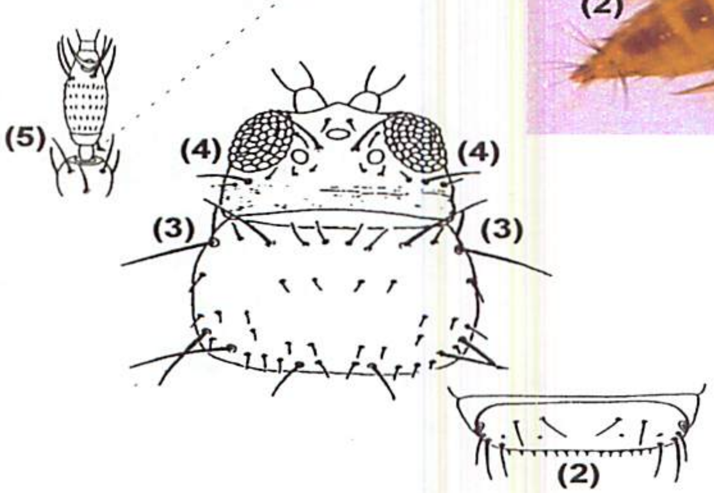
Western flower Thrips

Frankliniella occidentalis (Pergande)

(1) has light and dark color forms
(2) setal comb on posterior margin of 8th abdomenal segment complete
(3) main setae on front of pronotum equal length
(4) setae behind eyes strong
(5) 8 antennal segments with pedicel of 3rd segment straight







D. Riley (2000) CPES - Tifton, figures from Oetting et al. 1993

Figure 1. Identification of thrips.

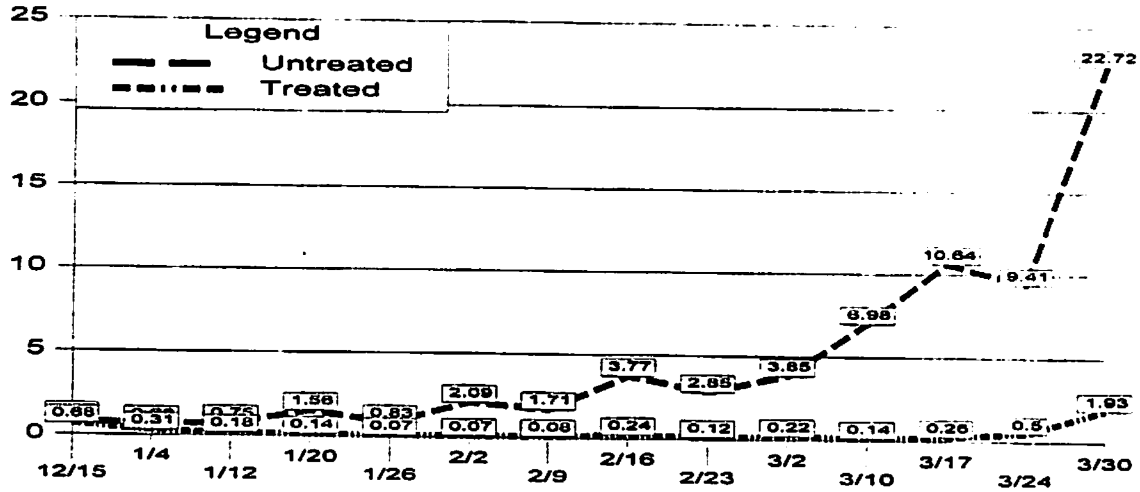


Figure 2. Number of thrips per plant over time in insecticide treated and untreated onion plots. Dates with significant treatment effects (P<0.05, LSD) were 1/4, 1/12, 2/9, 2/23, and afterwards.

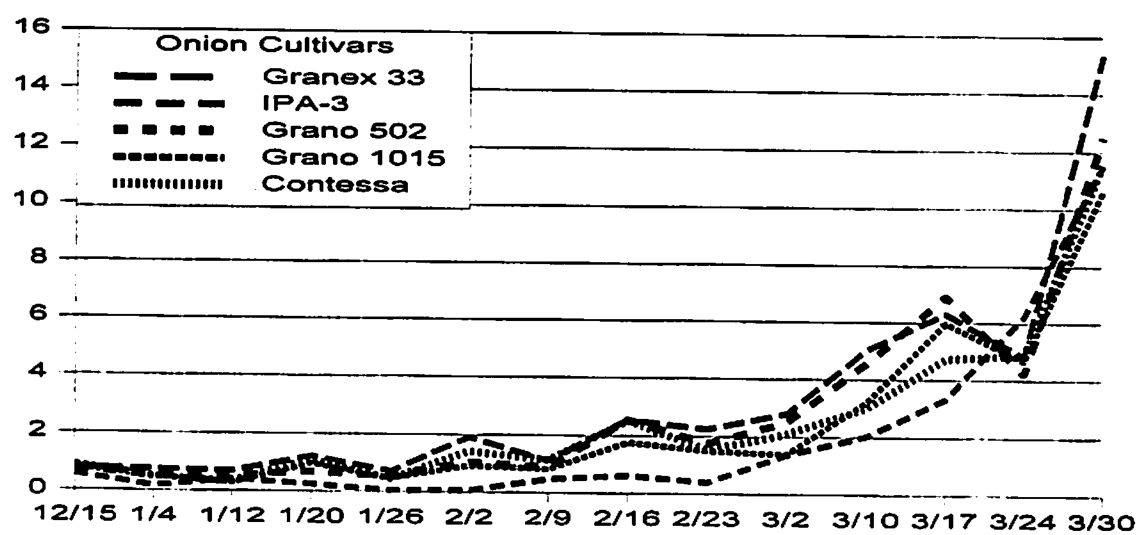


Figure 3. Thrips numbers by onion cultivar over time. Note that significant differences between cultivar treatments (P<0.05, LSD) occurred on 2/16 and 2/23.

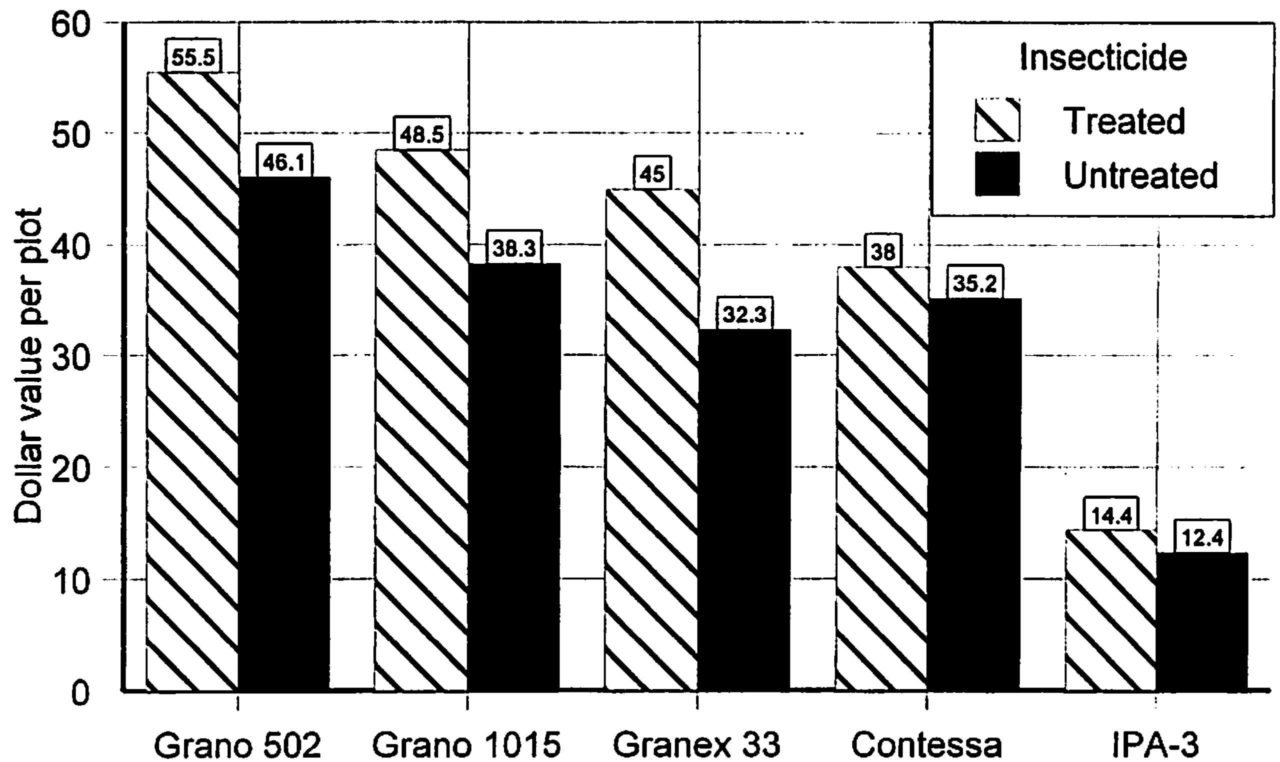


Figure 4. The effect of insecticide treatment for thrips control on individual onion cultivars.

CONTROL OF SOILBORNE PATHOGENS AND BULB ROT WITH SOIL FUMIGATION IN DIRECT-SEEDED SWEET ONION, 1998-1999

Donald R. Sumner, Research Plant Pathologist, Retired

Materials and Methods

The field of Tifton loamy sand at the Blackshank farm had been planted in an onion-soybean rotation since the fall of 1994. Soybeans were mowed and disk-harrowed in mid August, and the residues deep-turned with a moldboard plow. Raised beds 6 ft wide were prepared and rototilled before fumigation. A randomized complete block design with five replications was used. The experimental design was the same as in 1997, and the plots were remeasured from a benchmark, and all treatments were applied to the same plots as in 1997. Each plot was 50 feet long and 12 ft (two beds) wide, with an untreated alley 10 ft wide between plots. Plots were fumigated September 14, 1998 with Telone II (10 gal/A), Telone C-17 (15 gal/A), Vapam HL (42% metam sodium, 50 gal./A), Sectagon (42% metam sodium, 50 gal/A), Telone C-17 (15 gal/A) + Vapam HL (50 gal/A), and Telone C-17 (15 gal/A) + Sectagon (50 gal/A); control plots were not fumigated. Telone II and Telone C-17 were injected 8-10 in. deep with chisels 10 in. apart. Sectagon and Vapam HL were sprayed on the soil surface with a machine that incorporated the fumigant 4-6 inches deep with a power-driven rototiller. When Telone C-17 and Vapam HL or Sectagon were both applied in the same treatment, Telone C-17 was injected first, and then Vapam HL or Sectagon was applied.

All plots were irrigated with 0.5 in. through overhead sprinklers after fumigation was completed. On October 7 fertilizer was broadcast (1000 lbs/A 5-10-15) and incorporated with a rototiller, and beds were direct seeded with Granex 33 onion. A Stanhay planter was used to plant four double rows per bed with seeds spaced 3 in. apart (116,160 seeds/A) in the alternate rows. Dacthal was applied immediately after planting, and the plots were irrigated. Soil samples were taken (10 cores, 4 in. deep, 1 inch in diameter) in each plot 30 days after fumigation. Soil was assayed for *Pythium* spp., *Rhizoctonia solani*, *Fusarium* spp., the pink-root pathogen (*Phoma terristris*), and several soil-inhabiting saprophytic fungi.

Plots were top dressed with 300 lb/A 15-0-14 December 4; and 200 lb/A February 4, March 4, and April 2nd. Goal was applied for weed control November 18 and again January 28, and Karate + malathion was applied to control thrips March 19th. The foliar fungicides Rovral or Bravo 720 were applied every 7-15 days from January 22 through April 22nd. Plots were irrigated to prevent drought from planting until harvest.

Plants in five 3.3 ft sections of row in the right bed of each plot were counted weekly from 2 through 5 weeks, and at 10 and 14 weeks after planting. On May 13 (when approximately 10% of the tops were down), the middle 15 ft of the middle two rows of the right bed in each plot were lifted by hand with a fork. It rained the next day, and plants were allowed to dry in the field for an additional 3 days. May 14, five plants adjacent to each end of the yield area in each plot were dug and evaluated for symptoms of pink root and other external symptoms of root and bulb rot. May 17 bulbs were harvested, cured in onion bags for 68 hrs at 99 F with forced air, weighed, graded into jumbo, large, medium, small, and nonsalable (misshapen or decayed) bulbs, and each category weighed and counted. After grading 25 marketable jumbo or large bulbs from each plot were placed into cold storage at 34 F, and May 24 controlled atmospheric (CA) conditions of 3 % O_2, 5 % CO_2, and 92 % N were established. An additional 10 marketable bulbs from each plot were cut and rated for internal discoloration and decay May 25, and fungi were isolated and identified from discolored or decayed tissues.

The CA storage conditions were discontinued August 24, and bulbs were left in the unit in cold storage at 34 F until August 31, when they were removed, cut, and rated for discoloration and decay. Fungi were isolated and identified from discolored or decayed tissues.

All data were analyzed with SAS using PROC ANOVA or PROC GLM statistical programs. Fisher's least significant difference ($P = 0.05$) test was used for means separation. Data were transformed as necessary (square root transformations for small numbers [$<$ 100], log 10 for large numbers [$>$ 100], or arcsin transformations for percents) for statistical analysis, but all data are reported as nontransformed values.

Results and Discussion

Fumigation with Telone II, Sectagon, Vapam HL, Telone C-17, Telone C-17 + Sectagon, and Telone C-17 + Vapam HL significantly reduced population densities of *Pythium* spp. in soil, compared with the nonfumigated control (Table 1). Telone C-17 + Sectagon, and Telone C-17 + Vapam HL reduced population densities of *Fusarium solani* and total saprophytic fungi, but none of the fumigation treatments reduced population densities of *Trichoderma* spp. Population densities of *P. terristris* and *Rhizoctonia solani* were apparently very low, and were not detected in soil in any plot.

Plant stands were improved by Telone II. Telone C-17, and Sectagon treatments 21 days after planting, compared with the nonfumigated control, but there were no significant differences in plant stands among treatments after that (Table 2). Post-emergence damping-off was low to moderate, and there were no significant differences among treatments. November 17 weed cover was reduced in all plots by soil fumigation compared with the control, but Telone C-17 + Sectagon and Telone C-17 + Vapam HL reduced weed cover the most (Table 2). Goal was applied to control weeds November 18 and January 28. February 10 all fumigated treatments had low weed cover compared with the control, but Vapam HL, Telone C-17 + Sectagon and Telone C-17 + Vapam HL reduced weed cover the most (Table 2).

Only 16 % of the plants in the control plots dug May 14 had visible symptoms of pink-rot, and none had more than slight (10% of the root system discolored) pink root. At harvest, only 0.5 % of the plants had seedheads, and only 0.2% of the bulbs had external symptoms of bulb rot. However, after curing and grading, 18 5 % of the bulbs were decayed or misshapen and nonsalable. There were no significant differences among treatments in the percentage of bulbs decayed, in the percentage of the number of the bulbs jumbo, or in the percentage of the number or weight of large plus jumbo bulbs. Soil fumigation with Vapam HL, Telone C-17 + Sectagon and Telone C-17 + Vapam HL increased yield of jumbo bulbs, but none of the fumigation treatments increased the total yield of marketable bulbs significantly (Table 3) .

When 10-bulb samples of marketable bulbs from each plot were removed and cut after grading, very few of the bulbs had symptoms of internal discoloration or decay. *Aspergillus niger*, the black mold pathogen, was isolated from one bulb, but no other fungi were isolated. In the 25-bulb samples from each plot removed from CA storage August 24, 12 % of the bulbs had symptoms of external discoloration and decay and 25.5 % had symptoms of internal discoloration and decay. The primary kinds of symptoms were neck rot (caused primarily by *B. allii*, 15.2 %), and watery soft rot (caused primarily by bacterial pathogens, 14.1 %). The fungi isolated most frequently from decayed bulbs were *B. allii* (3.1 %) and *Penicillium* spp. (0.2%). There was significantly more watery soft rot in bulbs in the Telone C-17 + Vapam HL treatment (33.6 %) than in bulbs in the control treatment (8 %), but bulb decay in other fumigation treatments was not different than in the control treatment. There were no significant differences among treatments in the numbers of cultures of fungi isolated from decayed bulbs.

Table 1. Population densities of fungi in soil 30 days after fumigation, October 14, 1998.

Treatment[x]	Rate/A (gal)	Phoma[y] terristris	Pythium spp.	Fusarium solani	Trichoderma spp.	Total fungi
Telone II	10	0	41 b[z]	1,927 a	3,855 a	91,368 a
Telone C-17	15	0	58 b	532 a	2,313 ab	28,142 abc
Vapam HL	50	0	9 bc	1,046 a	385 b	117,969 a
Sectagon	50	0	41 bc	606 ab	385 b	68,623 a
Telone C-17 + Sectagon	15 + 50	0	13 bc	294 bc	771 ab	17,348 bc
Telone C-17 + Vapam HL	15 + 50	0	0 c	18 c	0 b	9,252 c
Control	-	0	117 a	2,808 a	1,157 ab	79,802 a

[x] Formulations: Telone II = 94% 1,3 dichloro propene (D), Telone C-17 = 78% 1,3 D + 17% chloropicrin; Sectagon and Vapam HL = 42% metam sodium.

[Y] Phoma terristris causes pink root; population densities of all fungi are in colony forming units/g of soil.

[z] Numbers in columns followed by different letters are different according to t-tests (Fisher's LSD) P = 0.05. No letters indicates no significant differences.

Table 2. Plant stands and root disease severity in onion direct seeded into fumigated soil, 1998-1999.

Treatment[w]	Rate/A (gal)	Plants/16.4 ft of row days after planting: 21	37	100	Post-emergence damping-off (%)	Weed[x] cover, Nov. 17, (%)	Weed[x] cover, Feb. 10, (%)
Telone II	10	48 a[z]	49	45	13.7	20 b	6.6 b
Telone C-17	15	47 a	44	42	13.5	19 b	6.1 b
Vapam HL	50	42 b	46	43	11.8	13 bc	0.6 cd
Sectagon	50	47 a	45	45	7.4	20 b	3.9 bc
Telone C-17 + Sectagon	15 + 50	42 b	41	38	16.6	13 bc	1.0 cd
Telone C-17 + Vapam HL	15 + 50	45 ab	41	45	6.7	11 c	0.3 d
Control	-	41 b	41	42	8.0	31 a	17.0 a

[w] Formulations: Telone II = 94% 1,3 dichloro propene (D), Telone C-17 = 78% 1,3 D + 17% chloropicrin; Sectagon and Vapam HL = 42% metam sodium.

[x] Estimated percentage of plot area with visual green weed cover.

[z] Numbers in columns followed by different letters are different according to t-tests (Fisher's LSD), P = 0.05. No letters indicates data was not analyzed statistically.

Table 3. Root disease, seed heads, harvestable plants and yield of bulbs, May 17, 1999

Treatment[x]	Rate/A (gal)	Plants with pink root [y] (%)	Plants with root disease [y] (%)	Seed heads (%)	Harvestable plants 45 ft^2	Total yield 50 lb bags/A	Jumbo bulbs 50 lb bags/A
Telone II	10	0	0	0.0	66	662	231 abc[z]
Telone C-17	15	6	6	0.9	72	701	166 bc
Vapam HL	50	0	0	0.3	70	860	342 a
Sectagon	50	4	4	0.8	74	819	241 abc
Telone C-17 + Sectagon	15 + 50	4	4	1.4	80	880	291 ab
Telone C-17 + Vapam HL	15 + 50	0	0	0	77	814	309 a
Control	-	16	16	0	64	665	165 c

[x] Formulations: Telone II = 94% 1,3 dichloro propene (D), Telone C-17 = 78% 1,3 D + 17% chloropicrin; Sectagon and Vapam HL = 42% metam sodium.

[y] Plants with slight (>1% but < 10 %) root discoloration and decay. No plants had more than slight discoloration and decay.

[z] Numbers in columns followed by different letters are different according to t-tests (Fisher's LSD), P = 0.05. No letters indicates no significant differences.

X-RAY IMAGING FOR CLASSIFYING FOOD PRODUCTS BASED ON INTERNAL DEFECTS

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Introduction

X-ray line scan imaging was used to detect internal defects in apples and onions. Noise removal is the first step performed in an image analyses based classification system.

Materials and Methods

A noise filter was designed based on image noise analyses. Low correlation between the noise and the signal indicated that the noise present in x-ray images can be treated as the Gaussian noise.

Results and Discussion

Selected image features correlated well with the respective defects both for apples and onions.

Summary and Conclusions

The following conclusions may be drawn from the results obtained in this research.

* X-ray line scan imaging can be used for detecting internal defects in apples (watercore, old bruises) and onions (ring decay, ring separation, internal sprouting). Detection of new bruises in apples with line scan imaging, however, was not very successful.
* Gaussian filters can be used for noise removal from x-ray line scan images. A 5x5 mask was found suitable for detecting bruise features in apples and defect features in onions). No filtering is needed for extracting watercore features using morphological operations.
* Combined spatial and DCT features provided good indicators of defects in apples and onions. Figure 1 below shows onions before processing. Figure 2 shows onions after processing. Morphological and discrete cosine transforms were applied to Figure 2.Three image features (mean gray value, fruit area after morphologicalopening, and DCT10) successfully classified apples based on watercore. Four image features (edge length and 3 DCT coefficients) were required for apple classification based on old bruises. For new bruise, spatial features did not prove to be useful indicators. Seven DCT coefficients were selected as the major contributors but accuracy of classification was low. Onion classification required 12 image features (2 spatial features and 10 DCT coefficients).
* Neural network classifiers performed better than both the fuzzy logic and the Bayesian classifiers in terms of higher accuracy as well as lower losses and false positives. Fuzzy logic performed as well as the Bayesian, however, difficulty involved in tuning the model is a limiting factor. With the neural network classifiers, classification accuracy approached 90% both for apples and onions.

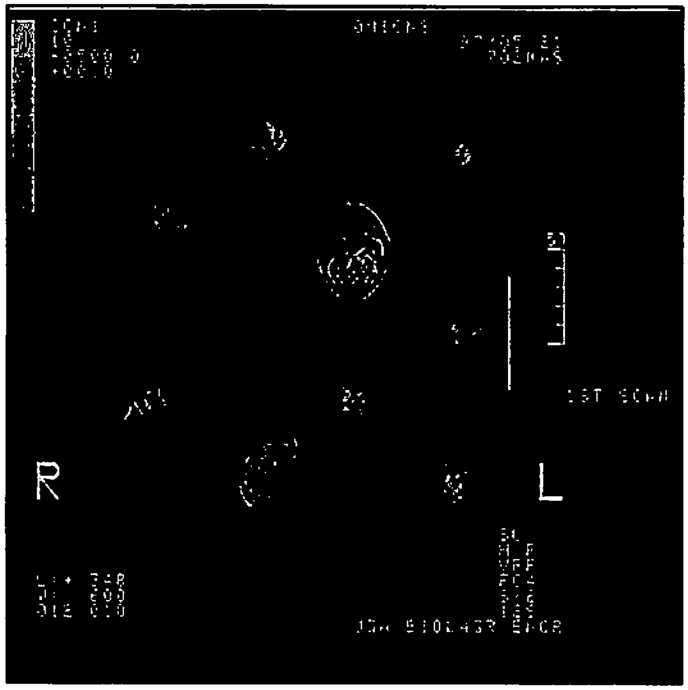

Figure 1. Original line scan image of onions. Dark features indicate defects.

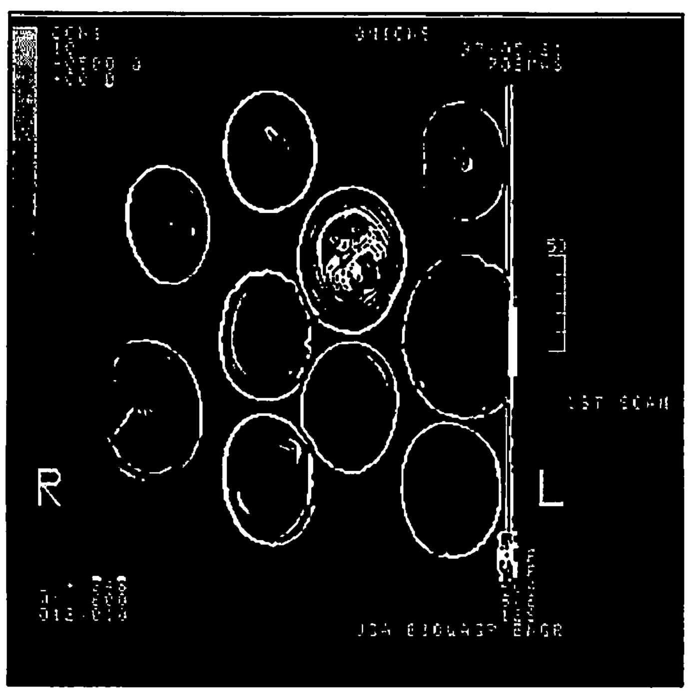

Figure 2. Processed image showing features of good and defected onions. Bright arcs/lines inside bulb boundary indicate defects.

MANKOCIDE TOLERANCE EVALUATION ON VIDALIA SWEET ONION SEEDLINGS

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Introduction

There have been documented cases of foliar injury due to the application of fixed copper compounds on a number of crops, including onions. In the Vidalia onion production area, there have been instances over the years where foliar burn occurred as well. This phytotoxic response resulted in a drastic reduction in the use of copper materials in the area by local growers. However, the more recent problems with the devastating bacterial diseases in Georgia onions has required producers to return to extensive use of the copper compounds in combination with mancozeb. This past fall an outbreak of Pantoea annanas in onion plant beds resulted in widespread use of the aforementioned combination of materials in an effort to limit the effects of the pathogen. I was alerted to one case of copper toxicity in onion plant beds, and injury was particularly evident at the ends of the rows where more material was likely applied. There was an obvious burn on the foliage of onion, Texas panicum, and sicklepod. In an effort to duplicate such injury, I designed a test using the same product, Mankocide, as was used on this farm.

Materials and Methods

Mankocide is a commonly used prepackaged material containing copper and mancozeb. It contains 15% mancozeb and 46.1% copper hydroxide (a 30% metallic copper equivalent). The rate range for bacterial infections is 1.5 - 2.25 lbs. of material per acre. The lower rate is recommended on smaller onions such as those grown on a plant bed. Plots were set up in a field of plant beds where onions were approximately four inches tall with an average of three leaves per plant. Plots were each 50 feet long and 5 rows wide. Rates were applied at a standard 2 pounds per acre, a 2X rate of 4 pounds per acre, and a 4X rate of 8 pounds per acre. Each was applied in 18 gallons of water per acre. Applications were made on October 22nd during the middle of the day. The weather was clear with daytime high temperatures in the 80's.

Results

Treatments were evaluated on October 28th. There was no detectable difference across the treated plots in comparison to the untreated area around the plots. No phytotoxic symptoms were evident. There may be very specific environmental conditions that make injury from copper compounds more likely.

EVALUATION OF NEEM OIL FOR THRIPS CONTROL IN VIDALIA SWEET ONIONS

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Introduction

Neem oil has been promoted for a number of crops as a broad spectrum fungicide, as well as an insect suppression product. Trilogy, a brand name product containing 70% clarified hydrophobic extract of neem oil, has a label for several pests that are important to onions. It is labeled for the suppression of thrips, which cause considerable injury to onions in Georgia, and lists a number of diseases prevalent in the Vidalia Onion production area. Labeled diseases include Alternaria, Botrytis, and Downy Mildew. Some area growers had been using the material, but no data had been generated regarding it's effectiveness on these pests. Additionally, there was some question as to whether the neem oil would have an adverse effect on the waxy cuticle of the onion leaf, which helps protect the onion from bacterial infections, specifically Pseudomonas and Pantoea species.

Materials and Methods

'Sweet Vidalia' onions were transplanted December 1, 1998 at a plant population of about 70,000 plants per acre. Soil tests taken November 16th indicated 1000 pounds of dolomitic lime and 130-40-120 for N-P-K were needed per acre. Extension recommendations also call for 40-60 lbs/A sulfur. Dolomitic lime was applied as recommended. The fertility program consisted of 200 lbs/A of 18-46-0 on Dec. 12th, 370 lbs/A 6-12-18 on Jan.11th, 280 lbs/A 6-18-18 on Jan.27th, 170 lbs/A $CaNO_3$ on Feb. 12th, and 180 lbs/A $CaNO_3$ on March 1st. The total fertility level was 129 N, 187 P_2O_5, 117 K_2O, and 35 lbs/A sulfur.

No fungicide or insecticide treatments were applied during the growing season. A replicated trial of 2 treatments and 4 replications arranged in a randomized complete block design was conducted. The plots were 25 feet long and 6 feet wide. One treatment was Trilogy applied at a rate equivalent to 1 qt./A in 40 gallons of water at 65 psi. The second was an untreated check. Applications were made on the following dates: Feb. 1st, Feb. 8th, Feb. 15th, March 1st, March 16th, and March 29th.

Results and discussion

Thrips counts were made on March 1st, using 10 plants in a row in two locations within each replication. Counts averaged 8.5 thrips per ten plants in the treated plots, and 8.3 thrips in the control. An additional assessment was made on April 12th, counting thrips on 10 plants in a row per plot. There was an average of 523.6 thrips per 10 plants in the Trilogy treated plots, and an average of 429.5 thrips per 10 plants in the untreated control.

On April 14th assessments were made on the effect of Trilogy on the labeled pathogens that infect onions. There was no mildew in any of the plots. Botrytis and Alternaria lesions were rated based on visual interpretation of severity and counts of lesions to support the accuracy of the interpretation. Plots were rated on a scale of 1-10 with 10 being the most severe infection. The Trilogy plots averaged 2.8 on the scale for Botrytis leaf blight, while the control averaged 4.0 across the test. In the Alternaria (Purple Blotch) ratings the Trilogy treatments averaged 3.0, while the control averaged 1.75 per plot.

To determine whether neem oil may have an adverse effect on the waxy cuticle and the plants ability to resist bacterial infections, the number of plants infected with bacterial diseases within each plot were counted on April 14th. There was an average of 3.7 infected plants per plot in the Trilogy treatments, and an average of 3.5 infected plants in each control plot.

Trilogy had no apparent benefit for the control of thrips at any point during the test. Most of the thrips were found under folded leaves where the tip had collapsed which makes it very difficult to control these pests. While some suppression of Botrytis was assessed, it was of minimal consequence. Alternaria incidence did not differ statistically between treated and untreated plots. In answering the question of the effect of neem oil on the leaf cuticle and any possible relationship between it's use and bacterial infections, there was none. The average percent infection across the plots was virtually the same regardless of treatments. Therefore, Trilogy is not predisposing plants to bacterial infections. Neem oil did not do anyapparent harm to the plants, but neither did it show any particular benefit.