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Stored Short Day Onions are Adversely Affected by High Preharvest Levels of Purple Blotch and Thrips

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ABSTRACT

Preharvest infection by *Alternaria porri* (Ellis), causal agent of purple blotch, or infestation by thrips (*Thrips tabaci* L.) can greatly reduce yields of short-day onion (*Allium cepa* cv. 'Texas Grano 1015Y'), but their effects on postharvest quality are unknown. In this study, onions were treated during the production season for control of thrips and purple blotch (treated), control of thrips but not purple blotch, control of purple blotch but not thrips, or not controlled for thrips or purple blotch (untreated). Plants from treatments not having controlled thrips or purple blotch or both had reduced bulb yields compared to control (treated) plants. Bulb size was reduced in onions not treated for purple blotch and thrips compared to other treatments. Harvested onions stored at 13°C for 4 weeks were evaluated for quality and chemical composition before and after storage. Following storage, medium and extra large onions subjected to high levels of both purple blotch and thrips before harvest had more weight loss compared to onions where purple blotch and thrips had been controlled. Onion sweetness declined during storage for all sizes and was generally lower in bulbs from treatments with high purple blotch or from thrips + purple blotch treatments. Pungency was initially higher in medium sized onions. Pungency increased during storage, particularly in large and extra-large onions, but was not different among treatments. Results indicate that onions subjected to a high incidence of both purple blotch and thrips in the field are of poorer quality at harvest and that quality is further reduced following storage compared to noninfected onions.

RESUMEN

La infección precosecha por *Altenaria porri* (Ellis), el agente causal de la mancha púrpura de la cebolla, o la infestación por trips (*Thrips tabaci* L.) pueden reducir considerablemente el rendimiento de la cebolla de día corto (*Allium cepa* cv. 'Texas Grano 1015Y'), pero sus efectos en la calidad en postcosecha son desconocidos. En este estudio, las cebollas se trataron durante la estación de producción para controlar los trips y la mancha púrpura (tratadas), se trataron para controlar los trips pero no la mancha púrpura, se trataron para controlar la mancha púrpura pero no los trips o no recibieron ningún control ni para trips ni para la mancha púrpura (no tratadas). En las plantas de aquellos tratamientos en que los trips, la mancha púrpura o ambos no fueron controlados se presentó una reducción en la cosecha de bulbos en comparación con las plantas control (tratadas). El tamaño del bulbo se redujo en las cebollas en las que no se controló ni a la mancha púrpura ni a los trips en comparación con los otros tratamientos. Se evaluó la calidad y la composición química de las cebollas cosechadas antes y después de ser almacenadas a 13 °C por 4 semanas. Después del almacenamiento, las cebollas medianas y extra grandes que estuvieron expuestas a altos niveles tanto de mancha púrpura como de trips antes de la cosecha presentaron mayor pérdida de peso en comparación con las cebollas en las que la mancha púrpura y los trips fueron controlados. La dulzura de las cebollas de todos los tamaños disminuyó durante el almacenamiento y fue generalmente más baja en los bulbos de los tratamientos con alta incidencia de mancha púrpura o provenientes de los tratamientos con trips + mancha púrpura. La naturaleza picante fue inicialmente mayor en las cebollas de tamaño medio. La naturaleza picante aumentó durante el almacenamiento, particularmente en las cebollas grandes y extra grandes, pero no varió entre los tratamientos. Los resultados indicaron que las cebollas sometidas a una alta incidencia en campo tanto de mancha púrpura como de trips son de menor calidad al momento de la cosecha y esta calidad se ve adicionalmente reducida durante el almacenamiento en comparación con las cebollas no infectadas.

Short-day or sweet onions are in high demand due to their mild pungency and high sugar content. These onions are a valuable agricultural crop and accounted for $80 million in sales in Texas in 1995 (personal communication, Texas Agric. Statistics Service, Austin, TX). Extra large sweet onions command premium prices while small onions are excluded from sale by the Texas onion marketing order (Anon., 1988). Reduced yields of short-day onions, caused by decreased bulb

Table 1. Pest effects on yield and distribution of onion sizes after harvest, 1990[z].

Preharvest incidence	$\bar{x}$ seasonal damage• onion plant[-1x] Thrips	Purple Blotch	Total yield	Bulb diameter (cm)[y] Small	Medium	Large	Extra-large
			(kg•ha[-1] x 10[3])	(% onions per size)			
Treated (No pests)	2a	12.0a	57.3a	9a	20a	46a	25a
Purple blotch	3a	49.4b	43.1b	15a	25a	46a	14b
Thrips	40b	28.6a	45.5b	11a	25a	47a	17b
Thrips + purple blotch	60b	54.9b	32.6c	34b	28a	35b	3c

[z]Interaction of size x treatment significant, P<0.001. Means are separated within columns by LSD, P<0.05.
[x]Thrips damage represents seasonal average; purple blotch damage represents lesions present on plant one week before harvest.
[y]Small diameter is <5 cm; medium diameter is 5 to 7 cm; large is 7.5 to 9.5 cm and extra large is >10 cm.

size and/or plant loss, often result from thrips *(Thrips tabaci* L.) insect feeding damage on leaves and from the foliar disease purple blotch (Edelson et al., 1986; Miller et al., 1986). Thrips populations of >5 thrips•plant[-1] decreases onions bulb size and high thrips thresholds (>15•plant[-1]) can reduce onion yields by 40% (Edelson et al., 1986). Purple blotch (*Alternaria porri* (Ellis)) is an opportunistic fungus in onions, invading leaves at stomatal or injury sites (Maude, 1983) and can reduce onion yields in south Texas when environmental conditions enhance pest populations (Miller et al., 1986). McKenzie et al. (1993) demonstrated that the severity levels of purple blotch increased with increasing thrips populations. The subsequent effects of these organisms on onion harvest quality and postharvest shelf life are unknown. The objective of our experiment was to determine the effects of high preharvest levels of thrips and/or purple blotch on onion yield and quality before and after storage.

MATERIALS AND METHODS

Field Plot Experiments

'Texas Grano 1015Y' onions were grown in plots at the Texas A&M Research & Extension Center at Weslaco, Texas (est. 26% latitude) in 1990 following recommended cultural practices. Plots consisted of four, 102- cm beds, 6.1 M long with two rows of plants per bed, and 7.6 cm spacing between plants. Plots were arranged in a randomized complete block using a factorial arrangement of treatments with four replications per treatment.

Treatments. Two factors, thrips population and purple blotch severity, were maintained at low and high levels in a factorial combination. Treatments were as follows: 1) control of both purple blotch and thrips (treated); 2) control of purple blotch but not thrips; 3) control of thrips but not purple blotch; 4) no control of purple blotch or thrips (untreated). Purple blotch (PB) severity levels were maintained by 10 weekly

Table 2. Effect of pest pressure and bulb size on mean percentage onions with *Aspergillus niger* and percentage weight loss.

Preharvest incidence and size[z]	*A. niger* Week 0	Week 4	Weight loss per bulb Week 4
	(%)		
		Medium	
Treated (low pests or control)	47a	62ab*	1.8a
High purple blotch, low thrips	36a	52a*	2.0ab
High thrips, low purple blotch	44a	70bc*	2.4bc
High thrips+purple blotch	61b	73c	2.7c
		Large	
Treated (low pests or control)	55a	78a*	1.5a
High purple blotch, low thrips	44a	71a*	1.9b
High thrips, low purple blotch	51a	81a**	1.5a
High thrips+purple blotch	66a	76a	1.8ab
		Extra Large	
Treated (low pests or control)	66a	77a	1.5a
High purple blotch, low thrips	63a	78a*	1.6a
High thrips, low purple blotch	64a	74a	1.5a
High thrips+purple blotch	71a	73a	2.1b

[z]Interactions of size x week storage and size x treatment significant, P≤0.05.
Treated onions were sprayed with pesticides to control purple blotch and thrips.
Means separated within column and size by LSD, P≤0.05. Significance between weeks indicated by *, **; P≤0.05, 0.01 respectively.

Table 3. Changes in sweetness (%SSC) and pungency (μmol/g pyruvate) in 'Texas Grano 1015Y' onions during storage as affected by preharvest pest pressure and blub size.

Preharvest incidence and Size[z]	SSC Week 0	SSC Week 4	Pyruvate Week 0	Pyruvate Week 4
	-----(%)-----			
Medium				
Treated (low pests or control)	7.3a	5.0a**	4.8b	5.1a
High purple blotch, low thrips	6.2a	5.1a**	4.9b	5.5a
High thrips, low purple blotch	7.1a	5.0a**	4.8b	5.4a
High thrips+purple blotch	6.2a	4.8a**	3.5a	5.1a**
Large				
Treated (low pests or control)	6.4b	5.1ab*	2.8a	4.2a**
High purple blotch, low thrips	6.4b	5.0bc**	2.7a	4.6a**
High thrips, low purple blotch	7.2a	5.4a*	4.2b	4.7a*
High thrips+purple blotch	6.1b	4.6c**	3.2a	4.4a**
Extra Large				
Treated (low pests or control)	7.2a	5.1a*	3.2b	4.5a**
High purple blotch, low thrips	6.5b	4.5b*	2.6a	4.2a**
High thrips, low purple blotch	7.2a	5.0ab*	3.5b	4.4a*
High thrips+purple blotch	6.5b	4.9ab**	3.4b	4.5a*

[z]Treated onions were sprayed with pesticides to control purple blotch and thrips.
Interaction of size x treatment significant at P≤0.05. Means within columns within a size category with different letters are significantly different by LSD (P≤0.05). Significance between weeks indicated by *, **; P≤0.05, 0.01 respectively.

treatments of either iprodione at 1.12 kg active ingredient (ai)/ha (low PB) or no fungicide (high PB). Thrips (TH) population levels were maintained as follows: cypermethrin at 89.7 ai·ha^{-1} + endosulfan at 1.12 kg ai·ha^{-1} when populations reached 0-5·plant^{-1} (low TH) or no insecticides (high TH).

Thrips infestations were monitored by examining three arbitrarily selected plants per plot for 10 weeks and recording the number of adult and larval thrips. The progression of purple blotch was monitored by examining five arbitrarily selected plants for 10 weeks. Percentage tissue damage was determined by measuring total leaf length, lesion length, and dividing leaf length by lesion length.

Postharvest material

Onions were harvested when approximately 50% of the tops had fallen over. The onions were placed in cardboard onion boxes and cured for 7 days at approximately 30°C in a ventilated shed at Weslaco while awaiting transport to Lane, Oklahoma.

Approximately 1.6 MT of the above onions were transported by truck from Weslaco, Texas, to Lane, Oklahoma. Only the commercially important grades of medium (5 to 7 cm diam., 150-175 g), large (7.5 to 9.5 cm diam., 225-275 g) and extra large (>10 cm diam., 325-400 g) onions were used for analyses (Anon., 1988). Onions were stored in cardboard onion boxes (0.3x0.2x0.3 m) arranged on palettes in a split plot design with size as main plot and treatment as subplot. Onions were held at 13°C, 65% RH for 4 weeks, following recommendations for Texas sweet onions (Yoo et al., 1989).

Appearance. Onions were weighed and rated for the visual presence of the disease-causing pathogens *Aspergillus niger*, *Botrytis* sp., *Alternaria* sp., *Fusarium* sp., *Penicillium* sp. and for visible sprouting and rooting before and after storage.

Compositional analysis. Compositional measurements of percentage soluble solids concentration (%SSC), titratible acidity (%TA) and pungency were assessed before and after storage for each size category using four onions per replication per treatment (16 onions per treatment). Onions were cut in half longitudinally through the shoot and root zones. A 10 g sample was removed from the center layers using a 4 cm diameter cork borer, homogenized with 10 ml distilled water for 30 seconds in a Waring Blendor, and the slurry centrifuged at 5°C, 12,000 xg for 15 min. About 0.5 ml of supernatant was placed on an Abbe 3-L refractometer to determine %SSC. Ten ml of supernatant was diluted with 90 ml water, titrated to a final pH of 8.1 and titratable acidity (TA) expressed as % citric acid. Pungency was determined from previously frozen supernatant by measuring enzymatic pyruvate conversion, following the methods of Mikitzel and Fellman (1994) and Yoo et al. (1995).

Statistics

Yield data were analyzed with analysis of variance for a factorial design. Postharvest data were analyzed with analysis of variance for a split plot design. Pest treatment levels were whole plots, bulb sizes were sub plots, and storage intervals were sub, sub plots. Means were separated among size, treatment and storage intervals by LSD, P≤0.05.

RESULTS AND DISCUSSION

Size distribution

When both thrips and purple blotch were controlled (no pests), total yield and percent extra large bulbs were highest compared to all purple blotch/thrips combinations (Table 1).

The presence of only thrips or only purple blotch reduced total yield and percent extra large bulbs by about 20% compared to yields from treated (control) plots. Onions from plots having high levels of both thrips and purple blotch had 40% less total yield and almost no extra large onions compared to treated (control) onions. The ratio of medium, large, and extra-large onions in control onions was about 1:2:1, compared to a 10:8:1 ratio in the thrips + purple blotch treatment.

Appearance and weight loss

Postharvest decays were generally absent after four weeks storage, with the exception of black mold caused by *A. niger*. Less than one percent of onions had other decay causing organisms (data not shown). Medium sized bulbs had less black mold initially and after storage than extra large onions, regardless of treatment. After four weeks of storage, the percentage onions with black mold was 52 to 81%, an increase of 10 to 30% from initial levels (Table 2). Onions of all sizes which had been subjected to high levels of both thrips and purple blotch had more black mold than other treatments although differences were usually not significant.

Onions used in this study had unusually high levels of black mold prior to storage. Black mold was so prevalent that any treatment effects on further disease development may have been masked. Excessively high relative humidity during harvest and curing can increase the black mold prevalence (Thamizharasi and Narasimham, 1992). Onions untreated for thrips + purple blotch had 4% sprouting after four weeks storage compared to less than 1% from all other treatments (data not shown).

Percentage weight loss during storage was significantly more ($P<0.05$) in the medium and extra large onion bulbs from the high thrips + high purple blotch treatments compared to all other treatments (Table 2). Onions with a high preharvest incidence of thrips had high weight loss in medium bulbs, but weight loss was similar to controls in large and extra large bulbs. Weight loss was generally higher in medium sized bulbs compared to large and extra large onions, regardless of treatment. Yoo et al. (1995) reported similar results for 'Texas Grano 1015Y' onions stored two to three weeks at 15°C. The higher weight loss from medium onions may have been due to greater surface area : volume ratio compared to extra large onions (mean bulb weights of 165 and 360 g, respectively). Higher weight loss is a negative characteristic, as bulbs tend to shrink and soften more quickly.

Compositional changes

Onion sweetness (%SSC) decreased 18 to 32% after storage for all onions, regardless of bulb size or pest treatment (Table 3). Initially, all the onions had 6 to 7% SSC, which was similar to that reported for other mild onion cultivars (Randle, 1992). The titratable acidity of all onions was very low (0.03%) and was not different before or after storage (data not shown).

Onion flavor consists of pungency and sweetness (Randle, 1992; Wall and Corgan, 1992) and pungency can be affected by soil type and environmental stresses (Vavrina and Smittle, 1993). In our study, onion pungency was affected more by size and storage conditions than by treatment. Pungency, measured as pyruvate concentration, was initially higher for most treatments in medium onions compared to large and extra-large onions, (Table 3). Pyruvate concentration increased 12 to 45% during the four weeks of storage for all onions, and was highest in medium bulbs. 'Texas Grano 1015Y' onions were mild to slightly pungent before storage and slightly to moderately pungent following storage, based on the pyruvate content:sensory relationship presented by Wall and Corgan (1992). The increased pungency and decreased sweetness indicates the relatively rapid deleterious change in quality for 'Texas Grano 1015Y' under these storage conditions.

When only one pest, either thrips or purple blotch, was present on onions in the field, postharvest quality was little affected although yields were reduced. However, when both thrips and purple blotch were present on onions prior to harvest, yield, postharvest weight loss and pungency were adversely affected compared to onions which were free of these pests. Medium-sized onions (control plots) were more pungent than larger onions. As preharvest pests greatly influence final bulb size, use of IPM to control thrip and purple blotch could result in a shift to larger bulb sizes and less pungent, higher quality onions.

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