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EFFECT OF WINTER STORAGE ON THRIPS DAMAGE TO CABBAGE

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The effect of winter storage on damage to cabbage by the onion thrips *(Thrips tabaci* Lindeman) was measured in two experiments: 1) using the varieties 'Superdane'[1] and 'Bartolo,'[1] stored commercially with a natural-air storage system at 30° F (-1.1° C); and 2) using 'Supergreen,' 'Titanic 90,' and 'Falcon,' grown in experimental plots and kept in refrigerated storage at 36° F (2.2° C). Of the different varieties, 'Falcon,' highly resistant to thrips, showed very little initial damage and no increase in damage with storage. The moderately resistant variety 'Titanic 90' and the susceptible variety partolo[1] had moderate levels of initial damage, and increasing depth of damage with storage. The depth of damage sufficiently severe to be easily noticed by consumers also increased for 'Titanic 90'. The varieties with heavier initial damage, 'Superdane' and 'Supergreen,' had different results in the two different experiments: 'Superdane' had no increase in damage during storage, but 'Supergreen' had significant increases in overall levels of damage, number of leaves which were severely damaged, and depth of noticeable damage.

INTRODUCTION

Approximately 30% of all cabbage grown in New York State is stored and sold during the winter and early spring. This practice ensures a continuous supply of cabbage for cole slaw, fresh market, and other purposes throughout the winter, and allows New York growers to compete with the fresh crop grown in the southern states in winter and spring.

The optimum storage environment for cabbage is **a** temperature of 31° F or -0.5° C, and relative humidity above 95% (Ryall and Lipton 1979). If the fluid in cabbage cells reaches a temperature of 30.5° F (-0.9° C), the heads will be damaged by freezing, and above 35° F (1.7° C), they will be damaged by decay and disease organisms (Davis et al. 1978, Lorenz and Maynard 1980). The practice of harvesting cabbage late in the fall, storing in an insulated structure, and then cooling with ventilation equipment is called a natural- air or "common" storage system. This system is economical and practical, but temperatures may remain above the optimum level for up to a month under certain conditions: if warm fall days occur after harvest when cabbage still holds considerable field heat, or if there are warm periods in the spring before cabbage is removed (Davis et al. 1978). A mechanical refrigeration system is used for an earlier harvest, a longer storage period in the spring, or a more rapid cooling to the desired storage temperature.

Many cabbage varieties suitable for winter storage are susceptible to damage by *Thrips tabaci* Lindeman, the onion thrips (Shelton et al., 1988). These thrips feed directly on the head, causing unsightly brown blisters (Andaloro and Shelton, 1983). When this damage is severe, the cabbage becomes unmarketable. Live thrips adults and larvae are still found inside heads after several months of storage (unpublished observations). Growers and storage operators are concerned that visible thrips damage to cabbage might increase during storage, due to either continued thrips activity or physiological changes in the cabbage during storage. Because storage temperature is not always under the operator's control, it is important to know whether thrips damage increases at temperatures slightly above optimum, as well as at the optimum temperature. This study reports observations on thrips damage to different cabbage varieties after varying amounts of time in storage and under two storage conditions: in natural-air storage at -1.1° C, and in refrigerated storage at 2.2° C.

MATERIALS AND METHODS

Experiment 1: Monitoring changes in thrips damage in commercial storage. Two varieties of cabbage, 'Superdane,' and 'Bartolo,' both susceptible to thrips, (Shelton et al., 1988) were harvested from commercial fields on November 26 to 27, 1985 and placed in commercial storage in Marion, NY the following day. The air temperature in storage was maintained at -**1.1°C** (30°F) with a natural-air or common storage system. Humidity was not recorded. Cabbage generates heat from its own respiration, keeping the temperature in the cabbage itself slightly above air temperature (Bartsch and Blanpied 1984). Evidently this heat of respiration was enough to keep the cabbage from freezing, because no freezing damage was ever observed. Air temperature was well-maintained, and did not begin to rise until April. One bin of each variety was selected at random on December 17, 1985, and 15 heads of each variety were selected at random from the bin and evaluated for thrips damage. The same two bins were used for similar evaluations on January 15, February 11, March 12, and April 21,1986. Each head was split in half and 10 layers were peeled from one half of the head. The damage on each layer was visually categorized as 'Heavy' (> 25% damaged), 'Medium' (5 -10% damaged), 'Light' (1 - 5% damaged) or 'Very Light' (< 1% damaged). A numerical rating was calculated by assigning four points for each layer rated 'Heavy,' three points for each layer rated 'Medium,' two for 'Light,' one for 'Very Light," and none for layers with no damage, and adding the total nurruer of points for all the layers of each head. Other measures of damage used were the number of layers rated as 'Medium' or 'Heavy' (a measure of how many layers were severely damaged), the number of layers into the head that damage was found (depth of damage), and the number of layers into the head that damage more severe than 'Very Light' was found. The rationale for using both of these last two measurements is that 'Very Light' damage is so inconspicuous that it would probably not be trimmed off in processing or noticed by consumers, and is thus not economically important; but it does indicate how far thrips have moved inside the heads. Analyses of variance were performed for the four measures of damage over the five sample dates. The data for each variety were analyzed separately. When the F test indicated **a** significant difference (E_< 0.05), means were separated using **an** LSD test (Snedecor and Cochran, 1980).

Experiment 2: Comparing thrips damage in paired samples of freshly harvested and stored cabbage in refrigerated storage slightly **above optimum temperature.** Four varieties of cabbage were originally used: 'Market Prize,' highly susceptible to thrips damage, 'Supergreen,' moderately susceptible, 'Titanic 90," moderately resistant, and 'Falcon,' highly resistant. However, data for 'Market Prize' were not used because this variety deteriorated significantly in storage, and the effects of storage rots could not be reliably distinguished from thrips damage. These varieties were planted in a randomized complete block design with four blocks, and each variety represented in each block by one row with 20 plants. Plants were spaced 46 cm. apart in the row, and the rows were 1 m. apart. These plots were not treated with any insecticides for thrips control, just with an initial soil treatment of chlorpyrifos for control of cabbage maggot, and treatment as needed with *Bacillus thuringiensis* Berliner for control of Lepidoptera. One pair of heads from each block was collected on September 23, September 30, and October 7, 1985 for this experiment. Each pair consisted of one head chosen at random, and the adjacent head, also collected at the same time. Of this pair, one head was immediately evaluated for thrips damage, by peeling the first 10 leaves (rather than splitting the head in half and evaluating "layers," the leaves on one side of the head, as was done if Experiment 1) and evaluating the damage on each leaf according to the four categories above. The other head

Table **8.1. Mean thrips damage to heads of two cabbage varieties removed from cold storage** (temperature - 1.1 degrees C) **on** different dates over the winter. Marion, New **York. 1985-1986**

Bartolo

Date	Numerical rating	No. of layers rated Mor H[a]	Depth of damage	Depth of damage >thanVL[b]
Dec. 17	2.4	0.1	2.1a	0.5
Jan. 15	3.9	0.1	3.8a	1.7
Feb. 11	4.3	0.0	4.9b	2.2
March 12	4.6	0.0	6.6b	1.1
April 21	2.6	0.0	4.9b	0.9
	ns	ns	E< 0.001	ns
			LSD = 2.1	

Superdane

Date	Numerical rating	No. of layers rated M or H[a]	Depth of damage	Depth of damage MhanVL"
Dec. 17	9.7	1.5	4.5	3.8
Jan. 15	9.1	1.6	4.3	3.2
Feb. 11	7.7	1.5	3.9	2.5
March 12	8.0	1.1	4.9	2.9
April 21	6.6	0.8	4.3	2.8
		ns	ns	ns

[a] "M", visually rated as Medium (5 -10% damaged); "H", rated as Heavy (> 25% damaged).

b damage > than "VL" includes all damage evaluated as Light, Medium, or Heavy, and does not include damage that was visible, but evaluated as Very Light (< 1% damaged).

[c] ns, no significant difference among dates at £ = 0.05. Analysis of variance, df = 4,70.

^ Means followed by the same letter are not significantly different. Protected least significant difference test, £ = 0.05, df = 70.

was stored in a "wet coil" refrigerated storage room at the Raw Products Building, New York State Agricultural Experiment Station, Geneva, NY (Bartsch and Blanplied, 1984). Storage conditions were maintained at a dry bulb temperature of 2.2°C (36°F) and relative humidity ca. 93%. The stored heads were evaluated in the same way for damage after 3.5 to five months in storage.

The d fferent overall measurements of thrips damage were calculated as described above. These data were analyzed -jsing paired t-tests to compare the damage to fresh and stored cabbage heads for each type of measurement of damage and for each variety.

RESULTS AND CONCLUSION

Experiment 1. For the cabbage in commercial storage, the only significant change in thrips damage over four months was an increase in depth of damage for the variety 'Bartolo' from 2.1 layers deep in the initial sample to 4.9 - 6.6 layers in the three later samples (L.S.D. 2.1 layers forE=0.05, Table 8.1). There was no difference in the number of layers with severe ("Medium[1] or 'Heavy') damage, and differences in numerical rating and depth of damage greater than 'Very Light' were not statistically significant. Thus, there was a substantial increase in the depth of very light damage, but no significant increase in severity of damage per leaf, or in overall level of damage. There wee no significant changes in damage to the variety 'Superdane.'

Experiment 2. For the paired comparison between fresh heads and heads stored under slightly warmer conditions than used commercially, there were statistically significant ($P< 0.05$) differences for the susceptible variety 'Supergreen' in overall numerical rating, the number of leaves rated 'Medium' or Heavy, and in the depth of damage greater than 'Very Light.' 'Titanic 90' pairs also had a significant difference in overall depth of damage, and damage greater than 'Very Light' (Table 8.2). There was very little thrips damage to the highly resistant 'Falcon' heads both before and after storage, and thus no sianificant differences.

Although 'Bartolo' has been reported as a susceptible variety (Shelton et al. 1988), the level of initial damage of 'Bartolo' in these experiments was closer to that of 'Titanic 90' than to the susceptible varieties 'Superdane' and 'Supergreen' ('Bartolo': 0.1 layers rated medium or heavy, depth of damage 2.1 layers, depth of damage heavier than very light 0.5 layers compared to 'Titanic': 0.0 leaves, 4.4 leaves, and 0.4 leaves, respectively), perhaps because of low infestation levels in the field or partial control of the infestation with insecticides. In the two experiments, the patterns of increases in depth of damage and depth of damage greater than 'Very Light' were similar for the two varieties 'Bartolo' and Titanic 9G.' The difference in scale between the two experiments (using leaves instead of layers in Experiment 2) and the technique of using paired Comparisons instead of independent samoles made Experiment 2 more sensitive to small changes in thrips damage than Experiment 1. For example, a difference of one leaf in depth of damage greater than 'Very Light' for 'Titanic 90' was statistically significant in Experiment 2, while a difference of up to 1.8 layers (the equivalent of between three and four leaves) was not significant for 'Bartolo' in Experiment 1. A difference of one leaf in depth of noticeable damage is probably not enough to be of practical significance to cabbage processors or consumers, but a difference of three to four leaves in depth might be.

The two varieties with heavier initial damage ('Superdane' in Experiment 1 and 'Supergreen[1] in Experiment 2) had very different answers to the question of whether thrips damage increases in storage. For 'Supergreen,[1] overall damage, number of leaves severely damaged, and depth of noticeable damage increased in storage, but for 'Superdane' they did not. These different results are probably not due to differences in sensitivity of the two experiments, because "Superdane[1] does not even show any trend toward increased damage in storage. Some possible explanations why these two similar susceptible varieties showed such different results are:

1. A large fraction of the increased thrips damage could appear during the early weeks of storage. (The initial evaluation of commercially stored cabbage was made three weeks after harvest, while the initial evaluation of damaged heads to be refrigerated was made immediately after harvest.)

Table 8.2. Mean differences in thrips damage between paired samples of stored and fresh cabbage heads of four varieties. Stored heads were kept at 2.2° C for 3.5 to 5 months. Geneva, NY 1985-1986.

	Varieties		
	Supergreen	Titanic 90	Falcon
Numerical rating			
Fresh	13.9	4.5	2.0
Storage	19.4	5.6	2.0
Mean difference[a]	5.5'"*	1.1ns	0.0 ns
Std. error of difference	1.68	.9	.43
No. of leaves rated M or H			
Fresh	1.3	0.0	0.0
Storage	3.5	0.08	0.0
Mean difference	2.2 '"*	0.08 ns	0.0 ns
Std. error of difference	0.52	0.08	0.0
Depth of damage			
Fresh	7.8	4.4	2.5
Storage	9.0	5.9	3.0
Mean difference	1.2 ns	1.5***	0.5 ns
Std. error of difference	0.68	0.45	0.72
Depth of damage > VL			
Fresh *	5.3	0.4	0.0
Storage	7.1	1.4	0.0
Mean difference	1.8*	1.0*	0.0
Std. error of difference	0.89	0.49	0.0

ns , mean difference between pairs of stored and fresh cabbage heads is not significantly different from zero; * difference is significant at leve $p < 0.05$; *** , mean difference is significant at level $p < 0.005$; paired t - test, df = 11.

2. The difference of 3° C in storage temperature between commercial storage and experimental storage could have resulted in a large difference in thrips activity and /or survivorship, and thus damage.

3. Other factors (e.g. genetic differences between the two varieties, growing conditions, differences in timing of harvest) could have created conditions more suitable for thrips damage to continue in the experimental cabbage than in commercially grown and stored cabbage.

These are all hypotheses that would be suitable for further testing.

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