Effect of Planting Date and Timing of Growth Stages on Damage to Cabbage by Onion Thrips (Thysanoptera: Thripidae)

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ABSTRACT The same cabbage varieties remain resistant or susceptible to damage by the onion thrips, *Thrips tabaci* Lindeman, regardless of changes in planting date or synchronization of other growth stages. Thus, varietal resistance observed in previous studies is true resistance, not pseudoresistance caused by differences in timing of maturity or other critical growth stages. Delaying planting from 6 June or 18 June to 2 July significantly reduced damage ratings for susceptible varieties and depth of thrips damage (number of leaves into the head where damage estimated at <1% of leaf area was found) for all four varieties. This result suggests that farmers can reduce thrips damage on their cabbage heads by planting susceptible varieties late in the season, as well as by planting resistant varieties.

KEY WORDS Insecta, *Brassica oleracea* var. *capitata, Thrips tabaci,* plant resistance

IN MANY plant species, the physiological age of tissues affects their susceptibility to insect damage (examples reviewed in Tingey & Singh [1980]). One result of this difference in susceptibility with differing maturity is referred to as pseudoresistance (Painter 1951). For example, if a plant is susceptible to damage by insects during only a certain period of its life, then a plant variety may appear to be resistant in a particular environment because its susceptible stage occurs when the insect population is low. Another variety, maturing at a different time, may be in a susceptible period when insect numbers are high. If the timing of maturation is altered by changing the planting date, the apparent susceptibility or resistance of the varieties also could change.

In the study reported here, we investigated whether varietal resistance to the onion thrips, *Thrips tabaci* Lindeman, in cabbage is related to differences in timing of growth stages, and whether thrips damage to cabbage can be reduced by changing the time of planting. Previous work by Shelton & North (1986) and North & Shelton (1986 a,b) showed that the time of appearance of *T. tabaci* in cabbage fields was synchronized with their movement out of wheat, oats, and alfalfa; for example, movement of *T. tabaci* out of wheat and colonization of cabbage peaks during a short period (about 3 wk) as the wheat matures. If the period for movement of onion thrips into cabbage from an adjacent wheat field is limited, and if susceptibility of cabbage to onion thrips differs over the season, then reduction of damage to otherwise susceptible varieties may be possible by eliminating the synchrony between movement of onion thrips and the susceptible stages of the cabbage plant.

In a study of varietal resistance to damage by onion thrips in processing cabbage varieties planted at the same time, Shelton et al. (1983) found that thrips resistance was not related to date of maturity. One objective of our study was to test the influence of maturity on resistance in fresh market and storage varieties by varying planting dates and measuring damage in relation to the timing of certain identified stages of cabbage development (Andaloro et al. 1983). Another objective of this study was to test the possibility that alteration of planting dates, within the range normally used by New York growers, might be used to decrease the severity of thrips damage to cabbage, particularly for susceptible varieties.

Materials and Methods

The four varieties used in this study were 'Market Prize' (Harris Moran Seed, Rochester, N.Y., rated in previous experiments as highly susceptible), 'Supergreen' (Reed's Seeds, Cortland, N.Y., moderately susceptible), 'Titanic 90' (Ferry-Morse, San Juan Bautista, Calif., moderately resistant), and 'Falcon' (Royal Sluis, Salinas, Calif., highly resistant). The usual order in which these varieties mature in upstate New York is: first, 'Market Prize,' 'Titanic 90,' 'Supergreen,' and last, 'Falcon.' These varieties were transplanted to the field as 5–6-wk-old seedlings on 6 June (first planting date), 18 June (second planting date), and 2 July (third planting date) 1985 at the Vegetable Research Farm near Geneva, N.Y. Planting dates were tested in the main plots and varieties in subplots (split-plot design). Each combination of planting date and variety was replicated four times, but an outbreak of

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Table 1. Damage ratings of cabbage heads of four varieties harvested from plots that were in the same growth stages on 29 July 1985; Geneva, N.Y.

Variety	Cupping (or a mixture of cupping and early head)															9-12-leaf stage								
	Harvested 30 Sept.			Harvested 6 Sept.			Harvested 13 Sept.			Harvested 20 Sept.			Harvested 27 Sept.			Harvested 20 Sept.			Harvested 27 Sept.			Harvested 4 Oct.		
	n	$\bar{x}$	SEM	n	$\bar{x}$	SEM	n	$\bar{x}$	SEM	n	$\bar{x}$	SEM	n	$\bar{x}$	SEM	n	$\bar{x}$	SEM	n	$\bar{x}$	SEM	n	$\bar{x}$	SEM
Market Prize				9	3.06	0.15	9	3.61	0.27	3	3.50	0.29				12	1.17	0.09	12	1.33	0.09	12	1.50	0.16
Supergreen	12	2.00	0.26	15	1.83	0.18	9	2.67	0.29	12	1.83	0.23				9	0.94	0.10	9	1.28	0.12	9	1.39	0.11
Titanic 90	3	1.17	0.44	15	1.07	0.08	12	1.25	0.12	9	1.39	0.07				6	0.25	0.11	6	0.83	0.11	6	0.75	0.17
Falcon	12	0.50	0.06	3	0.50	0	21	0.52	0.04	21	0.45	0.05	12	0.75	0.08				9	0.39	0.07	9	0.22	0.09

clubroot (caused by *Plasmodiophora brassicae* Woronin) occurred in one replication. Data from plants visibly affected by clubroot (easily identified by severe wilting and deformed roots) were not used in the analysis, and the entire replication in which the outbreak of clubroot occurred was not used in the analysis of variance. Each main plot comprised four rows (0.9 m apart, 10 plants per row, with 45-cm spacing between plants) for each of the four varieties. Spacing between plots was 0.9 m. Soil was a silt-loam with pH of 6.5 and was fertilized on a per-ha basis with 184 kg of 15-15-15 on 23 May and sidedressed with 32 kg N on 10 July. To ensure a high onion thrips population infesting the cabbage, the trial was located ca. 7 m downwind from a 1-m strip of wheat and ca. 20 m downwind from a 1-ha field of wheat. Both fields were cut on 22 June, which is unusually early for wheat in this area.

On 29 July 1985, each plant in the experiment was evaluated to determine its growth stage according to the scale established by Andaloro et al. (1983), and each varietal subplot was later categorized as being in one or a mixture of two of the eight growth stages. Cabbage heads were harvested and evaluated for onion thrips damage over 7 wk (23 August to 4 October 1985). Three heads per subplot were harvested, evaluated for damage, and weighed each week that the subplot was judged mature: all subplots were evaluated over 2 or 3 wk. Ratings of damage were made according to the methods of Shelton et al. (1983) but with the following modifications. First, the damage on each of the first 10 leaves was rated visually as none, very light (0–1% of leaf area damaged), light (1–10%), medium (10–25%), or heavy (25–100%). Then, overall damage ratings (0–4.5, using 0.5 intervals with 0 = no damage and 4.5 = very severe damage) were assigned to each head, using individual leaf ratings to ensure that overall ratings remained consistent over time.

To compare different varieties in the same developmental stages at the same time, plots in the same growth stages on 29 July 1985 were grouped together. The only two groups including plots of all four varieties were those plots in the cupping stage (also including a few plots divided between cupping and the next stage—early head formation) and those with 9–12 true leaves. Data on the damage to these groups of plots were gathered by variety and harvest date, and means and standard errors were compared.

To measure the effect of altering planting date on damage to the four varieties, an analysis of variance was performed on data from all plots except the block affected by clubroot. Two measures of severity of damage were used: overall damage ratings as described above, and depth of damage (measured as number of leaves into the head up to 10) more severe than "very light." This second measure of damage was appropriate because, when handlers encounter thrips-damaged cabbage, they

Table 2. Damage rating and weight per head for four varieties planted on three planting dates; Geneva, N.Y., 1985

Variety	Planting date[a]	Damage rating[b]		Depth of damage[c]		Weight per head (kg)	
		$\bar{x}$	SEM	$\bar{x}$	SEM	$\bar{x}$	SEM
Market Prize	1	3.19	0.13	9.10	0.55	1.84	0.12
	2	3.31	0.16	10.00	0.68	1.44	0.12
	3	1.37	0.13	5.50	0.55	1.08	0.10
Supergreen	1	2.94	0.18	9.30	0.42	1.10	0.11
	2	2.06	0.18	8.30	0.42	1.03	0.11
	3	1.20	0.18	4.80	0.42	1.06	0.11
Titanic 90	1	1.09	0.13	4.00	0.53	2.39	0.17
	2	1.21	0.14	5.10	0.57	2.17	0.12
	3	0.72	0.13	2.00	0.53	1.91	0.11
Falcon	1	0.44	0.06	0.41	0.07	1.60	0.26
	2	0.56	0.06	0.67	0.06	1.52	0.24
	3	0.25	0.07	0.00	0.07	1.15	0.30

[a] Planting date: 1, 6 June 1985; 2, 18 June 1985; 3, 3 July 1985.
[b] Ratings from 0 (no damage) to 4.5 (very severe damage). For further detail, see text.
[c] Depth into head (up to 10 leaves) where damage was found more severe than "very light" (1% of leaf surface area).

trim off any obviously damaged leaves before paying the farmer by weight.

Results and Discussion

Damage ratings from two groups of plots, each group representing one growth stage on 29 July 1985, are shown in Table 1. Each of the heads in the first part of Table 1 was in the cupping stage (when inner leaves begin to enclose the apical meristem to form a head) at the same time, and are grouped in the table by variety and harvest date. Each group harvested on the same date showed the same trend in resistance as seen in previous studies—'Market Prize' was highly damaged, 'Supergreen' moderately damaged, 'Titanic 90' lightly damaged, and 'Falcon' had only very slight damage.

In the lower part of Table 1, plots planted later at an earlier stage of development on 29 July are listed. There was still a perceptible trend toward higher damage in 'Market Prize' and 'Supergreen' compared with 'Titanic 90' and 'Falcon,' but all varieties had much less damage than in plots planted earlier, so the differences among varieties were correspondingly small. The substantial difference in damage between 'Market Prize' plots cupping on 29 July and in the 9–12 leaf stage, even for the same harvest date (20 September 1985), indicates that the critical stage whose timing influences thrips damage was closer to 29 July than to harvest.

Table 2 shows data concerning the influence of planting date on thrips damage for the four varieties. The overall analysis of variance of damage ratings for each combination of variety and planting date showed that planting date was a significant factor ($F = 60.6$; df = 2, 4; $P < 0.001$) and variety, as expected, was also a significant factor ($F = 151.6$; df = 3, 12; $P < 0.0001$). Because the planting date × variety interaction was also significant ($F = 13.4$; df = 6, 12; $P < 0.0001$) and variance differed for different varieties (see standard errors in Table 2), a separate analysis of variance was done for each variety, with planting date and block as factors.

In the separate analyses, planting date was a significant factor for the susceptible varieties 'Market Prize' and 'Supergreen' ($F = 62.6$; df = 2, 4; $P = 0.0009$ and $F = 23.4$; df = 2, 4; $P = 0.0062$, respectively), with the third planting having the lowest damage rating for each variety. The first and second planting dates had significantly different ($P < 0.05$) damage ratings only for 'Supergreen,' where planting date 2 had lower damage than planting date 1. Although the differences were not significant at the 5% level, 'Titanic 90' and 'Falcon' had a trend similar to that of 'Market Prize' over the three planting dates; damage ratings were almost equal for the first two planting dates but were lower for the third date.

In the overall analysis of variance of depth of damage, planting date ($F = 25.3$; df = 2, 4; $P = 0.0054$), variety ($F = 306.9$; df = 3, 12; $P = 0.0001$), and planting date × variety interactions ($F = 8.24$; df = 6, 12; $P = 0.0011$) were again all significant. In the separate analyses for each variety, planting date was a statistically significant factor for all four varieties—'Market Prize' $F = 16.2$; df = 2, 4; $P = 0.012$; 'Supergreen' $F = 30.7$; df = 2, 4; $P = 0.0037$; 'Titanic 90' $F = 8.7$; df = 2, 4; $P = 0.035$; and 'Falcon' $F = 23.9$; df = 2, 4; $P = 0.0060$. The magnitude of the differences in depth for the susceptible varieties is not only statistically significant but also of practical significance—a difference between 9 or 10 leaves to trim (perhaps more, because the damage was measured only on the first 10 leaves) for early-planted 'Market Prize' compared with 5 or 6 leaves for the third planting makes a considerable difference in the labor involved in trimming and the price the farmer is paid. Even for the moderately resistant variety 'Titanic 90,' the difference between four or five damaged leaves to trim for the earlier plantings, and only two for the third planting, might well be of practical significance.

Farmers considering late planting as a way to reduce thrips damage would need to know if the size of heads and yield are affected. Because heads were evaluated individually at different times, only the weight of individual heads was measured. Planting date did not significantly change head weights (for planting date, $F = 1.92$; df = 2, 4; $P = 0.26$; for planting date × variety interaction, $F = 1.48$; df = 6, 12; $P = 0.266$), but the means in Table 2 show a trend toward lower weight per head, particularly for 'Market Prize,' for later plantings.

Whether grouped by similar timing of planting date or other growth stages, resistant varieties were always less damaged than susceptible varieties. Thus, the differences in susceptibility to thrips damage in these four varieties were not caused by pseudoresistance. However, the severity of thrips damage was much lighter on late-planted plots than on those planted earlier. This suggests that farmers can reduce thrips damage on their cabbage heads by planting susceptible varieties late in the season, as well as by planting resistant varieties. Further study is needed to test this possibility in other environments which may have peak onion thrips pressure at different times, depending on the crops from which the onion thrips originate. For a thorough understanding of the relationship of damage to the timing of cabbage development, a study would be needed to link the timing of onion thrips movement out of field crops and into cabbage to the timing of growth stages of cabbage and subsequent damage. This might be useful to farmers, not only for deciding when to plant but also in planning when to apply insecticides for thrips control.

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