Influence of Thrips on Bronzing of Strawberry Fruit

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Additional index words. flower thrips, bronzed fruit, marketable berries, strawberry yields

Abstract. Thrips are presumed to be the major cause of bronzed strawberry (*Fragaria × ananassa* Duchesne) fruit in the Midwestern United States. The objectives of this study were to 1) identify thrips species present in Iowa strawberry fields and 2) determine the relationship between the numbers of thrips collected from flowers and fruit and the percentage of mature fruit exhibiting bronzing damage. Thrips were collected from flowers and fruit for three growing seasons at three sites in central Iowa. Approximately 82% of these thrips were eastern flower thrips, *Frankliniella tritici* (Fitch) (Thysanoptera: Thripidae); the remaining 18% were primarily *Frankliniella fusca* (Hinds) (Thysanoptera: Thripidae). Mean number of adult and immature thrips per flower or fruit ranged from 0 to 7 in 2000, from 0 to 22 in 2001, and 0 to 16 in 2002. In 2001 and 2002, the incidence of thrips on both flowers and fruit was common; the mean number of thrips on flowers was 2 to 16 times greater than on fruit. However, in both years <1% of damage to fruit was attributed to thrips. Based on our results, we conclude that thrips infestations do not necessarily cause bronzed fruit in Iowa strawberry fields.

In New Brunswick, Canada, *Frankliniella tritici* has been identified as the causal agent of necrotic flecking or bronzing of strawberry fruit, in which a bronzed appearance or seediness of the fruit was associated with cell death caused by thrips feeding between achenes during fruit development (Lynch and Tremblay, 1995). Previously, Mitchell (1949) reported four *Frankliniella* species, including *F. tritici*, infesting unidentified strawberry cultivars in Iowa; however, no damage to strawberry fruit was observed. A study conducted in Illinois also noted that the presence of *F. tritici* in strawberry fields did not necessarily result in fruit damage (Farrar, 1936). In California, feeding by *Frankliniella occidentalis* (Pergande) (Thysanoptera: Thripidae) was not detrimental to ‘Shasta’ strawberry, and in cage studies, the presence of thrips was beneficial because they pollinated flowers (Allen and Gaede, 1963). In contrast, oviposition and feeding by *F. occidentalis* caused a bronzed color of berries and wilting of some flowers of ‘Chandler’ strawberries in Spain (Ribes, 1990).

In 1994, midwestern U.S. strawberry growers observed seedy fruit with a rubbery texture and poor color in selected strawberry fields (cultivars not specified) (Bordelon et al., 1999; Williams and Felland, 1995). It was not determined if this damage was caused by thrips feeding, low temperatures (<0°C) during fruit formation, or other factors (Bordelon et al., 1999). However, based upon observations of

damaged fruit, Bordelon et al. (1999) recommended that growers sample strawberry flowers and developing fruit and apply insecticides if thrips exceeded an average of two individuals per blossom. Based on greenhouse and insecticide field trials, an economic threshold for thrips infestations of strawberry fruit was determined to be >0.5 thrips per fruit, based on a sample of 50 ‘Kent’ strawberries (Lynch and Tremblay, 1995).

Due to the varying results of previous studies, it is not clear if thrips infestations are the sole cause, a minor contributing factor, or play no role in the occurrence of bronzed strawberries in Iowa. The objectives of this study were to identify thrips species infesting strawberry flowers and fruit in central Iowa and describe the relationship between thrips infestations and bronzed berries.

Materials and Methods

Field sites. From 2000 to 2002, adult and immature thrips were collected from strawberry flowers and fruit at three sites in central Iowa (Table 1). Sampling started in early May when primary flowers were first noted, and continued through fruit development (4 weeks in 2000, 7 weeks in 2001, and 8 weeks in 2002). Sample rows were randomly selected at each site. Each row was divided into four randomly selected plots, each 12 to 15 m in length.

These fields were not sprayed with insecticides. Drip irrigation was used at Farms 2 and 3, and Farm 1 had overhead irrigation. Because *F. tritici* has not been reported to overwinter in the midwestern U.S. (Stannard, 1968), we placed yellow and blue sticky cards at the beginning of the season in 2001 and 2002 to monitor migration of thrips into the field (Matos, 2001; Matos and Obrycki, 2004). In addition, we noted southerly winds when temperatures were above 10 °C and the first thrips were recorded on sticky cards. From 2 Apr. to 7 May 2001 and 1 Apr. to 9 May 2002, there

were 11 and 8 d of prevailing southern winds, respectively. Weather data were recorded starting in November 1999 to June 2000, 2001, and 2002 from the closest weather station (about 10, 46, and 26 km from Farms 1, 2, and 3, respectively) (Table 2).

Sample collection. In May 2000, one flower was selected at random each week from 10 randomly selected strawberry plants at each site. In May and June 2001 and 2002, the sample size was increased to 20 plants per week because in 2000, the SE to mean ratio of the samples ranged from 25% to 70%. Samples collected these years were categorized according to flower and fruit developmental stage: buds (closed flower), open flowers (white petals showing), and fruit (receptacle beginning to expand). Approximately equal numbers of flowers and fruit were sampled during the last 3 weeks before harvest.

Thrips infestation and identification. Each sampled bud, flower, and fruit was placed in 13-mL vials filled with 70% ethyl alcohol. In the laboratory, the vials were shaken to dislodge any thrips from the samples. The alcohol from each vial was then examined using a dissecting microscope (Olympus SZH; Olympus Corp., Lake Success, N.Y.) at 30× to count the number of thrips present.

Voucher specimens were mounted in Hoyer’s medium and sent to the USDA Systematics Entomology Laboratory (Beltsville, Md.) for identification. The specimens are presently housed in the Iowa State University Insect Collection in Ames.

Fruit damage. The strawberry field at the Iowa State University Horticulture Station was hand-harvested every 3 to 5 d, from 11 June to 24 June in 2001 and from 4 June to 24 June in 2002. Fruit were harvested from 2-m plots in even-numbered rows; eleven plots were harvested in 2001, and eight plots were harvested in 2002. Fruit were sorted as marketable or nonmarketable, and weighed. Marketable fruit were those considered round with deep-red color, no blemishes, and uniform distribution of developed achenes. Nonmarketable fruit were categorized as bronzed fruit, fruit diseased by fungal or bacterial pathogens, fruit with holes, fruit with apical seediness (concentration of seeds at the fruit apex) caused by *Lygus lineolaris* Palisot de Beauvois (Heteroptera: Miridae) damage (Handley et al., 1991) or poor pollination, and fruit damaged by unknown causes. Diseased fruit were either oozing liquid or had brown color, foul odor, or fungal mycelia growing on the fruit surface.

Statistical analysis. The numbers of thrips sampled from buds, flowers and fruit were analyzed with PROC GLM (SAS Institute, 1998). The analysis examined the effects of farm, plant developmental stage, and sample date on number of thrips in 2000–02; each year was analyzed separately.

Results and Discussion

Most thrips collected from strawberry flowers and fruit were identified as *F. tritici* (Fitch) and *F. fusca* (Hinds). In 2000, twelve

Received for publication 4 Sept. 2003. Accepted for publication 11 Dec. 2003. This project was supported in part by grants from The Leopold Center for Sustainable Agriculture and the North American Strawberry Growers Association. We thank Dean Henry and Angela Tedesco for allowing us to work on their farms and Steve Nakahara for identifying the specimens.

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Table 1. Strawberry fields where thrips were collected in 2000–02.

Field location ^a	Field size (ha)	Year planted	Cultivars	No. of rows sampled/cultivar
Iowa State University Research Station, Ames	0.16	1998	Honeoye	10–25 ^b
Turtle Farm, Granger, Iowa	0.18	1998	Delmarvel, Jewel, Northeast, Winona	5–6
Berry Patch Farm, Nevada, Iowa	0.20	1996	Honeoye, Jewel, Northeast, Winona	5–6

^aIowa State University Research Station (Farm 1), Turtle Farm (Farm 2), and Berry Patch Farm (Farm 3).

^bTen rows were sampled in 2000 and 25 rows were sampled in 2001 and 2000.

specimens (four per field site) were identified: four were *F. fusca* and eight were *F. tritici*. In 2001, 15 specimens (5 per field site) were identified, and all were *F. tritici*. In 2002, 29 (9 from Farm 1, 10 from Farm 2, and 10 from Farm 3) specimens were identified: 4 were *F. fusca*, 22 were *F. tritici*, 1 was *Frankliniella exigua* (Hood), and 1 was *Thrips tabaci* (Lindeman). Mitchell (1949) reported three other thrips species [*Frankliniella cephalica* (Cwfd.), *Frankliniella inornata* Mlt., and *Chirothrips manicutus* Hal. (Thysanoptera: Thripidae)] in Iowa strawberry fields, but these three species were not observed in our study.

Similar numbers of thrips were found at various sites, although thrips numbers varied with sample date ($P < 0.001$). The greatest number of thrips was observed each year at the flower stage of fruit development (Table 3). Buds and fruit had significantly lower number of thrips than flowers ($P < 0.001$) with averages ranging only from 0 to 5 thrips per bud or fruit.

In 2001, 68% of the fruit harvested at the Iowa State University Horticulture Station was marketable whereas in 2002, 63% of the fruit harvested was marketable (Table 4). In 2001, 22% of the fruit were damaged by fungal or bacterial disease, holes possibly caused by slugs, or apical seediness, while another 10% were damaged by unknown causes. In 2002, fruit damage was primarily associated with apical seediness. Little fruit damage (<1%), however, was associated with bronzing in either year (even though thrips were present on the fruit and flowers; Table 2).

Determining the relationship between thrips infestation and economic damage to strawberry fruit (caused by bronzing) is difficult, even though thrips may feed directly on strawberry flowers and fruit. Bordelon et al. (1999) developed a threshold of >2 thrips (adult and immature) per blossom (the number of flowers sampled was not specified) for Midwest strawberry growers. Similarly, Lynch

and Tremblay (1995) developed a threshold of 0.5 thrips per fruit in Canada. Our data do not support these threshold values as we often observed thrips numbers exceeding these thresholds without evidence of bronzing. For example, 22 and 16 thrips per flower, and as many as 5 thrips per fruit, were observed in 2001 and 2002, respectively, but bronzing damage was minimal in both years. Lack of relationships between thrips infestation and crop damage has also been noted for other crops, including cabbage (*Brassica oleracea* L.) (North and Shelton, 1986), tomato (*Lycopersicon esculentum* Mill.) (Salguero-Navas et al., 1991), and nectarine (*Prunus persica* (L.)) (Felland et al., 1995).

Thrips infestation threshold values may need to be revised to include additional factors such as cultivar, environmental conditions (Williams and Felland, 1995), plant stress levels (Williams et al., 1999), mulch type and irrigation practices (Larson and Sjulín, 2001), or the presence of insect predators. *Orius insidiosus* (Say) (Heteroptera: Anthracoridae) was the most common predatory insect observed on flowers. Additionally, Williams et al. (1999) suggested that below average rainfall in Ohio was an important factor contributing to strawberry damage by thrips.

Literature Cited

- Allen, W.W. and S.E. Gaede. 1963. The relationship of *Lygus* bugs and thrips to fruit deformity in strawberries. J. Econ. Entomol. 56:823–825.
- Bordelon, B., M. Ellis, and R. Weinzierl. 1999. Iowa commercial small fruit and grape spray guide. 1999. Iowa State Univ. Ext.
- Farrar, M.D. 1936. Effect of thrips on pollination and blossom blight in strawberries. J. Econ. Entomol. 29:483–486.
- Felland, C.M., D.A.J. Teulon, L.A. Hull, and D.F. Polk. 1995. Distribution and management of thrips (Thysanoptera: Thripidae) on nectarine in the Mid-Atlantic Region. J. Econ. Entomol. 88:1004–1011.
- Handley, D.T., J.F. Dill, and J.E. Pollard. 1991. Field susceptibility of twenty strawberry cultivars to tarnished plant bug injury. Fruit Var. J. 45:166–169.
- Iowa Department of Agriculture and Land Stewardship (IDALS). 1999. Iowa climate review. vols. 11 and 12. Iowa Dept. Agr. Land Stewardship,

Table 2. Summary of weather data taken from one weather station (Ames 8 WSW) (Lat 42.1, Lon 93.46) (IDALS, 1999, 2000, 2001, and 2002).

Date	Temp (°C)			Precipitation (mm)	
	Avg max	Avg min	Normal ^a	Avg	Normal
November 1999	14.6	0.6	3.1	23.6	40.4
December 1999	3.5	-7.6	-5.0	13.2	27.2
January 2000	0.4	-10.2	-7.7	14.2	17.5
February 2000	6.2	-4.1	-4.7	41.4	21.3
March 2000	13.1	0.2	2.3	11.2	53.1
April 2000	18.9	3.2	10.1	20.8	85.9
May 2000	25.2	11.2	16.4	120.4	108.5
June 2000	26.2	14.6	21.3	103.6	133.1
November 2000	4.9	-3.9	3.1	60.5	40.4
December 2000	-8.3	-17.1	-5.0	40.4	27.2
January 2001	-1.1	-9.5	-7.7	28.2	17.5
February 2001	-3.1	-12.2	-4.7	32.5	21.3
March 2001	3.4	-4.8	2.3	27.9	53.1
April 2001	19.8	5.8	10.1	96.0	85.9
May 2001	22.0	11.2	16.4	190.2	108.5
June 2001	27.2	15.2	21.3	49.8	133.1
November 2001	15.7	3.6	3.1	36.3	40.4
December 2001	4.1	-5.2	-5.0	9.7	27.2
January 2002	5.3	-7.1	-7.7	6.6	17.5
February 2002	4.1	-6.3	-4.7	26.2	21.3
March 2002	7.0	-5.8	2.3	10.2	53.1
April 2002	17.2	4.1	10.1	94.7	85.9
May 2002	21.7	8.2	16.4	129.8	108.5
June 2002	28.9	17.1	21.3	80.5	133.1

^aDeviation from normal temperatures.

Table 3. Mean number (SE) of adult and larval thrips sampled from flower buds, flowers, and fruit at three Iowa strawberry fields in 2000–02.

Date	Thrips (no.)								
	Flower buds			Flowers ^a			Fruit		
	2000	2001	2002	2000	2001	2002	2000	2001	2002
May ^b	---	5 (2)	0 (0)	11 (1)	26 (4)	3 (1)	---	5 (2)	2 (1)
June	---	0 (0)	0 (0)	---	16 (2)	21 (3)	---	3 (1)	3 (2)

^aFruit and flower buds had lower numbers of thrips compared to flowers ($P < 0.0001$).

^bSignificant differences between sampling dates were observed during the 3 years; 2000 ($P = 0.0063$), 2001 ($P = 0.0003$), and 2002 ($P < 0.0001$).

Table 4. Total fruit weight and percent marketable and nonmarketable 'Honeoye' strawberry fruit harvested at the Iowa State Horticulture Station in 2001 and 2002. Nonmarketable fruit were classified as bronzed fruit, fruit with fungal and bacterial disease, fruit with holes, fruit damaged by tarnished plant bug (TPB) or poor pollination, and fruit with damage caused by unknown factors.

Date in June	Total fruit wt (kg·ha ⁻¹)	Marketable fruit (%)	Nonmarketable (%)				
			Bronzed	Disease	Holes	TPB/poor pollination	Unknown
2001							
11	10.42	71	0	0	20	6	3
14	23.46	63	1	0	18	5	13
17	87.18	77	0	12	4	6	1
20	39.69	74	0	11	2	13	0
24	19.91	53	0	4	1	11	31
Mean (SE)	36.13 (13.61)	68 (4)	0 (0)	5 (3)	9 (4)	8 (2)	10 (6)
2002							
4	0.09	67	0	0	0	33	0
7	2.18	58	0	0	7	32	3
10	5.86	62	1	5	5	27	1
13	19.98	58	1	8	0	33	0
16	27.89	69	1	4	5	20	1
19	20.68	70	0	5	0	25	0
24	23.10	57	0	15	1	27	0
Mean (SE)	14.25 (4.24)	63 (2)	0 (0)	5 (2)	3 (1)	28 (2)	1 (0)

- Des Moines.
Iowa Department of Agriculture and Land Stewardship (IDALS). 2000. Iowa climate review.vols. 1–6 and 11–12. Iowa Dept. Agr. Land Stewardship, Des Moines.
Iowa Department of Agriculture and Land Stewardship (IDALS). 2001. Iowa climate review.vols. 1–6 and 11–12. Iowa Dept. Agr. Land Stewardship, Des Moines.
Iowa Department of Agriculture and Land Stewardship (IDALS). 2002. Iowa climate review.vols. 1–6. Iowa Dept. Agr. Land Stewardship, Des Moines.
Larson, K.D. and T.M. Sjulín. 2001. Influence of polyethylene bed mulch, drip irrigation rate, and intermittent, overhead sprinkling on strawberry fruit bronzing. *HortScience* 36:443 (abstr.).
Lynch, K. and R. Tremblay. 1995. Fruit bronzing of strawberry. New Brunswick Dept. Agr. Fact Sheet.
Matos, B. 2001. Ecological studies of *Lygus lineolaris* and phytophagous thrips in Iowa strawberry fields. MS thesis. Iowa State Univ, Ames.
Matos, B. and J.J. Obrycki. 2004. Potential sources of *Frankliniella* (Thysanoptera: Thripidae) species in Iowa. *J. Agr. Urban Entomol.* (in press).
Mitchell, W.C. 1949. Strawberry Insects of Iowa: A survey of the species and insecticidal control of *Empria fragariae* Rohwer. MS thesis. Iowa State Univ., Ames.
North, R.C. and A.M. Shelton. 1986. Ecology of Thysanoptera within cabbage fields. *Environ. Entomol.* 15:520–526.
Ribes, A. 1990. Problemática del trips *Frankliniella occidentalis* en el cultivo del fresón. *Cuadernos Phytomas-España* 6:17–24.
SAS Institute. 1998. User's manual. version 7.0. SAS Inst., Cary, N.C.
Salguero-Navas, V.E., J.E. Funderburk, S.M. Olson, and R.J. Beshear. 1991. Damage to tomato fruit by the Western flower thrips (Thysanoptera: Thripidae). *J. Entomol. Sci.* 26: 436–442.
Stannard, L.J. 1968. The thrips or Thysanoptera of Illinois. *Ill. Nat. Hist. Surv. Bul.* 29:1–552.
Williams, R.N. and C. Felland. 1995. Myth or fact: The flower thrips. Strawberry IPM Update. Iowa State Univ. (7 Jan.)1:10–11.
Williams, R.N., M.S. Ellis, D.S. Fickle, and C.M. Felland. 1999. Monitoring flower thrips activities in strawberry fields at two Ohio locations. *Ohio Agr. Res. Dev. Cent. Spec. Circ.* 99:82–86.