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Field Susceptibility of Twenty Strawberry Cultivars to Tarnished Plant Bug Injury[1]

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Abstract

Twenty Junebearing strawberry cultivars grown in a matted row trial in Monmouth, Maine were evaluated for susceptibility to tarnished plant bug injury during the 1987 and 1988 harvest seasons. A wide range of injury was observed among cultivars. 'Honeoye,' 'Sparkle,' 'Veestar' and 'Canoga' had significantly less injury than other cultivars, as measured by number and weight of fruit showing apical seediness. 'Mic Mac,' 'Scott,' 'Blomidon' and 'Redchief' were most susceptible. Cultivars with the least injury tended to have the greatest marketable yields. Characteristics that might impart resistance were not obvious from this study, but there is some evidence that tarnished plant bug resistance could be selected for in breeding programs.

The tarnished plant bug, *Lygus lineolaris* P.de B. (Hemiptera: Miridae), is a serious strawberry pest in northeastern and midwestern North America. Both adult and immature (nymph) stages feed on strawberry flowers and fruit causing a distinctive malformation of the developing receptacle described as "apical seediness" (6), and commonly called "buttoning." Tarnished plant bugs feed on developing achenes and/or their supporting tissues, halting their importation of photosynthates and their exportation of auxins to the receptacles. Apical seediness is ascribed to impaired achene and and receptacle tissue development (1, 4). There have been recent efforts to develop economic thresholds for tarnished plant bug in strawberries (2), but these have not yet been widely adopted by farmers. Most commercial strawberry fields receive two to five insecticide sprays each spring to prevent serious economic loss from tarnished plant bug injury.

Although resistance to tarnished plant bug has been observed and exploited in other crops, such as alfalfa and cotton (7), there has been no published report of resistance in strawberry. This experiment reports on the differences observed in tarnished plant bug injury among 20 strawberry cultivars in a field trial over two harvest seasons.

Materials and Methods

A strawberry trial was established at the Agricultural Experiment Station in Monmouth, Maine, in the spring of 1985. Twenty cultivars were planted in a randomized complete block design with five replications. Plants were initially spaced 46 cm apart in rows 1.2 m apart. They were deblossomed and runners allowed to develop in matted rows 50 cm wide x 366 cm long. Fertilizers, herbicides and fungicides were applied according to regional recommendations (5). Straw mulch for winter protection was applied each fall and removed the next spring. Following each harvest season the planting was renovated by mowing and rototilling rows to a 25 cm width.

In order to more closely represent conditions in a conventional strawberry field, all plots received insecticide sprays each spring to reduce populations of tarnished plant bug and strawberry bud weevil. In 1987, the plots

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were sprayed twice with endosulfan, once at bud stage and again at prebloom. In 1988 they were sprayed only once at prebloom with a tank mix of malathion and methoxychlor. In both seasons tarnished plant bugs were observed to be prevalent through-out the field during fruit development.

Tarnished plant bug injury to fruit was monitored in the planting during the 1987 and 1988 harvest seasons. Fruit was harvested from the center 2.7 m of each 3.7 m plot and divided into two grades: marketable and tarnished plant bug injured, the latter defined by apical seediness. Fruit losses from other causes, e.g. *Botrytis*, were negligible. Fruit from each plot and grade was counted and weighed. Tarnished plant bug injury was expressed as percentage of fruit number and fruit weight exhibiting apical seediness. Marketable fruit weight for each season was divided by marketable fruit number to determine mean fruit size. Means for percent tarnished plant bug injury by weight were adjusted by square root transformation. Duncan's Multiple Range Test was used to determine significant differences between means.

Results

Significant differences in tarnished plant bug injury, marketable yields and berry size were observed among cultivars in 1987 and 1988 (Tables 1, 2). 'Honeoye' had the lowest injury by weight and number during both years. Sparkle,' 'Veestar,' 'Annapolis' and 'Ca-

Table 1. Tarnished plant bug injury as percent fruit weight (g) and percent fruit number (no.), marketable yields and berry size of 20 strawberry cultivars in Monmouth, ME, 1987.[z]

Cultivar	% TPB Injury (g)[y]	% TPB Injury (no.)	Marketable Fruit (no.)	Marketable Fruit (g)	Berry Size (g)
Honeoye	8.4 a	27.2 a	309 a	4084 a	14.1 bc
Sparkle	10.2 ab	27.1 a	305 a	2674 bc	8.8 d
Canoga	10.3 ab	33.6 ab	139 cd	2290 bcd	19.3 a
Redcoat	11.1 abc	26.9 a	322 a	3224 ab	10.1 cd
Catskill	12.3 abc	30.4 a	288 a	3071 ab	10.7 cd
Veestar	13.1 abc	30.4 a	160 bcd	1377 de	8.6 d
Annapolis	15.1 abcd	39.3 abcd	113 cd	1750 cde	16.0 ab
Surecrop	15.8 abcd	38.4 abcd	158 bcd	1621 cde	10.3 cd
Midway	16.2 bcde	34.5 abc	173 bc	1859 cde	10.7 cd
Guardian	16.4 cde	38.0 abcd	115 cd	1400 de	12.0 bcd
Allstar	17.3 cde	39.0 abcd	62 d	887 e	14.4 bc
Glooscap	18.3 cde	45.6 bcde	175 bc	1866 cde	11.2 cd
Scott	22.0 cdef	45.9 bcde	125 cd	1539 cde	12.3 bcd
Redchief	22.0 cdef	49.0 cde	169 bc	1857 cde	11.0 cd
Blomidon	23.1 def	47.8 bcde	101 cd	1141 de	11.7 bcd
Earliglow	24.7 ef	47.7 bcde	132 cd	1318 de	9.8 cd
Raritan	25.0 ef	52.1 de	103 cd	1085 e	10.6 cd
Cornwallis	28.0 ef	57.4 e	99 cd	1132 de	11.6 bcd
Mic Mac	28.0 ef	55.8 e	78 cd	1071 e	14.1 bc
Kent	29.2 f	52.3 de	252 ab	3195 ab	12.8 bcd

[z]Means followed by the same letter within columns do not differ significantly (Duncan's Multiple Range Test, $P = 0.05$).
[y]Means adjusted by square root transformation.

Table 2. Tarnished plant bug injury as percent fruit weight (g) and percent fruit number (no.), marketable yields and berry size of 20 strawberry cultivars in Monmouth, ME, 1988.[z]

Cultivar	% TPB Injury (g)[y]	% TPB Injury (no.)	Marketable Fruit (no.)	Marketable Fruit (g)	Berry Size (g)
Honeoye	7.7 a	22.3 a	337 b	3314 a	10.0 bcdef
Annapolis	8.1 a	26.6 ab	73 g	1150 efgh	15.4 a
Glooscap	12.1 ab	27.3 ab	316 b	2830 ab	9.1 cdef
Veestar	12.4 ab	31.0 abcd	103 efg	798 gh	7.8 fg
Sparkle	14.6 abc	25.7 ab	449 a	2926 ab	6.5 g
Canoga	14.7 abc	29.9 abc	219 c	2405 bc	11.1 bc
Raritan	19.0 bcd	38.1 bcde	191 cde	1572 defg	8.2 efg
Earliglow	20.2 bcde	44.5 cdefg	104 efg	934 efgh	9.1 cdef
Redcoat	20.5 bcde	39.9 bcdef	204 cd	1669 de	8.1 efg
Guardian	22.1 cde	46.2 defg	118 defg	1352 efgh	11.5 b
Allstar	22.1 cde	47.2 efg	71 g	1031 efgh	14.8 a
Cornwallis	22.4 cde	47.8 efg	111 efg	1060 efgh	9.6 bcdef
Blomidon	24.7 def	48.1 efg	86 g	934 efgh	11.0 bcd
Redchief	24.9 def	53.5 efg	136 cdefg	1353 efgh	10.3 bcde
Scott	25.7 def	49.6 efg	99 fg	996 efgh	10.1 bcdef
Catskill	27.0 def	45.6 defg	185 cdef	1593 def	8.8 def
Kent	27.6 def	44.4 cdefg	216 c	2091 cd	9.8 bcdef
Mic Mac	29.9 def	54.9 fg	92 g	1069 efgh	11.7 b
Surecrop	31.8 ef	57.2 g	84 g	707 h	8.3 efg
Midway	34.8 f	55.5 fg	91 g	830 fgh	9.4 bcdef

[z]Means followed by the same letter within columns do not differ significantly (Duncan's Multiple Range Test, $P = 0.05$).
[y]Means adjusted by square root transformation.

noga' also had low injury. 'Kent,' 'Mic Mac,' 'Scott,' 'Blomidon' and 'Redchief' were highly susceptible to injury. 'Guardian' and 'Allstar' consistently fell into the middle range. 'Raritan,' 'Earliglow,' 'Redcoat,' 'Glooscap,' 'Cornwallis,' 'Catskill,' 'Surecrop,' and 'Midway' were inconsistent over the two years.

'Honeoye' produced the highest marketable yields by weight and number over the combined harvest periods, followed closely by 'Sparkle' and 'Canoga.' 'Kent,' 'Redcoat' and 'Catskill' had high yields in 1987, but much lower yields the following year. 'Veestar,' 'Earliglow,' 'Blomidon,' 'Cornwallis,' 'Mic Mac,' and 'Allstar' had the lowest yields. The remaining cultivars fell into a middle range not differing significantly from one another.

'Annapolis' fruit consistently was the largest, but also lowest in numbers. 'Allstar,' 'Canoga,' and 'Mic Mac' also had large fruit. 'Sparkle' and 'Veestar' consistently had the smallest fruit, followed by 'Redcoat,' 'Earliglow,' and 'Surecrop.'

There was a significant negative relationship between the amount of tarnished plant bug injury and marketable yield. Marketable yields were reduced by number ($r = -.63$) and by weight ($r = -.52$) as tarnished plant bug injury increased. There was no significant relationship between injury and fruit size.

Discussion

Significant and consistent differences in tarnished plant bug injury were

observed in this two year trial indicating resistance among the twenty cultivars studied. Cultivars such as 'Honeoye' and 'Sparkle' which were less susceptible to injury had consistently higher marketable yields than cultivars which were more susceptible, such as 'Mic Mac' and 'Blomidon.' 'Kent' was the exception, being both highly susceptible and relatively productive. This apparent anomaly may be explained by the large number of fruit produced by this cultivar.

Tarnished plant bug injury appeared greater when measured by fruit number rather than by weight. This is due to the injury being more prevalent on fruit developing later on the inflorescence, that is tertiary and quarternary fruit which tend to be smaller than primary and secondary fruit and thus weigh less regardless of injury. Despite this characteristic, cultivar susceptibility did not appear closely related to time of ripening. Some late ripening cultivars, such as 'Canoga' and 'Sparkle,' had little injury, while some early ripening cultivars, such as 'Earliglow' and 'Cornwallis,' had high injury levels. Therefore the differences observed in this trial are not simply attributable to the timing of insect activity with fruit development.

There is a possible genetic role in the range of susceptibility observed. 'Honeoye' and 'Canoga,' which had low susceptibility to injury, both have 'Holiday' as a parent, which, in a nonreplicated trial, had the lowest injury of any cultivar studied (Handley and Dill, unpublished data). 'Veestar,' and its parent 'Sparkle,' also had low susceptibility. 'Kent' and 'Mic Mac,' both highly susceptible to injury, share 'Tioga' as a parent, and 'Cornwallis,' for which 'Kent' was a parent, was also highly susceptible. 'Blomidon' however, which has 'Holiday' as a parent, was very susceptible, and 'Annapolis,' which has 'Mic Mac' as a grandparent, was not very susceptible.

Plant resistance to insects can include avoidance, nonpreference, tolerance and antibiosis (3). The mechanisms may be anatomical, physiological, biochemical, or phenological. The differences observed in this study may be due to one or a combination of these factors. The fact that significant differences exist indicates that investigations of the mode(s) of resistance and further screening of strawberry germplasm could yield effective control mechanisms for this important pest.

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Ozone Impact on Tree Fruit

Almond were more sensitive to ozone than peach or apricot. Foliar injury on almond occurred and growth was reduced. Apricot showed little foliar injury but developed a thinner trunk and more shoots than the untreated plants. Exposed peach trees had fewer shoots and thicker trunks.

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