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Resistance to Twospotted Spider Mite and Strawberry Aphid in *Fragaria chiloensis*, *F. virginiana*, and *F. ×ananassa* Clones

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Abstract. **More than 170 clones of *Fragaria ×ananassa* Duch., *F. chiloensis* (L.) Duch., and *F. virginiana* Duch. were tested for resistance to the twospotted spider mite (*Tetranychus urticae* Koch). Twenty-seven clones had >75% fewer mites than did *F. ×ananassa* 'Totem', a susceptible clone. About two-thirds of the clones also were tested for resistance to the strawberry aphid [*Chaetosiphon fragaefolii* (Cockerell)]. Survival and reproduction was significantly lower on two clones each of *F. ×ananassa* and *F. virginiana* than on 'Totem'.**

The twospotted spider mite (*Tetranychus urticae*) is a common pest of cultivated strawberries (*Fragaria×ananassa*). The strawberry aphid (*Chaetosiphon fragaefolii*) transmits several strawberry viruses. *Fragaria* clones vary considerably in their resistance to these pests, and these traits have been researched by several groups (Hancock et al., 1991). Giménez-Ferrer et al. (1993) reported further in vitro screening for mite resistance in strawberry cultivars. In greenhouse tests, Shanks and Garth (1992) reported on the resistance of plants of several *Fragaria* spp. clones to the strawberry aphid. They found that the strawberry aphid survived <5 days and reproduction ceased on aphid-resistant clones of *F. chiloensis* from California, Oregon, and Washington. Our paper reports the relative susceptibility of a large collection of *F. ×ananassa*, *F. chiloensis* from Chile, and *F. virginiana* clones to these pests in a greenhouse trial.

Materials and Methods

Thirty-nine cultivars and selections of *F. ×ananassa* [from the National Clonal Germplasm Repository (NCGR), Corvallis, Ore.; Sakuma Bros. Farms, Burlington, Wash.; and various breeders]; 32 clones of *F. chiloensis* collected in Chile in 1990 (Cameron et al., 1991); 20 clones of *F. virginiana* from Kentucky (11), New Hampshire (3), Oregon (2), Pennsylvania (1), Vermont (1), and Wyoming (2) (K. Hummer, NCGR); and 13 clones of *F. virginiana* from Minnesota and Wisconsin (Stahler, 1990) were included in this 1993 study. 'Totem', which is susceptible to the mite and aphid, was included as a standard.

Dormant runner plants were planted in a peat–perlite mixture in 2.3-liter plastic pots in Spring 1992 and kept in a greenhouse without supplemental heat or light. Fans kept temperatures near ambient, except if outside temperatures fell below –4C, heaters kept temperatures at –1 to 0C. Plants were fertilized weekly with 1.3 g of soluble 20N–20P–20K fertilizer (Peters Professional Water Soluble Fertilizer; Grace-Sierra, Milpitas, Calif.)/liter of water. Trace amounts of B, Cu, Fe, Mg, Mn, Mo, and Zn also were in the solution. Clones were replicated four times as single plants in a randomized complete-block design.

Spider mite counts typically begin increasing during the flowering period, reach a peak during harvest, and then rapidly decline (Chaplin et al., 1968; Inoue and Sugima, 1984; Marsden, 1974; Poe, 1971; Shanks and Doss, 1989). Therefore, mite counting began at the beginning of bloom and continued every 2 weeks until counts had declined. One leaflet was picked from each of three leaves per plant on each date, and the mites were counted. The six biweekly counts from each replication of each clone were totaled for the period 20 Apr. to 29 June 1993.

Resistance to the strawberry aphid first was measured by caging five 7- to 8-day-old nymphs on the underside of one leaflet on each

Table 1. Total number of twospotted spider mites on *Fragaria* clones from 20 April to 29 June 1993 in a greenhouse trial, Vancouver, Wash.

Clone	Species[z]	No. mites/three leaflets ± SE	Clone	Species[z]	No. mites/three leaflets ± SE
Totem	F ×a	408 ± 187	342-A-65	F ×a	226 ± 67
WSU 88061-5	B x Fc	37 ± 13	TDT 1D	Fc	228 ± 31
PNN 6A	Fc	55 ± 20	WSU 88061-2	B x Fc	231 ± 58
YEN 1H	Fc	55 ± 18	PUR 1A-2	Fc	240 ± 41
LCO 1C	Fc	56.3 ± 18	FRA 1180	Fv	240 ± 52
WSU 88061-4	B x Fc	76 ± 9	Gorella	F ×a	254 ± 67
TDT 5B	Fc	85 ± 16	M.S. 6-4	Fv	256 ± 57
FRA 472	Fv	90 (2 plants)	FRA 993	Fv	263 ± 35
Cavendish	F ×a	102 ± 38	Earliglow	F ×a	267 ± 78
YEN 1I	Fc	114 ± 28	FRA 1170	Fv	276 ± 67
MAU 1C	Fc	115 ± 47	FRA 960	Fv	279 ± 43
WSU 88061-6	B x Fc	118 ± 45	Pajaro	F ×a	282 ± 53
BAM 1E	Fc	119 ± 39	WSU 2068	F ×a	284 ± 67
YEN 1Q	Fc	119 ± 33	FRA 1007	Fv	289 ± 77
VAL 1A	Fc	120 ± 7	M.S. 12-6	Fv	292 ± 44
LCO 1D	Fc	120 ± 30	Gov. Simcoe	F ×a	299 ± 115
WSU 88061-3	B x Fc	121 ± 28	Senga Sengana	F ×a	308 ± 110
VIL 2A	Fc	124 ± 15	Sequoia	F ×a	310 ± 490
FRA 1178	Fv	127 ± 29	M.S. 4-12	Fv	316 ± 61
COY 11D	Fc	128 ± 34	FRA 552	Fv	316 ± 44
ANC 2D	Fc	130 ± 27	Glooscap	F ×a	320 ± 164
YEN 1P	Fc	132 ± 35	FRA 958	Fv	337 ± 59
YEN 1J	Fc	132 ± 37	M.S. 1-12	Fv	338 ± 18
Elsanta	F ×a	137 (1 plant)	Crimson King	F ×a	344 ± 61
TDC 1R	Fc	140 ± 23	BC 86-33-2	F ×a	353 ± 94
TDC 2B	Fc	140 ± 7	LCO 3H	Fc	363 ± 75
WSU 88061-1	B x Fc	140 ± 48	FRA 1179	Fv	364 ± 73
FRA 101	Fv	141 ± 17	Honeoye	F ×a	374 ± 35
TDC 6B	Fc	150 ± 16	White Pine	F ×a	375 ± 75
Annapolis	F ×a	162 ± 34	Parker	F ×a	381 ± 110
TDC 2D	Fc	164 ± 30	CA 71.98-605	F ×a	387 ± 82
TDC 1C	Fc	164 ± 30	Scott	F ×a	392 ± 62
M.S. 8-24	Fv	165 ± 49	M.S. 10-10	Fv	414 ± 129
YEN 1B	Fc	170 ± 12	Chandler	F ×a	431 (2 plants)

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Table 1. Continued.

Clone	Species[z]	No. mites/three leaflets ± SE	Clone	Species[z]	No. mites/three leaflets ± SE
M.S. 14-23	Fv	171 ± 40	Aiko	F ×a	432 ± 59
LON 3D	Fc	175 ± 36	Oso Grande	F ×a	453 ± 73
COY 10A	Fc	184 ± 11	Fern	F ×a	508 ± 111
Douglas	F ×a	188 ± 52	Capitola	F ×a	509 ± 123
Blomidon	F ×a	189 ± 59	FRA 1171	Fv	511 ± 54
M.S. 33-16	Fv	193 ± 23	Seascape	F ×a	552 ± 172
M.S. 24-1	Fv	196 ± 47	Muir	F ×a	602 ± 167
FRA 1176	Fv	198 ± 37	FRA 1173	Fv	619 ± 73
FRA 104	Fv	202 ± 11	Canoga	F ×a	622 ± 92
M.S. 30-15	Fv	203 ± 29	Selva	F ×a	639 ± 176
M.S. 34-4	Fv	204 ± 36	Tristar	F ×a	640 ± 70
Cardinal	F ×a	207 (3 plants)	FRA 1177	Fv	643 ± 146
Redcrest	F ×a	211 ± 15	CA 69.72-101	F ×a	658 ± 121
Bountiful	F ×a	212 ± 71	Seneca	F ×a	694 ± 216
M.S. 27-22	Fv	218 ± 70	Tillikum	F ×a	748 ± 109
FRA 994	Fv	223 ± 16	FRA 1181	Fv	837 ± 238
Shuswap	F ×a	224 ± 72	FRA 1182	Fv	901 ± 168
M.S. 21-5	Fv	226 ± 47	FRA 1174	Fv	946 ± 178

[z]F ×a = *Fragaria* ×*ananassa,* Fc = *F. chiloensis* (Chile), Fv = *F. virginiana* (eastern North America), B x Fc = *F.* ×*ananassa* 'Benton' x *F. chiloensis* clone CL-5.

of four plants of each clone (Shanks and Garth, 1992). Five days later, the number of survivors (which by then were adults) and nymphs produced were counted. Clones that showed resistance were tested a second time in the same manner, except that the aphids were left on the leaflets for 10 days and the total number of aphids were counted.

Standard errors of the means were calculated for data from screening 171 clones against mites and aphids (Tables 1–3). The data from the longer-term testing against aphids (Table 4) were subjected to analysis of variance for a complete-block design, and means were compared by Tukey's HSD test (Siegel, 1992).

In 1994, two clones of *F. virginiana* from Kentucky, one from Maryland, two from Montana, one from New Hampshire, and one from Washington (all from K. Hummer, NCGR) were tested for resistance to the twospotted spider mite and strawberry aphid as previously described. Mites were counted biweekly from 27 Apr. to 7 July 1994. Also in 1994, 60 clones of *F. chiloensis* that were collected in Chile in 1992 (Cameron et al., 1993) were evaluated. Our collection provided a diverse collection of germplasm from cultivated and wild octaploid *Fragaria* spp.

Results and Discussion

Spider mite. Spider mite populations varied from 37.0 to 946 mites per three leaflets in the 1993 trial (Table 1). Eight clones had ≥75% fewer mites than the susceptible standard ('Totem'), and 44 clones had >50% fewer than 'Totem'. 'Cavendish' was the only *F.* ×*ananassa* clone among the eight most resistant clones. WSU 88061-5 and WSU 88061-4 were from a 'Benton' x *F. chiloensis* 'CL-5' cross. Four were *F. chiloensis* from Chile (Cameron et al., 1991). The large proportion of Chilean *F. chiloensis* that seems to be resistant probably was due to their earlier selection as potentially resistant in an unreplicated trial of >200 clones of *F. chiloensis* from Chile (C.H.S., unpublished data). The only *F. virginiana* clone that seemed to be resistant was FRA 472 (v. *platypetala*) from Oregon.

In the 1994 trial, 19 Chilean *F. chiloensis* clones had ≥90% fewer mites than did 'Totem' (susceptible), and two (FUT-5A and CPU-1A) had 99% fewer than 'Totem' on 5 July (Table 2). Fifteen clones had fewer mites than *F. chiloensis* mite-resistant clone CL-5 (C.H.S., unpublished data). Some of the most resistant clones were evaluated for an additional 4 weeks because there was an upsurge in mite counts between 19 June and 5 July on some. On 2 Aug., cumulative mite counts on those clones were still much less than on 'Totem', and mite populations had not increased.

In the 1994 trial, *F. virginiana* clones averaged from 144.0 ± 51.3 to 1423 ± 51 mites per three leaflets from 28 Apr. to 7 July, while 'Totem' averaged 422 ± 187 mites per three leaflets (Table 2). Most (77%) of the mites on FRA 98 occurred on 7 July, so it was not considered to be resistant. Other clones also did not show mite resistance.

Among 21 clones that were included by Giménez-Ferrer et al. (1993) and in our studies (Table 3), those rated intermediate to highly susceptible to twospotted spider mite by the former also were susceptible in our study. 'Totem' was intermediate in relative susceptibility in both studies, but from a practical standpoint, it has been susceptible to spider mites (Barritt and Shanks, 1981; Shanks and Barritt, 1980). Many of the clones ranked intermediate to highly resistant to spider mites by Giménez-Ferrer et al. (1993) were nearly as or more susceptible than 'Totem' in our study. This variation could have been due to environmental differences or a difference in screening method. Giménez-Ferrer et al. (1993) used only one bioassay per clone taken on 1 day during 2 weeks. Shanks and Doss (1989) showed that susceptibility of 'Totem' changed greatly within 2 weeks and cited several other papers that reported similar rapid population declines of spider mites on other strawberry clones.

The level of resistance to spider mites in clones such as 'Annapolis' and 'Cardinal' is certainly preferable to that of 'Totem' and

Table 2. Total number of spider mites on *Fragaria* spp. clones from 28 Apr. 1994 to the indicated dates.

	Cumulative no. mites/three leaflets[z]		
Clone[y]	5 July	19 July	2 Aug.
	F. chiloensis *from Chile*[x]		
Totem	774 ± 222	822 ± 253	838 ± 246
CL-5	45 ± 15	48 ± 17	50 ± 19
CIS-1A	1504 ± 235		
FUT-6A	915 ± 266		
TAP-2A	538 ± 195		
QUI-1A	523 ± 219		
TAP-4C	421 ± 83		
SIM-1A	407 ± 135		
TAP-4A	402 ± 128		
CAM-1B	381 ± 221		
CAR-1A	346 ± 74		
COC-9A	311 ± 212		
COC-3A	288 ± 80		
MAR-1A	282 ± 37		
TAP-4B	279 ± 79		
CAR-4A	260 ± 223		
GRA-1A	248 ± 107		
MAR-1B	245 ± 135		
CAM-1A	244 ± 83		
BER-1A	232 ± 128		
TAP-3A	219 ± 66		
TAP-1A	209 ± 73		
CHY-1A	200 ± 127		
COC-4A	198 ± 33		
CAR-3B	189 ± 67		
CAM-1C	171 ± 140		
BAR-1A	168 ± 71		
CUC-1A	157 ± 71		
PAL-2B	156 ± 59		
VAL-1A	150 ± 93		
CAR-2A	149 ± 32		
COC-6A	137 ± 51		
COC-7A	137 ± 60		
BAK-2A	124 ± 49		
MAL-1A	122 ± 58		
MAL-2A	119 ± 49		
COC-2A	115 ± 65		
COC-5A	109 ± 65		
PAL-2A	84 ± 38	169 ± 53	
PAL-1A	84 ± 36	144 ± 44	
COC-1A	78 ± 17	80 ± 17	
QUI-2A	70 ± 37	139 ± 33	
BRA-1A	67 ± 45	89 ± 42	
GUA-1A	65 ± 54	125 ± 55	
COC-8A	59 ± 23	64 ± 24	
FUT-5B	31 ± 11	44 ± 10	
BRA-1B	30 ± 14	51 ± 11	
PAL-2C	26 ± 18	58 ± 23	64 ± 24
YEL-1A	26 ± 10	78 ± 32	96 ± 32
TOR-1A	24 ± 11	43 ± 10	
PAL-4A	24 ± 20	44 ± 17	
CPU-2A	24 ± 9	48 ± 20	49 ± 20
FUT-4A	22 ± 9	102 ± 19	117 ± 16
PUQ-1A	18 ± 12	78 ± 31	92 ± 31
GBN-1A	17 ± 14	27 ± 13	
CAE-1A	14 ± 10	55 ± 21	66 ± 20
FUT-4B	13 ± 7	42 ± 23	46 ± 26
AMA-2A	11 ± 4	42 ± 14	124 ± 58
FUT-5A	7 ± 1	25 ± 9	43 ± 22
CPU-1A	7 ± 3	20 ± 11	23 ± 13
	F. virginiana[w] *7 July*		
Totem	422 ± 187		
CL-5	16 ± 5		
FRA 98	144 ± 51		
FRA 434	193 ± 91		
FRA 381	307 ± 28		
FRA 67	430 ± 153		
FRA 560	577 ± 72		
FRA 1184	936 ± 104		
FRA 1172	1423 ± 152		

[z]Number of mites ± SE.
[y]'Totem' is mite-susceptible standard; CL-5 is mite-resistant *F. chiloensis* standard.
[x]Cameron et al., 1993.
[w]State of origin is as follows: FRA 98, Montana; FRA 434, Washington; FRA 381, New Hampshire; FRA 67, Maryland; FRA 560, Montana; FRA 1184, Kentucky; FRA 1172, Kentucky.

Table 3. Comparison of data from two studies on strawberry resistance to twospotted spider mite.

Clone	Ranking[z]	Current study: Percent Totem	Current study: Percent Canoga
Canoga	HS[y]	153	100[x]
Scott	S	96	63
Tristar	I–S	157	103
Selva	I–S	157	103
Muir	I–S	148	97
Oso Grande	I–S	111	73
Honeoye	I–S	92	60
Crimson King	I–S	84	55
Totem	I–S	100[w]	66
Blomidon	I–R	46	30
Earliglow	I–R	66	43
Chandler	I–R	90	59
Douglas	R	46	30
Govenor Simcoe	R	73	48
Glooscap	R	79	51
Parker	R	94	61
Annapolis	HR	40	26
Cardinal	HR	51	33
Pajaro	HR	69	45
Aiko	HR	106	69
Fern	HR	124	82

[z]Rank according to oviposition on leaf disks (Giménez-Ferrer et al., 1993).
[y]HS = highly susceptible, S = susceptible, I–S = intermediate to susceptible, I–R = intermediate to resistant, R = resistant, HR = highly resistant.
[x]'Canoga' was the most susceptible clone in this study and had a total of 622 mites per leaflet.
[w]'Totem' was the mite-susceptible clone in our study and had a total of 408 mites per leaflet.

Table 4. Five-day survival of strawberry aphids on various clones of *Fragaria.*

Clones	Mean no. survivors (± SE)[z]	Mean no. nymphs (± SE)	Clone	Mean no. survivors (± SE)	Mean no. nymphs (± SE)
Expt. 1—Fragaria chiloensis[y]					
Totem[x]	4.8 ± 0.25	13.0 ± 1.6	TDC 1R	4.5 ± 0.50	11.0 ± 4.6
PNN 6A	0.8 ± 0.75	4.0 ± 4.0	YEN 1H	4.5 ± 0.50	10.0 ± 4.3
LCO 1D	3.3 ± 1.03	8.8 ± 4.7	ANC 2D	4.8 ± 0.25	10.5 ± 1.6
YEN 1B	3.3 ± 0.85	13.5 ± 4.0	LCO 1C	4.8 ± 0.25	15.0 ± 5.5
WSU 88061-2	3.5 ± 1.19	12.8 ± 5.8	LCO 3H	4.8 ± 0.25	21.3 ± 2.8
WSU 88061-5	3.5 ± 0.65	9.5 ± 4.7	LON 3D	4.8 ± 0.25	12.3 ± 3.2
TDT 5B	3.5 ± 0.87	9.8 ± 2.1	PUR 1A-2	4.8 ± 0.25	14.0 ± 4.9
TDC 2D	3.8 ± 0.95	6.3 ± 2.9	TDC 1C	4.8 ± 0.25	20.3 ± 3.2
WSU 88061-6	3.8 ± 0.95	6.5 ± 3.2	TDC 2B	4.8 ± 0.30	18.5 ± 2.2
YEN 1Q	3.8 ± 0.75	9.5 ± 3.9	YEN 1I	4.8 ± 0.25	17.5 ± 1.8
VAL 1A	4.0 ± 0.41	8.3 ± 3.5	YEN 1J	4.8 ± 0.25	18.8 ± 4.5
WSU 88061-4	4.3 ± 0.25	6.5 ± 2.3	YEN 1P	4.8 ± 0.25	18.8 ± 4.4
BAM 1E	4.3 ± 0.25	5.3 ± 2.2	WSU 88061-3	5.0 ± 0	14.0 ± 1.7
COY 11D	4.3 ± 0.25	11.3 ± 3.1	COY 10A	5.0 ± 0	19.3 ± 4.7
TDC 6B	4.3 ± 0.48	9.0 ± 3.7	TDT 1D	5.0 ± 0	12.0 ± 6.3
WSU 88061-1	4.5 ± 0.29	9.3 ± 3.8	VIL 2A	5.0 ± 0	18.5 ± 2.4
MAU 1C	4.5 ± 0.50	10.8 ± 5.1			
Expt. 2—Fragaria virginiana[y]					
Totem	4.8 ± 0.25	11.3 ± 2.6	M.S. 34-4	4.3 ± 0.25	8.5 ± 2.7
M.S. 30-15	0.3 ± 0.25	0.0 ± 0	FRA 1170	4.5 ± 0.29	3.5 ± 2.4
M.S. 6-4	0.5 ± 0.29	1.3 ± 1.3	FRA 1178	4.5 ± 0.29	8.8 ± 4.3
FRA 1181	1.8 ± 0.75	3.3 ± 2.9	FRA 1180	4.5 ± 0.29	6.8 ± 4.3
M.S. 4-12	2.8 ± 0.48	4.3 ± 2.3	FRA 960	4.5 ± 0.29	11.5 ± 5.6
FRA 1171	3.0 ± 0.71	6.0 ± 3.7	M.S. 1-12	4.5 ± 0.50	17.8 ± 6.8
FRA 958	3.5 ± 0.87	9.0 ± 3.2	M.S. 33-16	4.5 ± 0.29	6.8 ± 3.1
FRA 552	3.8 ± 0.95	5.5 ± 2.2	FRA 101	4.8 ± 0.25	13.8 ± 2.0
FRA 994	3.8 ± 0.95	13.3 ± 5.7	FRA 1174	4.8 ± 0.25	4.3 ± 3.9
M.S. 27-22	3.8 ± 1.25	10.0 ± 4.0	FRA 1179	4.8 ± 0.25	13.3 ± 1.9
M.S. 10-10	4.0 ± 1.00	14.5 ± 7.8	FRA 1182	4.8 ± 0.25	9.5 ± 3.4
M.S. 14-23	4.0 ± 0.41	7.5 ± 0.6	FRA 472	4.8 ± 0.25	14.8 ± 3.8
M.S. 24-1	4.0 ± 0.71	4.5 ± 2.6	FRA 993	4.8 ± 0.25	12.5 ± 2.2
FRA 1007	4.3 ± 0.75	9.0 ± 3.5	M.S. 12-6	4.8 ± 0.25	10.5 ± 4.7
FRA 1173	4.3 ± 0.75	8.3 ± 1.7	FRA 104	5.0 ± 0	16.8 ± 4.4
FRA 1177	4.3 ± 0.75	14.8 ± 1.0	FRA 1176	5.0 ± 0	10.3 ± 1.7
M.S. 21-5	4.3 ± 0.75	7.3 ± 1.8	M.S. 8-24	5.0 ± 0	8.3 ± 2.3
Expt. 3—Fragaria ×ananassa[y]					
Totem	4.0 ± 0.58	6.3 ± 2.5	Douglas	3.3 ± 0.48	5.5 ± 2.1
Scott	0.5 ± 0.29	0.3 ± 0.3	Muir	3.3 ± 1.03	6.0 ± 3.6
Canoga	1.0 ± 0.71	3.8 ± 1.9	Oso Grande	3.3 ± 1.11	3.3 ± 2.0
Gov. Simcoe	1.0 ± 0.41	5.0 ± 4.1	Tillikum	3.3 ± 1.18	11.8 ± 6.6
Elsanta	1.3 ± 0.75	0.5 ± 0.3	CA. 71.98-605	3.3 ± 0.75	8.5 ± 5.1
CA. 69.72-101	1.5 ± 1.19	1.3 ± 0.8	Cardinal	3.5 ± 0.50	4.8 ± 1.4
Capitola	1.8 ± 1.18	1.8 ± 1.0	Earliglow	3.5 ± 1.19	1.5 ± 1.0
Seascape	2.0 ± 0.91	3.0 ± 2.4	Senga Sengana	3.5 ± 1.19	4.0 ± 2.5
Seneca	2.0 ± 1.00	3.3 ± 2.9	Aiko	3.8 ± 1.25	1.5 ± 0.9
342-A-65	2.0 ± 1.15	11.3 ± 3.8	Blomidon	4.0 ± 0.71	8.0 ± 4.1
WSU 2068	2.0 ± 1.08	0.8 ± 0.8	Cavendish	4.0 ± 0.71	8.3 ± 3.4
Gorella	2.3 ± 1.11	3.8 ± 2.3	Honeoye	4.0 ± 0.58	8.8 ± 2.9
Parker	2.3 ± 0.95	2.0 ± 0.8	Sequoia	4.0 ± 1.00	8.0 ± 2.4
Fern	2.5 ± 0.87	3.3 ± 1.9	BC 86-33-2	4.0 ± 0.71	12.3 ± 3.6
Shuswap	2.5 ± 0.50	6.0 ± 2.3	Glooscap	4.3 ± 0.48	12.8 ± 6.5
Pajaro	2.8 ± 1.31	4.8 ± 2.5	Redcrest	4.3 ± 2.5	9.8 ± 2.5
Selva	2.8 ± 1.11	11.3 ± 9.4	Tristar	4.5 ± 0.5	8.3 ± 3.6
White Pine	3.0 ± 0.82	1.8 ± 0.5	Annapolis	4.8 ± 0.25	10.8 ± 2.0
Chandler	3.3 ± 0.85	4.5 ± 3.8	Bountiful	5.0 ± 0	21.0 ± 2.4
Crimson King	3.3 ± 1.18	1.5 ± 0.9			

[z]Five aphids per replicate.
[y]See Table 1 for source of each clone.
[x]Susceptible standard.

other even more susceptible clones. However, there is a large amount of mite-resistant germplasm available, which should make it possible to develop even higher levels of resistance to spider mites in strawberries. The clones 'Cavendish', WSU 88061-4, and WSU 88061-5 are examples of *F. ×ananassa* with lower susceptibility to spider mites. Also, several *F. chiloensis* and *F. virginiana* clones had high levels of mite resistance compared to other resistant clones. This pool of germplasm should be useful to strawberry breeders in developing spider-mite-resistant cultivars, which would reduce or eliminate the need for chemical acaricides.

Aphids. PNN 6A, M.S. 30-15, M.S. 6-4, and 'Scott' were the only clones of the three *Fragaria* species showing any evidence for aphid resistance in the 5-day test (Table 4). Aphids had high survival and reproductive rates on most of the clones tested. One *F. chiloensis*, three *F. virginiana*, and six *F. ×ananassa* were selected for the 10-day test because they averaged less than two survivors per leaflet in the 5-day test. WSU 2068 also was included because few nymphs were produced in the 5-day test. In the 10-day test, M.S. 6-4, M.S. 30-15, 'Scott', and 'Elsanta' had >90% fewer aphids than did 'Totem' after 10 days (Table 5). PNN 6A was the only clone to show resistance to spider mites and the strawberry aphid and was only moderately resistant to aphids in the 10-day aphid test.

Aphid-borne viruses are a problem to the strawberry industry, although most currently grown cultivars have some tolerance to viruses bred into them. Resistance to the strawberry aphid, the principal vector of strawberry viruses, would be an additional defense against these pathogens. Swenson (1968) stated that any factor that consistently reduces aphid populations can be expected to reduce virus spread. This is the principle behind an area-wide spray program for reducing strawberry aphid populations and virus dissemination in the Pacific Northwest (Shanks, 1986). Using aphid-resistant cultivars would reduce or eliminate the need for the aphicide sprays.

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Table 5. Total number of adult and immature strawberry aphids on strawberry clones after 10 days.

Clone[z]	Mean no. aphids/replicate (± SE)[y, x]
M.S. 30-15	0.0 ± 0 a
Scott	0.6 ± 0.6 ab
M.S. 6-4	1.2 ± 0.8 a–c
Elsanta	2.0 ± 1.0 a–d
Canoga	6.2 ± 1.0 a–e
PNN 6A	7.4 ± 1.1 a–e
CA. 69.72-101	9.5 ± 0.6 a–e
FRA 1181	11.4 ± 0.2 b–e
Capitola	15.7 ± 0.4 c–e
Gov. Simcoe	16.1 ± 0.4 c–e
Totem[w]	24.0 ± 0.3 de
WSU 2068	29.3 ± 0.1 e

[z]See Table 1 for source of *Fragaria chiloensis* and *F. virginiana* clones.

[y]Four replicates.

[x]Data transformed to log(X + 1) before analysis and transformed to original scale for presentation. Numbers followed by the same letter are not significantly different at $P \leq 0.05$ using Tukey's HSD test.

[w]Aphid-susceptible standard.

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