

Variation in the Horticultural Characteristics of Native *Fragaria virginiana* and *F. chiloensis* from North and South America

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ABSTRACT. Variation in 14 horticultural traits of native octoploid *Fragaria* L. from North and South America was examined in a greenhouse. Significant levels of variation were found for all but a few of the traits at the species, subspecies, regional and genotypic level, with the highest amount of variation generally being partitioned among genotypes. *Fragaria chiloensis* (L.) Miller was superior to *F. virginiana* Miller for crown number, fruit weight, soluble solids and seed set, while *Fragaria virginiana* was superior for runner production, peduncle length, fruit number, fruit color and winter hardiness. *Fragaria chiloensis* ssp. *pacifica* Staudt had the highest soluble solids and among the earliest bloom dates, highest crown numbers and highest seed set. *Fragaria chiloensis* ssp. *chiloensis* f. *chiloensis* (L.) Duch. produced the largest fruit and among the earliest bloom dates and longest peduncles. *Fragaria chiloensis* ssp. *chiloensis* f. *patagonica* (L.) Duch. had among the highest crown numbers and the highest percentage seed set. *Fragaria virginiana* ssp. *platypetala* (Rydb.) Staudt produced the most crowns and its fruit ripened earliest. *Fragaria virginiana* ssp. *glauca* (Wats.) Staudt were the latest flowering, had the darkest fruit color and the most flowering cycles. *Fragaria virginiana* ssp. *virginiana* Duch. displayed the most winter dieback, the longest peduncles, and the highest flower and runner numbers. No significant differences were observed in any of the examined traits between *F. chiloensis* ssp. *pacifica* and *F. chiloensis* ssp. *lucida*, or *F. virginiana* ssp. *grayana* and *F. virginiana* ssp. *virginiana*. A number of individual genotypes were superior for more than one trait. CFRA 0024 possessed unusually high crown numbers, was extremely early blooming and displayed multiple fruiting cycles. CFRA 1121 had unusually long peduncles and much higher than average values for fruit weight, soluble solids, fruit color and seed set. CFRA 0094 was extremely early flowering and had much darker fruit color than most other *F. chiloensis* genotypes. CFRA 0368 flowered unusually early and had among the largest fruit. CFRA 0366 possessed unusually long peduncles and the largest fruit of any North American genotype. CFRA 0560 and CFRA 1369 had an unusual combination of multiple flowering cycles and high runner production. CFRA 1170 and 1171 were unusually late fruiting and had high numbers of large fruit on long peduncles. CFRA 1385 and JP 95-3-1 had extremely high flower numbers, long peduncles and large fruit.

The cultivated strawberry, *Fragaria ×ananassa* Duchesne in Lamarck, was the product of an accidental hybridization of *F. virginiana* Miller and *F. chiloensis* Miller in the 18th century. These species are completely inter-fertile and have many complimentary traits. Even after dozens of rounds of selection, Darrow (1966) was able to trace many of the morphological traits found in *F. ×ananassa* to one of the progenitor species.

While the germplasm base of *F. ×ananassa* remains narrow (Dale and Sjulín, 1990; Hancock and Luby, 1995; Sjulín and Dale, 1987), genes from native clones have been successfully incorporated into cultivars in a number of instances. Most notable was the capture of day-neutrality from a wild clone of *F. virginiana* ssp. *glauca* from the Wasatch Mountains of Utah by Bringhurst and Voth (1984). Other recent, successful infusions of wild germplasm include two other genotypes of *F. virginiana* from the Rocky Mountains and three genotypes of *F. chiloensis* from Northern California, the Pacific Northwest and Ecuador (Finn et al., 1998; Moore et al., 1995; Sjulín and Dale, 1987).

Key to using native germplasm in plant breeding is to catalog their horticulturally useful traits. Numerous studies have compared the horticultural characteristics of the octoploid strawberry species (Hancock, 1999; Luby et al., 1991), but most of these studies have been only regional in scope. These include: Californian *F. chiloensis* (Hancock and Bringhurst, 1979), Pacific northwestern *F. chiloensis*

(Catling and Poerbski, 1998; Luffman and MacDonald, 1993), Chilean *F. chiloensis* (Cameron et al., 1993; Lavín, 1997; Lavín et al., 2000), Rocky Mountain *F. virginiana* ssp. *glauca* (Hokanson et al., 1993; Sakin et al., 1997), Minnesotan *F. virginiana* ssp. *virginiana* (Luby and Stahler, 1993) and Ontarian *F. virginiana* (Dale et al., 1993). The most broadly encompassing studies have been those of Harrison et al. (1997, 2000), who used a combination of horticultural and taxonomic traits to evaluate eco-geographical relationships in the sub-species of *F. virginiana* across the northern United States, and Poerbski and Catling (1998) who employed primarily taxonomic characters to study relationships among the various subspecies of *F. chiloensis*.

While these comparisons give us clues about which genotypes of *F. virginiana* and *F. chiloensis* have the most desirable traits, ultimately the two species need to be grown together to accurately contrast their individual patterns of quantitative variation. The previous studies have been conducted on single species or subspecies under a wide range of greenhouse and field conditions, and as a result, patterns of variation among the various taxa cannot be directly compared. We recently evaluated a limited collection of elite native clones from both species at five locations across the United States, and found significant variation among taxa for percentage bed fill, foliar disease incidence, fruit weight and flesh color (Hancock et al., 2000, 2001). Herein, we describe a much more comprehensive greenhouse screen of 258 wild strawberry genotypes from North and South America. Our goals were to more

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thoroughly describe patterns of eco-geographical variability within the octoploid taxa, and search for additional elite selections that might be useful in plant breeding.

Material and Methods

The bulk of the collection was kindly provided by Kim Hummer, director of the National Clonal Germplasm Repository (NCGR), Corvallis, Ore.; 25 of the selections were maintained at Michigan State University (MSU). The collection represented all octoploid taxa of North and South American *Fragaria* including: *F. chiloensis* ssp. *chiloensis* f. *chiloensis* (10 genotypes), *F. chiloensis* ssp. *chiloensis* f. *patagonica* (31 genotypes), *F. chiloensis* ssp. *pacifica* (56 genotypes), *F. virginiana* ssp. *glauca* (27 genotypes), *F. virginiana* ssp. *grayana* (6 genotypes), *F. virginiana* ssp. *platypetala* (20 genotypes) and *F. virginiana* ssp. *virginiana* (108 genotypes). An attempt was made to incorporate as much of the geographical range of each taxa as was possible within the existing collections. For more complete details on where the individual genotypes were collected, consult www.berrygenetic.com.

Young runner plants were placed under intermittent mist for rooting in a commercial peat-perlite soil mixture in April 1999. The runner plants were obtained from greenhouse grown mother plants either collected fresh at MSU or sent from NCGR by overnight mail in plastic bags. After ≈2 weeks, the rooted runners were set into 12 × 12 × 25-cm pots in the same commercial soil mixture. Two replications of each genotype were set in a completely randomized

design on four greenhouse benches in a single greenhouse at MSU under natural light. Plants were irrigated, fertilized and protected from various pests and diseases as needed. Runners were removed periodically in the first growing season. Temperatures in the unheated greenhouse ranged from 20 to 32 °C during the summer and 3 to 17 °C during the winter.

In early February 2000, the percentage of leaves of each plant that had died-back during the late fall and winter was estimated in 10% intervals. During the first week of March 2000, the number of crowns produced by each mother plant was determined. When flowering began in April and continuing until October, the presence or absence of flowers on each plant was recorded on a weekly basis. A genotype was considered multiple cropping if flowering episodes were separated by at least 3 weeks. At the conclusion of the first flowering period for each plant, the number of flowers per inflorescence was measured on three random inflorescences, and their lengths were measured from crown to tip. A camel hairbrush was used to mix pollen from all open flowers in the greenhouse on a 3- to 4-d sequence. The first three ripe fruit of each genotype were weighed and analyzed for soluble solids using a hand-held refractometer. The percentage of ovules that were fully developed on each fruit were estimated by 10% intervals; their skin and flesh color was evaluated on a scale of 1 to 9 (white to deep red). During the last week of August, the total number of runners produced by each plant was recorded.

Model variance components were estimated using the SAS procedures (SAS Inst., Inc., 1990). Variance was partitioned into

Table 1. Mean, standard deviation, and range (in parenthesis) for 14 horticultural traits of *Fragaria chiloensis* and *F. virginiana* compared in a greenhouse at Michigan State University, East Lansing.

	<i>F. chiloensis</i>							
	ssp. <i>chiloensis</i>				<i>F. virginiana</i>			
	f. <i>chiloensis</i>	f. <i>patagonica</i>	<i>lucida</i>	<i>pacifica</i>	<i>glauca</i>	<i>grayana</i>	<i>platypetala</i>	<i>virginiana</i>
Winter dieback (%)	17.1 ± 9.4 (10.0–39.2)	19.0 ± 9.8 (10.0–56.8)	14.8 ± 7.4 (10.0–39.2)	18.8 ± 10.0 (10.0–56.8)	42 ± 15.3 (10–77.1)	46.0 ± 13.0 (18.4–77.1)	27.1 ± 11.6 (10.0–50.8)	46.5 ± 13.7 (10.0–77.1)
Crown number	3.0 ± 2.3 (1.0–9.0)	3.4 ± 2.1 (1.0–13.0)	2.9 ± 1.2 (1.0–6.0)	3.6 ± 2.1 (1.0–10.0)	3.3 ± 1.4 (1.0–9.0)	2.7 ± 1.3 (1.0–7.0)	3.5 ± 1.7 (1.0–8.0)	2.4 ± 1.1 (1.0–6.0)
Runner number	17.4 ± 15.3 (3.0–60.0)	15.0 ± 10.7 (0.0–47.0)	27.3 ± 14.3 (6.0–62.0)	19.3 ± 13.7 (0.0–55.0)	13.3 ± 13.2 (0.0–46.0)	24.8 ± 12.7 (0.0–65.0)	20.2 ± 16.0 (0.0–71.0)	26.5 ± 13.1 (0.0–66.0)
Bloom start	110 ± 31 (67–182)	114 ± 32 (67–209)	119 ± 40 (67–202)	118 ± 39 (67–207)	131 ± 40 (74–313)	123 ± 31 (67–232)	126 ± 42 (67–202)	130 ± 31 (74–197)
Bloom end	137 ± 34 (97–202)	142 ± 35 (88–216)	145 ± 33 (104–209)	146 ± 41 (74–232)	161 ± 46 (97–313)	147 ± 34 (74–232)	151 ± 42 (88–216)	157 ± 37 (81–243)
Bloom cycles	2.0 ± 0.8 (1.0–4.0)	1.7 ± 0.7 (1.0–4.0)	1.7 ± 0.8 (1.0–4.0)	1.8 ± 0.8 (1.0–4.0)	2.4 ± 1.0 (1.0–5.0)	1.5 ± 0.7 (1.0–4.0)	1.8 ± 0.7 (1.0–3.0)	1.7 ± 0.9 (1.0–5.0)
Peduncle length (cm)	6.0 ± 2.7 (2.6–12.0)	3.4 ± 1.7 (1.0–7.2)	3.1 ± 1.7 (0.8–7.5)	3.7 ± 2.3 (0.8–10.2)	5.3 ± 2.8 (1.4–12.0)	7.5 ± 3.0 (0.8–13.5)	5.4 ± 3.6 (1.5–13.5)	6.7 ± 2.9 (1.0–13.0)
Fruit number	4.0 ± 3.1 (1.0–14.0)	2.2 ± 0.9 (1.0–4.0)	4.1 ± 4.2 (1.0–20.0)	2.6 ± 1.3 (1.0–7.0)	3.6 ± 2.2 (1.0–10.0)	5.6 ± 2.7 (1.0–16.0)	3.5 ± 2.3 (1.0–9.0)	5.1 ± 2.7 (1.0–18.0)
Harvest date	144 ± 19 (121–179)	142 ± 15 (117–179)	158 ± 13 (140–167)	142 ± 13 (126–174)	146 ± 21 (118–197)	146 ± 15 (107–176)	141 ± 14 (118–166)	150 ± 17 (120–209)
Fruit weight (g)	2.2 ± 1.6 (1.1–5.9)	1.3 ± 1.0 (0.6–5.7)	0.8 ± 0.5 (0.4–1.6)	1.7 ± 1.7 (0.3–7.7)	0.6 ± 0.3 (0.2–1.3)	1.0 ± 0.6 (0.2–3.2)	0.6 ± 0.3 (0.3–1.1)	0.9 ± 0.6 (0.2–2.8)
Soluble solids (%)	9.1 ± 2.0 (5.2–12.7)	8.7 ± 1.6 (5.0–11.7)	10.0 ± 0.9 (9.0–11.0)	10.4 ± 2.1 (6.0–14.0)	8.0 ± 1.6 (4.0–10.0)	8.3 ± 1.7 (5.4–13.6)	9.2 ± 2.1 (6.2–12.6)	7.8 ± 1.6 (4.8–12.5)
Skin color	5.3 ± 2.8 (1.8–8.5)	6.5 ± 2.0 (1.0–9.0)	7.2 ± 1.0 (1.0–8.0)	4.9 ± 1.9 (1.0 ± 8.0)	7.1 ± 1.1 (4.0–8.6)	6.2 ± 1.7 (1.0–9.0)	5.7 ± 2.2 (2.0–8.5)	6.7 ± 1.2 (3.0–9.0)
Flesh color	4.8 ± 2.6 (1.3–7.5)	6.2 ± 2.1 (1.0–9.0)	6.6 ± 1.9 (4.0–8.0)	4.3 ± 1.9 (1.0–9.0)	6.9 ± 1.4 (3.0–8.3)	6.1 ± 1.6 (3.0–9.8)	5.8 ± 1.8 (2.4–8.0)	6.4 ± 1.3 (2.0–9.0)
Seed set (%)	53.0 ± 15.6 (26.6–71.6)	64.0 ± 9.8 (32.2–77.1)	57.3 ± 21.0 (33.2–71.6)	63.8 ± 10.4 (30.0–73.6)	48.8 ± 14.4 (18.4–77.1)	52.0 ± 11.0 (26.6–71.6)	61.0 ± 11.0 (45–71.6)	51.8 ± 13.0 (18.4–71.6)

species, subspecies, location, genotype and error. Mean values for only the most superior genotypes are provided in this publication; results for all other genotypes can be found at www.berrygenetics.org.

Results

Most of the subspecies displayed significant differences for individual traits, except *F. chiloensis* ssp. *pacifica* and *F. chiloensis* ssp. *lucida*, and *F. virginiana* ssp. *grayana* and *F. virginiana* ssp. *virginiana* (Table 1). *Fragaria virginiana* ssp. *grayana* tended to have more, slightly larger fruit than *F. virginiana* ssp. *virginiana*, but the ranges of the two species overlapped substantially and the means were not significantly different. Because these subspecies showed little difference, they were lumped together in the subsequent ANOVA analysis into either *F. chiloensis* ssp. *lucida* or *F. virginiana* ssp. *virginiana*. This allowed us to more effectively examine for regional variation by increasing the sample sizes of *F. chiloensis* in the Pacific Northwest and *F. virginiana* in the

midwestern and southeastern United States. As will be discussed below, the taxonomic separation of these subspecies has been questioned (Porebski and Catling, 1998; Rydberg, 1898).

For all the traits but percentage winter dieback, peduncle length, fruit number and seed set, more variation was partitioned among genotypes than either species, subspecies or region (Table 2). Most of the variation in seed set was partitioned into species, while the majority of the variation in winter dieback was among species and subspecies. For peduncle length, the variation was distributed relatively evenly among species, subspecies, region and genotype. The highest amount of variation in fruit number was partitioned into subspecies.

A much higher percentage of *F. virginiana* leaves (43%) died back in early winter than *F. chiloensis* (18%) (Table 2, Fig. 1). Overall, there was little geographical pattern observed among subspecies and taxa, with four exceptions. The most northern collections of *F. chiloensis* ssp. *lucida* from Alaska (33%) and British Columbia (28%) had significantly more dieback than the

Table 2. Analysis of variance for 13 horticultural traits of *Fragaria chiloensis* and *F. virginiana* compared in a greenhouse at Michigan State University, East Lansing.

Source	N	Winter dieback		Crown no.	Runner no.	Bloom			Peduncle length (cm)	Flower no.	Fruit wt (g)	Soluble solids (%)	Skin color ^y	Flesh color ^y	Seed set (%)
		(%)	no.			Start ^z	End ^z	Cycles							
Species															
<i>F. chiloensis</i>	97	18	3.4	18.8	116	144	1.4	3.8	2.9	1.5	9.4	5.9	5.4	62	
<i>F. virginiana</i>	161	43	2.7	23.2	128	155	1.5	6.5	4.8	0.9	8.1	6.5	6.3	52	
Subspecies															
<i>F. chiloensis</i> ssp. <i>chiloensis</i> f. <i>chiloensis</i>															
Ecuador and Peru	2	27	1.8	40.0	105	138	1.5	4.1	3.0	3.3	7.8	5.3	4.3	53	
Chile Region VII and VIII	4	12	3.5	14.3	116	133	1.8	5.9	2.6	2.2	9.4	3.6	3.4	50	
Chile Region X and XI	4	17	3.0	12.1	107	141	1.6	6.9	5.4	1.8	9.0	8.2	7.3	58	
<i>F. chiloensis</i> ssp. <i>chiloensis</i> f. <i>patagonica</i>															
Chile Region VIII	5	30	3.9	5.1	108	150	0.5	2.8	1.7	2.3	8.8	4.3	4.0	69	
Chile Region IX	5	14	2.8	10.9	108	135	1.9	2.5	2.0	2.0	8.9	5.2	5.6	65	
Chile Region X	8	16	3.5	22.6	135	164	1.2	4.2	2.3	1.3	8.5	7.2	7.0	66	
Chile Region XI	13	19	3.5	15.7	103	127	1.4	3.2	2.2	1.0	8.7	7.0	6.4	62	
<i>F. chiloensis</i> ssp. <i>lucida</i>															
Alaska	4	33	5.0	9.4	100	125	1.5	6.1	2.6	1.6	10.8	4.6	3.7	64	
British Columbia	5	28	3.8	28.6	115	132	1.1	4.8	2.0	4.3	7.9	3.0	3.0	60	
Washington	11	20	2.5	17.7	128	156	1.3	3.2	3.5	1.5	10.7	4.3	4.0	67	
Oregon	16	15	3.7	24.5	116	144	1.7	2.9	2.5	0.8	10.7	5.8	5.4	62	
California	20	14	3.3	20.9	121	150	1.4	3.8	3.2	2.0	10.3	6.1	5.0	65	
<i>F. virginiana</i> ssp. <i>glauca</i>															
Alaska and Yukon	4	41	3.1	7.9	104	141	2.3	4.5	3.5	0.7	7.4	7.5	7.5	44	
Northeastern U.S. ^x and Quebec	5	43	2.7	32.8	130	164	2.4	8.3	4.7	0.6	8.9	7.0	7.0	48	
Northern Rocky Mountains ^w	11	35	3.6	8.3	157	182	1.8	4.1	3.0	0.3	8.5	7.8	7.6	55	
Southern Rocky Mountains ^y	7	52	3.1	9.4	160	185	1.7	4.5	3.5	0.6	7.3	6.3	5.7	48	
<i>F. virginiana</i> ssp. <i>platypetala</i>															
Southwestern Canada ^u	3	29	3.3	28.3	119	143	1.5	5.1	2.4	0.4	12.4	5.3	5.3	65	
Washington	5	22	3.5	29.3	115	140	1.7	4.4	3.0	0.6	9.9	4.9	4.7	58	
Oregon	9	30	3.8	13.0	134	159	0.9	6.6	4.2	0.6	8.3	6.3	6.4	59	
California	3	25	3.0	17.5	131	153	1.2	2.3	4.0	1.1	8.3	4.3	4.0	69	
<i>F. virginiana</i> ssp. <i>virginiana</i>															
Ontario	7	50	2.2	24.4	146	164	2.1	3.9	4.5	0.4	6.3	5.5	5.0	43	
Northeast ^t	11	39	2.8	32.7	140	163	1.3	6.0	3.7	0.8	7.9	8.0	7.6	64	
West-central U.S. ^s	14	57	2.4	22.4	143	166	2.0	5.8	4.5	0.4	6.9	6.9	6.2	47	
East-central U.S. ^f	4	46	2.3	34.4	134	156	1.4	5.7	4.7	0.7	5.7	8.3	7.8	63	
Upper-southern U.S. ^q	14	47	2.5	26.0	142	175	1.4	6.9	5.3	0.9	8.0	6.6	6.3	51	
Mid-Atlantic U.S. ^p	20	48	2.5	29.6	120	153	1.3	7.1	5.3	0.9	8.7	6.1	5.6	50	
Southeastern U.S. ^o	18	44	2.3	23.9	114	138	0.8	8.4	5.5	0.7	9.0	6.9	6.8	50	
Mid-southern U.S. ⁿ	26	40	2.6	24.8	112	136	1.4	8.0	6.6	1.1	8.3	6.5	6.4	56	

more southern collections from Oregon (15%) and California (14%). The collections of *F. chiloensis* ssp. *chiloensis* from Chile Region VIII (30%) and Ecuador and Peru (27%) had more dieback than all the other South American collections (12% to 19%). *F. virginiana* ssp. *platypetala* (27%) displayed significantly less dieback than the other *F. virginiana* subspecies (42% to 46%). The highest amount of dieback within *F. virginiana* ssp. *virginiana* was observed in clones from the west-central United States (57%), although the regional averages across the northern states were not significantly higher than the southern ones (48% vs. 46%).

Extreme outliers were found for levels of winter dieback in all subspecies. A clone from British Columbia (CFRA 0883, 54%) and another from Alaska (CFRA 1486, 36%) had unusually high percentages of winter dieback for *F. chiloensis* ssp. *lucida* (18%) (Table 3). Two clones of *F. chiloensis* ssp. *chiloensis* f. *patagonica* from Regions VII (CFRA 0796, 45%) and XI (CFRA 1112, 39%) in Chile showed much more dieback than was typical for other Chilean *F. chiloensis* clones (19%). Most genotypes of *Fragaria virginiana* ssp. *glauca* displayed high percentages of dieback (42%), but a few individuals from Idaho (CFRA 0279, 10%), Montana (CFRA 0561, 14%) and Oregon (CFRA 1221, 18%) were largely

evergreen. Two genotypes from Oregon (CFRA 0472, 48%) and Alberta (CFRA 0273, 42%) had unusually high percentages of dieback for *F. virginiana* ssp. *platypetala* (27%).

Fragaria chiloensis had significantly higher average crown numbers than *F. virginiana* (3.4 vs. 2.7), although the difference was not significant (Table 2, Fig. 1). There was a significant difference in crown numbers between species, with *F. virginiana* ssp. *virginiana* (2.5) being significantly lower than all the rest (3.0 to 3.5). By far the highest crown numbers were found in Alaskan clones of *F. chiloensis* ssp. *lucida* (5.0), but a wide range of crown numbers was found in all regions. Some of the most notable individual genotypes of each subspecies for crown number were K19 (8.5) of *Fragaria chiloensis* ssp. *lucida*, CFRA 0024 (7.5) of *F. chiloensis* ssp. *chiloensis* f. *chiloensis*, CFRA 1083 (7.0) of *F. chiloensis* ssp. *chiloensis* f. *patagonica* and CFRA 1221 (6.5) of *F. virginiana* ssp. *glauca* (Table 3).

Fragaria virginiana averaged significantly more runners (23.2) than *F. chiloensis* (18.8), but considerable variation was observed within subspecies (Table 2, Fig. 1). In fact, runner numbers within all the subspecies varied by more than 40. *Fragaria chiloensis* ssp. *lucida* produced significantly more runners (21.2) than the two

Table 2 (continued). Analysis of variance for 13 horticultural traits of *Fragaria chiloensis* and *F. virginiana* compared in a greenhouse at Michigan State University, East Lansing.

Source	df	Winter		Bloom		Peduncle		Fruit	Soluble	Skin	Flesh	Seed		
		dieback (%)	Crown no.	Runner no.	Start ^z	End ^z	Cycles	length (cm)	Flower no.				wt (g)	solids (%)
Significance ¹	df													
Replication	1	115	2.6	12530	1227	2057	0.4	3.9	0.6	0.9	0.4	1.0	1.0	16.8
Species (S)	1	26140^m	6.5	805	13912	11462	2.1	58.4	59.3	29.1	16.4	15.0	27.3	992.9
Subspecies (SS)/S	4	2992	12.4	1617	216	203	3.8	30.3	24.5	1.0	14.7	6.8	8.6	403.8
Region (R)/S, SS	22	805	3.3	659	3247	3096	2.4	18.1	8.3	1.5	5.7	4.5	4.3	153.3
Genotype (G)/S, SS, R	230	168	3.2	221	1517	1709	1.2	7.7	5.8	0.9	3.2	3.3	3.9	169.2
Error	252	77	2.1	39	662	970	0.6	4.0	5.9	0.3	1.2	1.4	1.2	99.7
Variance components														
Replication		0.1	0.0	50.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		(0)	(0)	(21)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Species (S)		248.0	0.0	0.0	80.6	68.1	0.0	2.0	0.8	0.3	0.4	0.1	0.3	34.9
		(51)	(0)	(0)	(4)	(3)	(0)	(18)	(9)	(23)	(11)	(3)	(7)	(17)
Subspecies (SS)/S		129.2	0.4	39.2	103.3	122.7	0.0	2.5	1.9	0.0	0.6	0.1	0.2	25.0
		(26)	(14)	(16)	(5)	(5)	(1)	(22)	(22)	(0)	(15)	(4)	(4)	(12)
Region (R)/S, SS		13.6	0.0	6.8	416.6	373.6	0.1	1.4	0.7	0.0	0.0	0.0	0.0	0.0
		(3)	(0)	(3)	(21)	(15)	(6)	(12)	(9)	(0)	(0)	(0)	(0)	(0)
Genotype (G)/S, SS, R		22.1	0.6	107.3	717.2	978.9	0.3	1.8	0.0	0.8	1.4	2.4	2.5	17.5
		(5)	(19)	(45)	(36)	(39)	(33)	(16)	(0)	(67)	(35)	(72)	(65)	(8)
Error		75.1	2.1	36.5	662.0	970.3	0.6	3.6	5.2	0.1	1.5	0.7	0.9	129.0
		(15)	(68)	(15)	(33)	(39)	(59)	(32)	(60)	(10)	(39)	(20)	(24)	(62)

^zDays from 1 Jan.

^y1 = white to 9 = dark red.

^mMaine and New Hampshire.

ⁿIdaho, Montana, and Oregon.

^oSouth Dakota, Utah, and Wyoming.

^pAlberta and British Columbia

^qNew Hampshire, Quebec, and Vermont.

^rMichigan, Minnesota, and Wisconsin.

^sNew York, Ohio, and Pennsylvania.

^tKentucky, Missouri, and Tennessee.

^uNorth Carolina, Virginia, and Maryland.

^vGeorgia and South Carolina.

^wAlabama and Mississippi.

¹Significance at *P* = 0.05 indicated in bold.

^mVariance component were considered 0 when the estimation was negative; % variance component of each variable are in parenthesis.

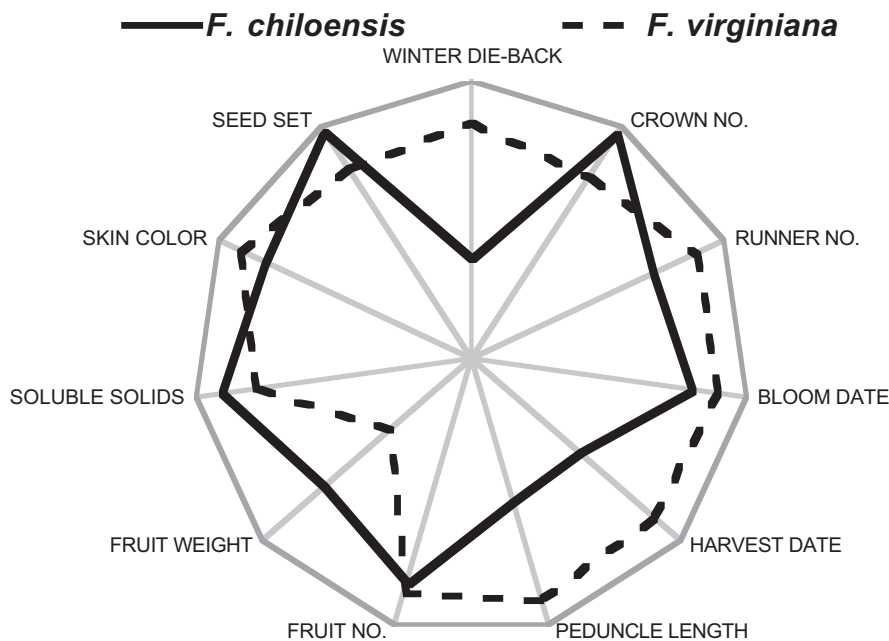


Fig. 1. Pictogram contrasting the mean values for 11 horticultural traits of *Fragaria virginiana* and *F. chiloensis*. The outer circumference represents the highest mean value of any individual. Each axis was normalized by dividing each trait by the highest overall value.

forma of *F. chiloensis* ssp. *chiloensis* (15.0 and 17.4), and *F. virginiana* ssp. *glauca* produced far fewer runners (13.3) than the other *F. virginiana* subspecies (20.2 to 26.0). Some important regional variation was also apparent, with *F. chiloensis* ssp. *chiloensis* f. *chiloensis* from Ecuador and Peru producing many more runners (40.0) than those from Chile (12.1 to 14.3), and *F. chiloensis* ssp. *lucida* from Alaska (9.4) having a much lower number of runners than those from more southernly locations (17.7 to 28.6). CFRA 0034 of *F. chiloensis* ssp. *lucida* produced the most runners of any *F. chiloensis* genotype (56.5), followed by CFRA 0372 of *F. chiloensis* ssp. *chiloensis* f. *chiloensis* (54.5) and CFRA 0883 of *F. chiloensis* ssp. *lucida* (52.0) (Table 3).

In general, *F. chiloensis* bloomed earlier than *F. virginiana* (average season from 116 to 144 d after 1 Jan. compared to 128 to 155) (Table 2). Significant variation was not observed among subspecies, but there was considerable variation across regions and genotypes. Latitudinal gradients in bloom date were found in the eastern United States, and along the Pacific Northwest and western Canada. The earliest blooming genotypes were *F. chiloensis* ssp. *lucida* sampled from Alaska (100 to 125), while the latest were *F. virginiana* ssp. *glauca* from the southern Rocky Mountains (160 to 185). Some of the earliest blooming clones were CFRA 0368 (78 to 122) and CFRA 0094 (71 to 122) of *F. chiloensis* ssp. *lucida*, CFRA 1082 (74 to 104) of *F. chiloensis* ssp. *chiloensis* f. *patagonica*, CFRA 0024 (71 to 104) of *F. chiloensis* ssp. *chiloensis* f. *chiloensis*, EBB-2 (74 to 122) of *F. virginiana* ssp. *glauca*, CFRA 1458 (71 to 78) and CFRA 1530 (74 to 81) of *F. virginiana* ssp. *virginiana* (Table 3). Some of the latest blooming clones were K19 (174 to 181) of *F. chiloensis* ssp. *lucida*, CFRA 0434 (174 to 276) and CFRA 0098 (197 to 204) of *F. virginiana* ssp. *platypetala*.

There was not a significant difference in mean number of bloom cycles between *F. chiloensis* and *F. virginiana* (1.4 vs. 1.5), but significant differences were found among subspecies, regions and genotypes (Table 2, Fig. 1). The subspecies *glauca* averaged more

cycles than any other subspecies (1.9), with the highest average number of cycles being found in northeastern (2.4) and northwestern North America (2.3). The *F. virginiana* ssp. *glauca* genotypes, CFRA 0560 (3.5) and 1369 (4.0) had the highest mean number of cycles, although some *F. chiloensis* genotypes also had unusually high numbers including CFRA 0024 (3.0) of *F. chiloensis* ssp. *chiloensis* f. *chiloensis*, and OF 6 (3.0) and YSP 62 (3.5) of *F. chiloensis* ssp. *lucida* (Table 3).

Fragaria chiloensis fruit were significantly heavier than those of *F. virginiana*, (1.5 vs. 0.9 g) with the largest fruit being found in the cultivated subspecies *F. chiloensis* ssp. *chiloensis* f. *chiloensis* from Ecuador and Peru (3.3 g), and *F. chiloensis* ssp. *lucida* from British Columbia (4.3 g). Some of the largest fruited genotypes were CFRA 1480 (3.3 g) and Puren 1 (3.7 g) of *F. chiloensis* ssp. *chiloensis* f. *chiloensis*, CFRA 0752 (4.9 g) of *F. chiloensis* ssp. *chiloensis*, f. *patagonica*, CFRA 0366 (4.7 g) of *F. chiloensis* ssp.

lucida, and CFRA 1180 (3.2) of *F. virginiana* ssp. *virginiana* (Table 3).

Average seed set was significantly higher in *F. chiloensis* than *F. virginiana* (62% vs. 52%) (Table 2, Fig. 1). In general, all the subspecies of *F. chiloensis* were significantly higher than the *F. virginiana* subspecies, except for *F. virginiana* ssp. *platypetala* (61%). Regional variation was not apparent for this trait. Numerous genotypes of *F. chiloensis* had fertility in excess of 70%. Among *F. virginiana*, only a few genotypes had fertility this high including GCL-8 (72%) of *F. virginiana* ssp. *platypetala*, CFRA 0959 and CFRA 0960 (72%) of *F. virginiana* ssp. *virginiana*, and CFRA 0108 (77%) of *F. virginiana* ssp. *glauca* (Table 3).

The number of flowers per inflorescence was significantly higher in *F. virginiana* than *F. chiloensis* (4.8 vs. 2.9), with *F. virginiana* ssp. *virginiana* (5.3) having the highest numbers of any subspecies (Table 2, Fig. 1). Within *F. virginiana* ssp. *virginiana*, the highest flower numbers were found in the mid-southern United States (6.6). Among the *F. chiloensis* subspecies, the most flowers per inflorescence were found in ssp. *chiloensis* f. *chiloensis* in Regions X and XI of Chile (5.4). Among individual genotypes, the highest numbers of flowers per inflorescence were found in CFRA 1385 (14.5) and JP 95-3-1 (15.0) of *F. virginiana* ssp. *virginiana*; within *F. chiloensis*, the highest flower numbers were found in CFRA 1068 (9.5) of *F. chiloensis* ssp. *chiloensis* f. *chiloensis* and W19 (11.5) of *F. chiloensis* ssp. *lucida*.

In general, *F. virginiana* had much longer peduncles than *F. chiloensis* (6.5 vs. 3.8 cm) (Table 2, Fig. 1). Among the *F. virginiana* subspecies, *F. virginiana* ssp. *virginiana* (6.9) had the longest peduncles. *Fragaria chiloensis* ssp. *chiloensis* f. *chiloensis* had the longest peduncles of any *F. chiloensis* taxa. Regionally, the longest peduncles were found in *F. virginiana* ssp. *virginiana* from the southeastern (8.4) and mid-southern United States (8.0), and *F. chiloensis* ssp. *chiloensis* from southern Chile (6.9). The longest peduncles on individual genotypes of *F. virginiana* were observed on CFRA 0110 (12.4) of *F. virginiana* ssp. *platypetala*, and the *F. virginiana* ssp. *virginiana* genotypes, CFRA 1385 (12.5), CFRA 1578 (12.0) and CFRA 1389 (12.6) (Table 3). The longest peduncles in *F. chiloensis* were on CFRA 1121 (10.3) of *F. chiloensis* ssp.

Table 3. Horticultural characteristics of elite *Fragaria chiloensis* and *F. virginiana* compared in a greenhouse at Michigan State University, East Lansing, Mich. Unique characteristics of each genotype are underlined; genotypes represented in supercore of Hancock et al. (2001) are bold.

Genotype	Location	Anthers	Winter	Crown	Runner	Bloom			Peduncle	Fruit	Soluble	Skin	Flesh	Seed	
			dieback			start ²	end ²	cycles	length	Flower					wt
			(%)	no.	no.				(cm)	no.	(g)	(%)	color ³	color ³	(%)
<i>F. chiloensis</i> ssp. <i>chiloensis</i> f. <i>chiloensis</i>															
CFRA 0024	Chile, VIII	Yes	14	7.5	13.5	71	104	3.0	4.8	3.0	1.3	9.9	3.4	3.2	42
CFRA 0372	Peru	Yes	39	2.5	54.5	103	285	1.5	4.4	2.5					
CFRA 0774	Chile, X	Yes	10	1.5	20.5	85	122	1.0	7.2	3.0	1.1	5.2	8.0	7.0	45
CFRA 1068	Chile, X	Yes	22	1.5	14.0	139	181	1.5	6.0	<u>9.5</u>					
CFRA 1121	Chile, XI	Yes	23	3.5	4.0	97	108	2.5	<u>10.3</u>	3.0	2.2	11.0	8.3	7.5	65
CFRA 1480	Ecuador	Yes	14	1.0	11.0	139	147	1.5	3.6	4.0	3.3	7.8	5.3	4.3	53
PUREN 1	Chile, VII	Yes	10	2.0	8.0	108	146	2.0	8.1	1.0	<u>3.7</u>	8.8	1.9	1.6	49
<i>F. chiloensis</i> ssp. <i>chiloensis</i> f. <i>patagonica</i>															
CFRA 0752	Chile, IX	No	10	2.0	6.0	86	122	2.0	5.4	<u>4.9</u>	10.7	1.4	1.2	63	
CFRA 0796	Chile, VII	Yes	45	2.0	6.0	174	182	1.0		1.0					
CFRA 1081	Chile, XI	No	23	3.0	30.0	122	143	2.5	3.3	3.5	1.0	5.9	<u>9.0</u>	<u>9.0</u>	51
CFRA 1082	Chile, XI	Yes	14	3.5	8.5	<u>74</u>	<u>104</u>	1.0	2.5	2.0	0.9	8.9	8.1	6.5	66
CFRA 1083	Chile, X	No	14	<u>7.0</u>	35.0	104	125	1.0			1.1	8.8	7.3	7.0	60
CFRA 1112	Chile, XI	No	<u>39</u>	1.0	24.5	154	161	1.5	1.7	2.0	0.9	6.0	5.5	5.5	48
<i>F. chiloensis</i> ssp. <i>lucida</i>															
CFRA 0034	California	Yes	14	3.5	56.5	104	122	2.5	4.0	3.0					
CFRA 0059	Oregon	No	18	3.0	31.0	97	111	0.5	7.2	2.0	1.6	<u>12.8</u>	6.0	1.0	72
CFRA 0094	Oregon	Yes	23	4.0	21.0	<u>71</u>	<u>122</u>	2.0	4.9	4.0	0.5	10.0	<u>8.0</u>	<u>8.0</u>	52
CFRA 0097	California	No	18	2.5	26.5	140	147	2.5	3.0	3.5	1.1	11.7	<u>8.0</u>	<u>8.0</u>	73
CFRA 0366	California	Yes	33	3.0	28.0	139	169	2.5	<u>9.7</u>	3.0	<u>4.7</u>	7.6	6.0	4.0	54
CFRA 0368	Alaska	No	23	5.5	19.0	78	122	2.0	5.1	4.0	2.4	10.4	4.6	4.0	68
CFRA 0883	British Columbia	Yes	54	4.5	<u>52.0</u>	132	139	2.5	5.0	4.0					
CFRA 1486	Alaska	No	<u>36</u>	4.0	7.0	101	111	2.0	3.8	2.0	1.4	<u>12.6</u>	4.0	3.7	64
K 19	California	Yes	14	<u>8.5</u>	24.5	174	181	0.5	1.7	2.0					
M3	Oregon	Yes	10	4.0	25.5	86	100	2.5	1.5	1.0	1.0	<u>13.3</u>	5.4	4.4	73
OF 6	California	Yes	10	4.0	9.0	81	132	<u>3.0</u>	<u>9.8</u>	5.0					
W 19	Washington	Yes	10	1.5	18.5	136	143	1.0	4.5	<u>11.5</u>					
YSP 62	Oregon	Yes	10	1.5	27.5	118	128	<u>3.5</u>							
<i>F. virginiana</i> ssp. <i>glauca</i>															
CFRA 0108	Wyoming	Yes	15	1.5	50.8	164	217	1.0	4.6	2.5	1.1	7.8	8.0	8.0	<u>77</u>
CFRA 0279	Idaho	Yes	<u>10</u>	2.0	18.0	<u>85</u>	<u>111</u>	0.5	1.4	1.0					
CFRA 0560	Montana	Yes	48	2.5	14.5	125	143	<u>3.5</u>							
CFRA 0561	Montana	Yes	<u>14</u>	1.5	14.2										
CFRA 1221	Oregon	Yes	<u>18</u>	<u>6.5</u>	3.0	129	202	2.0	3.9	6.5					
CFRA 1369	Quebec	Yes	36	3.5	42.0	135	142	<u>4.0</u>	8.3	5.0					
EBB-1	Alaska	No	39	2.5	7.0	115	129	3.0	3.2	3.0	1.0	8.2	7.4	7.4	38
EBB-2	Alaska	Yes	42	4.5	3.0	<u>74</u>	<u>122</u>	3.0	4.8	4.0	0.2	7.0	7.0		
LH 50-4	Montana	Yes	42	2.5	11.5	106	153	1.5	8.0	3.0	0.3	8.4	8.6	8.2	59
<i>F. virginiana</i> ssp. <i>platypetala</i>															
CFRA 0098	Montana	Yes	27	3.0	0.0	<u>197</u>	<u>204</u>	1.0	5.5	1.0					
CFRA 0110	Oregon	Yes	10	2.5	16.5	115	181	1.0	12.4	7.0	0.7	8.3	8.2	7.8	67
CFRA 0273	Alberta	Yes	<u>42</u>	5.0	14.0	111	146	2.0	8.0	4.0					
CFRA 0434	Washington	Yes	39	3.0	18.5	<u>174</u>	<u>216</u>	1.5	5.0	4.0					
CFRA 0472	Oregon	Yes	<u>48</u>	5.0	0.0	111	118	1.0			0.4	6.8	6.5	6.8	55
CFRA 1333	British Columbia	Yes	23	2.5	37.5	81	108	2.0	3.4	1.5	0.4	<u>12.4</u>	5.3	5.3	65
GCL-8	Washington	No	21	1.5	14.2	96	132	2.5	8.0	5.0	0.9	11.3	2.8	2.4	<u>72</u>
<i>F. virginiana</i> ssp. <i>virginiana</i>															
CFRA 0959	New Hampshire	Yes	27	1.5	42.1	132	163	2.0	5.4	3.0	1.2	7.2	7.0	7.0	<u>72</u>
CFRA 0960	New Hampshire	No	27	1.5	39.2	132	168	1.5	4.2	4.0	0.4	7.8	9.0	9.0	<u>72</u>
CFRA 1170	Kentucky	Yes	48	3.0	17.0	140	212	2.0	11.3	7.5	<u>2.6</u>	6.2	6.9	6.4	51
CFRA 1171	Kentucky	Yes	57	2.5	16.0	129	158	1.5	6.3	5.5	1.1	9.0	8.0	8.0	51
CFRA 1175	Kentucky	Yes	61	2.0	31.5	143	178	1.0	7.5	7.0	1.7	6.8	6.7	6.6	58
CFRA 1180	Kentucky	No	57	2.0	22.0	108	129	1.5	7.0	4.5	<u>3.2</u>	5.4	6.0	7.0	51
CFRA 1385	Quebec	No	39	3.5	14.5	101	118	2.0	<u>12.5</u>	<u>14.5</u>	2.3	9.8	5.8	5.5	57
CFRA 1389	South Carolina	Yes	42	3.5	22.0	143	174	1.5	<u>12.6</u>		0.5	8.1	8.0	8.0	39
CFRA 1458	Georgia	No	30	3.5	34.0	<u>71</u>	<u>78</u>	3.0	8.0	6.0	1.7	7.9	4.0	7.6	69
CFRA 1522	Alabama	Yes	55	2.5	30.0	125	164	1.0	10.4	5.5	0.2	<u>13.6</u>	7.5	7.5	45
CFRA 1530	Alabama	No	42	1.5	38.0	<u>74</u>	<u>81</u>	1.5	7.2	5.0	0.6	5.1	6.0	6.5	39
CFRA 1578	South Carolina	Yes	58	1.0	31.0	143	157	1.0	<u>12.0</u>	8.0					
JP 95-3-1	Georgia	Yes	48	2.5	19.0	97	121	1.5	10.5	<u>15.0</u>	2.0	7.8	5.8	5.2	57
RH 18	New York	Yes	51	2.5	13.0	129	151	2.0	6.2	4.0	0.4	6.5	<u>8.7</u>	<u>8.7</u>	63

²Days after 1 Jan.

³1 (white) to 9 (dark red).

chiloensis f. *chiloensis*, and OF 6 (9.8) and CFRA 0366 (9.7) of *F. chiloensis* ssp. *pacifica*.

The soluble solids in *F. chiloensis* were significantly higher than *F. virginiana* (9.4 vs. 8.1) (Table 2, Fig. 1). *Fragaria chiloensis* ssp. *lucida* (10.3) had the highest average values of any subspecies (8.0 to 9.2), although the few clones of *F. virginiana* ssp. *platypetala* from southwestern Canada had unusually high regional values (12.4). The highest individual genotypes of *F. chiloensis* were CFRA 0059 (12.8), CFRA 1486 (12.6) and M3 (13.3) (Table 3). Within *F. virginiana*, the highest values were recorded in CFRA 1333 (12.4) and CFRA 1522 (13.6).

Fragaria virginiana was on the average more fully colored than *F. chiloensis*, both interior (6.5 and 5.9) and exterior (6.3 vs. 5.4) (Table 2, Fig. 1). Overall, *F. virginiana* ssp. *glauca* (7.1 and 6.9) had the darkest skin and flesh color, but *F. virginiana* ssp. *virginiana* from the Northeast had the highest regional values. *Fragaria chiloensis* ssp. *chiloensis* f. *patagonica* from Chilean Regions X and XI (8.2 and 7.3) were the most darkly colored of any of the *F. chiloensis* populations. Among the darkest colored individual genotypes of *F. chiloensis* were CFRA 1081 (9.0 and 9.0), CFRA 0094 (8.0 and 8.0) and CFRA 0097 (8.0 and 8.0); the darkest colored *F. virginiana* were RH 18 (8.7 and 8.7) and LH 50-4 (8.4 and 8.6) (Table 3).

Discussion

As has been reported previously (Darrow, 1966), *F. chiloensis* was generally superior to *F. virginiana* for crown number, fruit weight, soluble solids and seed set. *Fragaria virginiana* was superior to *F. chiloensis* for runner production, peduncle length, fruit number, skin and flesh color. *Fragaria chiloensis* bloomed earlier and its fruit ripened sooner than *F. virginiana*. A much higher proportion of *F. virginiana* genotypes appeared to go dormant during the winter than *F. chiloensis*, as indicated by the percentage of their leaves that dieback in the late fall.

We observed substantial overlap in individual traits between *F. chiloensis* ssp. *pacifica* and *F. chiloensis* ssp. *lucida*, and *F. virginiana* ssp. *grayana* and *F. virginiana* ssp. *virginiana*. While these species can be distinguished by hair type (Staudt, 1999), they are genetically quite similar and probably do not warrant taxonomic recognition at the subspecies rank (Porebski and Catling, 1998; Rydberg, 1898).

Fragaria chiloensis ssp. *lucida* was the earliest blooming taxa and had the highest soluble solids. *Fragaria chiloensis* ssp. *chiloensis* f. *chiloensis* produced the largest fruit, while *F. chiloensis* ssp. *chiloensis* f. *patagonica* had the highest percentage seed set. *Fragaria virginiana* ssp. *platypetala* produced the most crowns and its fruit ripened fastest. *Fragaria virginiana* ssp. *glauca* had the darkest fruit color and the most flowering cycles. *Fragaria virginiana* ssp. *virginiana* produced the most runners.

The early flowering of *F. chiloensis* ssp. *lucida* was a surprise, as in a previous field study, representatives of this species were much later than most genotypes of *F. virginiana* (Hancock et al., 2001). Perhaps in the milder greenhouse environment they remained more active during the winter than *F. virginiana*, and as a result were able to develop more rapidly in the spring.

Most of the leaves of *F. chiloensis* genotypes remained ever-green during the winter, although some outlying genotypes had a high percentage of winter dieback (CFRA 0883, CFRA 1468, CFRA 0796, CFRA 0372 and CFRA 1112). These genotypes may be more winter hardy than most other *F. chiloensis* clones, as they mimic winter hardy *F. virginiana* which lose all but their most central, primordial leaves during the late fall. In fact, we found

CFRA 0883 and CFRA 1488 to be among the hardiest clones of *F. chiloensis* in an earlier field trial (Hancock et al., 2001). This suggests that *F. chiloensis* might be most effectively used in cold-season breeding projects, if care is taken to select the hardiest genotypes. Eco-geographic location might be used to help find the most winter hardy *F. chiloensis* genotypes, as CFRA 0883 is from cold, coastal regions of British Columbia, CFRA 1468 is from Alaska, and CFRA 0796 was collected at 1900 m elevation in Chile. This approach is not foolproof, however, as CFRA 1112 came from the warm coast of Chile.

It appears that the Mapuche Indians, who domesticated *F. chiloensis* in Chile, had a strong preference for white-fruited types, as most of the clones of *F. chiloensis* ssp. *chiloensis* f. *chiloensis* had white to pale colored fruit, even though all the wild genotypes of *F. chiloensis* that we analyzed were pink to red. Lavín (1997) described a few white-fruited clones of native *F. chiloensis* in Chile, but they were extremely rare. Deeply colored fruit were found in all the *F. chiloensis* subspecies including CFRA 0774 and CFRA 1068 of *F. chiloensis* ssp. *chiloensis* f. *chiloensis*, CFRA 1081 of *F. chiloensis* ssp. *chiloensis* f. *patagonica*, and CFRA 0094 and CFRA 0097 of *F. chiloensis* ssp. *pacifica*. All *F. virginiana* ssp. *virginiana* fruit were at least lightly colored on their surface, although they varied considerably in flesh color.

The most northern collections tended to have the latest flowering dates, but there was considerable variation within all regions and subspecies. A number of genotypes appeared to be day-neutral, as they flowered in both the short days of spring and fall, and the long days of summer. The highest mean number of flowering cycles were found in *F. virginiana* ssp. *glauca*, but outliers with three or more cycles were discovered in several subspecies including CFRA 0024 of *F. chiloensis* ssp. *chiloensis* f. *chiloensis*, YSP 62 and OF 6 of *Fragaria chiloensis* ssp. *lucida* and CFRA 1458 of *F. virginiana* ssp. *virginiana*. It should also be noted that a high percentage of multiple cropping genotypes were found in northeastern populations of *F. virginiana* ssp. *glauca*. These may prove to be a valuable germplasm source for breeding eastern day-neutrals, as all our current day-neutral *F. xananassa* cultivars are derived from Wasatch Mountain *F. virginiana* ssp. *glauca*.

One of the problems associated with day-neutral breeding has been the difficulty in getting sufficient runner production for bed fill and propagation. In this study, several strong day-neutral genotypes were found with relatively vigorous runner production (i.e., CFRA 1458 and CFRA 0560). In our previous field comparison, another day-neutral clone of *F. virginiana* ssp. *virginiana*, LH 50-4, also produced numerous runners (Hancock et al., 2001). When we crossed short-day *F. xananassa* with day-neutral *F. virginiana*, numerous day-neutral hybrids were generated that were strong runner producers (Hancock et al., 2002).

FUTURE GERmplasm NEEDS. It would appear that the NCGR has an abundance of valuable germplasm already in hand. To complement this collection, future sampling efforts can be targeted towards the most promising subspecies and ecogeographical regions, based on the information provided herein. Of course, important outliers can probably be found in all taxa and regions, but it makes the most economic sense to direct sampling to those parts of the world where it is known high proportions of elite germplasm reside. Our study has shown that to obtain the earliest blooming strawberry genotypes with high soluble solids, germplasm explorers should collect *F. chiloensis* ssp. *chiloensis* in Alaska. We only evaluated a few clones from this region, but they were in general quite exceptional for crown numbers, fruit weight, percentage seed set, and perhaps winter hardiness. For extremely large fruit, the collector should

concentrate on *F. chiloensis* ssp. *chiloensis* f. *chiloensis* from South America. Lavín and co-workers in Chile have already done this rather extensively (Lavín et al., 1997 and 2000). *Fragaria virginiana* ssp. *glauca* from the northeastern United States would be an excellent place to search for dark-fruited, day-neutral types, with reasonable runner production.

Recently, a supercore collection of octoploid strawberries was selected from the literature and evaluated in the field at five locations (Hancock et al., 2001). Several of these clones proved exceptional, but a few proved to be poor choices. Several of the clones identified in this greenhouse screening could serve as replacements for the unimpressive members of the supercore and should be evaluated in the field. CFRA 1121 of *F. chiloensis* ssp. *chiloensis* f. *chiloensis* had unusually long peduncles for *F. chiloensis* and had much higher than average values for fruit weight, soluble solids, fruit color and seed set. CFRA 0094 of *F. chiloensis* ssp. *lucida* was extremely early flowering and had much better fruit color than the other very early supercore member of *F. chiloensis*, CFRA 0024. CFRA 0366 of *F. chiloensis* ssp. *lucida* also had unusually long peduncles for *F. chiloensis* and possessed the largest fruit of any North American clone. As noted previously, CFRA 0560 and CFRA 1369 of *F. virginiana* ssp. *glauca* have an unusual combination of high numbers of flowering cycles and high runner production. CFRA 1170 of *F. virginiana* ssp. *virginiana* had high numbers of large fruit and long peduncles. Another *F. virginiana* ssp. *virginiana*, CFRA 1171, was very late in flowering and had much better colored fruit than CFRA 1170. CFRA 1385 and JP 95-3-1 had extremely high flower numbers, long peduncles and large fruit.

One of our breeding goals has been to reconstruct *F. ×ananassa* using elite clones of native *F. virginiana* and *F. chiloensis* (Hancock et al., 1993). We began this effort with a limited set of North American *F. chiloensis* ssp. *pacifica*, *F. virginiana* ssp. *virginiana* and *F. virginiana* ssp. *glauca* (Hancock, et al., 2001). While this effort shows promise, we are now ready to begin anew with a new set of clones that will be selected from this greenhouse screening and the previous field effort. Critical to this effort will be the incorporation of South American material, large fruited *F. virginiana* ssp. *platypetala* and day-neutral *F. virginiana* that produce numerous runners.

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