Morphological and Phenological Characterization of 52 Accessions of *Fragaria chiloensis* (L.) Duch.

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The Chilean strawberry (*F. chiloensis*) is one of the progenitors of the commercial strawberry (*F. ×ananassa*). The INIA station at Cauquenes (35°59'S; 72°20'W) has a collection of nearly 300 accessions of *F. chiloensis* that could be used for breeding purposes; but has not been properly characterized for horticultural traits. The objective was to characterize a portion of the collection from Chile, between latitudes 34° and 47°S, plus an accession from Ecuador (Lat. 01°00'S), at the INIA-Cauquenes station

for several morphological and phenological traits, so as to gather the basic information to select parents for future crossings in the scope of a breeding program to obtain improved *F. chiloensis* cultivars.

Materials and Methods

Plants were planted in the field in a sandy soil possessing a high quartz content (Cauquenes series), in late August 1998 on 30-cm-high and

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80-cm-wide beds at a 40-cm distance among plants. Plastic mulch (80 µm in thickness; white on top, black on the bottom) was used to control weeds. Although no pests were detected during the season, Systhane 40 WP (DOW AgroSciences, Midland, Mich.) was applied (10 g/100 L water) to control powdery mildew. Ultrasol

Table 1. Morphological characteristics of *Fragaria chiloensis* accessions (L.) Duch. 1998–99.

Accession	Characteristic ^z																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
96AMB1A	12.8	2.4	3	1	3.8	11	3	3	8.4	5	2.2	1.2	19.8	5	3	1	1	4.6	1	5.0	5.0	5.0	3
92ILO1A ^y	16.2	1.9	5	1	3.5	11	1	5	4.9	5	2.2	1.0	20.2	5	3								
3HUE1A	14.3	1.7	3	1	2.4	7	7	5	4.2	5	2.0	0.7	7.9	5	3	1	3	7.2	1	5.5	5.5	5.5	1
3CUR1A	18.0	1.9	1	1	3.7	7	3	5	9.6	5	2.9	1.0	10.2	5	1	1	5	9.5	1	7.0	7.0	7.0	3
3BUC2A ^y	31.8	1.6	3	1	3.5	7	3	3	10.8	5	1.8	1.1	11.0	5	3								
3COB1A	17.0	2.0	3	3	4.6	11	3	3	13.1	5	2.5	0.8	13.0	5	3	1	3	9.0	5	6.0	6.0	6.0	1
94CAY1A	13.6	2.4	3	3	4.3	11	3	3	8.1	5	2.7	1.0	11.0	5	3	1	5	8.4	1	7.0	7.0	7.0	3
97PUR1A	10.5	2.6	3	3	5.1	11	1	5	10.9	5	2.9	1.2	12.8	5	3	1	5	6.3	1	7.0	7.0	7.0	3
3SAA2A ^x	14.3	1.6	3	3	2.9	7	7	3	5.4	5	2.0	1.3	13.0	5	5								
3NIM1A	18.6	1.2	3	1	2.0	7	3	3	4.1	5	1.8	1.0	6.0	5	5	1	3	7.2	1	6.0	6.0	6.0	3
3FLO2A	34.0	1.1	3	1	2.7	7	1	5	6.5	5	1.7	1.1	9.4	7	1								
2LTS1A	19.7	1.6	3	1	3.8	11	1	3	8.7	5	2.1	0.8	11.2	5	3	1	1	9.3		7.0	7.0	7.0	3
2BRA1A	20.3	1.3	3	1	3.1	11	7	3	3.7	5	2.0	0.8	13.1	5	3	1	5	6.0	5	7.0	7.0	7.0	3
90SAU1A	17.5	1.6	3	1	3.1	7	1	5	5.8	5	2.3	1.0	12.1	5	3	3	5	5.9		5.5	5.5	5.5	3
3LLE1A	19.7	1.4	3	1	2.3	7	3	5	6.5	5	2.3	0.8	8.4	5	5	3	5	8.7	1	5.0	5.0	5.0	3
3TCH5A	15.7	1.7	3	1	3.2	7	3	3	7.1	5	2.1	0.7	9.8	5	3	3	5	9.2	1	6.0	6.0	6.0	3
3LLI2A	23.6	1.1	3	1	2.6	7	1	3	7.1	5	2.0	0.9	6.2	7	3	1	5	8.0		6.0	6.0	6.0	1
3RAM1A	22.8	1.2	3	1	2.4	7	3	5	7.9	5	1.3	0.9	7.8	5	3	3	5	7.3	1	7.0	7.0	7.0	3
3LAJ2A	28.0	1.1	3	1	2.5	7	3	5	5.2	5	2.0	1.0	7.4	7	3	1	5	4.1	1	6.0	6.0	6.0	3
3APO1A ^x	15.0	1.3	5	1	3.3	7		3	9.6	5	1.6	0.8	11.3		1	1	3	5.9		5.0	5.0	5.0	3
3IDA1A	24.7	1.1	3	1	2.3	7	3	5	6.1	5	1.4	0.8	6.5	5	3	3	5	8.0	1	6.0	7.0	7.0	5
3TRO1A	22.9	0.9	3	1	2.0	7	3	5	5.4	5	1.7	0.9	6.9	3	3	3	5	7.9	3	6.0	6.0	6.0	3
3CAN1A	28.4	1.0	1	1	2.3	7	7	5	5.1	5	1.7	1.0	7.9	5	3	1	5	6.1		7.0	7.0	7.0	1
3FRI1A	11.8	1.6	3	1	2.8	7	3	5	6.2	5	1.8	1.0	9.9	3	5	3	5	6.5	3	5.0	5.0	5.0	1
3NAH7A	18.8	1.6	3	1	2.8	11	3	5	7.1	5	2.0	0.7	6.1	7	3	3	5	7.0	1	6.0	6.0	6.0	3
3MAN1A	16.3	1.5	3	1	2.8	7	3	3	6.6	5	1.8	1.0	11.1	5	3	1	1	5.9	1	7.0	7.0	7.0	1
3CAY5A	17.0	1.5	1	1	2.7	7	3	3	4.8	5	2.2	0.7	9.9	5	5	1	3	8.2	1	6.0	6.0	6.0	5
3ELI1A	40.0	1.1	3	1	2.2	7	3	3	7.4	5	1.8	0.6	8.6	5	3	3	5	8.5	3	6.0	6.0	6.0	1
3CON2A	32.1	1.0	3	1	2.1	7	3	3	5.2	5	1.4	0.8	7.2	5	5	1	5	3.9	1	6.0	6.0	6.0	3
3LOL2A	22.0	1.3	3	1	2.7	7	3	1	13.1	5	2.1	0.9	6.9	5	3	3	5	8.3	3	6.0	6.0	6.0	3
3NIT1A	24.9	1.0	3	1	3.4	11	1	3	9.8	5	2.2	1.0	10.1	7	3	3	3	8.0	1	6.0	6.0	6.0	3
3OYO1A ^x	17.0	1.3	3	1	3.0	11	3	5	8.0	5	1.5	0.9	12.0	5	3	3	3	12.3	1	7.0	7.0	7.0	3
3LON6A ^x	22.0	1.3		1	2.9	7	3	3	7.7	5	2.1	0.6	9.8	5	3	3	5	7.0		6.0	6.0	6.0	3
3SIE1A ^y	31.8	1.3	3	1	2.9	7	1	3	8.1	5	1.7	0.9	10.8	5	3								
3GAL2A ^x	9.5	1.8	1	1	2.8	7	1	5	7.4	5	2.2	0.9	6.5	5		3	3	7.9		6.0	6.0	6.0	1
3PIN2A	30.3	1.3	3	1	2.2	7	3	5	5.7	5	2.0	0.7	6.5	5	5	3	5	8.5	3	7.0	7.0	7.0	5
3GUI2A ^x	11.0	2.5	1	1	3.1	7	3	3	6.2	5	1.3	1.5	6.5	5	3	3	5	8.4	1	6.0	6.0	6.0	5
3ICA8A ^w	33.3	1.1	3	1	2.4	7	3	3	6.0	5	1.8	0.6	8.7	7	3	3	5	8.8		5.0	5.0	5.0	1
3LLA1A	45.2	1.4	3	1	2.6	7	1	3	6.9	5	1.9	0.9	7.0	5	3	3	5	12.2	1	7.0	7.0	7.0	5
3ICA7A ^w	38.0	1.0	3	1	1.9	7	3	5	9.2	5	1.9	0.5	7.5	5	3	3	5	5.9		5.0	5.0	5.0	3
3MEL5A	26.3	1.2	3	1	2.4	7	3	3	6.5	5	1.8	0.8	8.5	5	3	3	5	5.1	3	5.0	5.0	5.0	3
3BUD1A	23.5	0.9	3	1	2.5	7	1	3	6.6	5	1.8	0.8	6.5	5	3	3	3	5.3		7.0	7.0	7.0	1

Table 1 (continued). Morphological characteristics of *Fragaria chiloensis* accessions (L.) Duch. 1998–99.

Accession	Characteristic ^z																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
3ICA4A	33.0	1.1	3	1	2.5	7	3	3	6.3	5	1.5	1.1	9.0	5	3	1	5	7.0	3	7.0	7.0	7.0	3
3CUN1A	24.5	1.1	3	1	7.2	7	3	5	7.7	5	1.5	0.7	6.8	5	3	1	5	9.8	3	7.0	7.0	7.0	3
3HAN1A	33.4	1.1	1	1	2.1	7	3	3	6.7	5	1.4	0.7	6.3	5	3	1	3	5.4	1	7.0	7.0	7.0	5
3NIG1A ^x	23.9	1.1	3	1	2.3	7	3	3	7.5	5	1.9	0.7	7.6	5	5								
3NIE1A	23.8	1.5	3	1	1.8	7	3	5	5.1	5	1.7	0.6	6.0	5	5				1	5.0	5.0	5.0	3
3COR1A	44.6	1.0	3	1	2.1	7	5	3	5.7	5	1.9	0.7	4.5	7	5	3	5	6.0		5.0	5.0	5.0	1
3HUI1A	20.6	1.3	1	1	2.8	7	1	1	7.8	5	1.6	0.8	6.8	5	3	1	3	5.3		7.0	7.0	7.0	3
3FLO1A ^w	9.7	1.2	1	1	2.3	11	1	3	6.8	5	1.5	0.9	7.0	5	5	1	3	5.4		7.0	7.0	7.0	3
3ONO1A	34.5	1.2	1	1	2.3	7	3	1	17.5	5	1.5	1.0	8.3	5	3	1	5	6.4		7.0	7.0	7.0	1
3MAI1A	12.2	1.3	3	1	2.5	7	1	1	11.7	5	1.5	1.1	10.0	5	3	3	3	11.6	1	7.0	7.0	7.0	3
3RIÑ1A	24.5	1.4	3	1	2.9	11	3	1	13.6	5	2.0	0.8	8.4	5	3	3	5	7.0		6.0	6.0	6.0	1
3PUY5A	20.1	1.3	3	1	2.3	7	1	1	9.4	5	1.5	0.9	8.9	5	5	3	3	10.0	1	6.0	6.0	6.0	3
3PUY1A	21.9	1.5	3	1	2.4	7	3	3	10.3	5	1.7	0.7	6.4	5	5	1	3	8.6	1	7.0	7.0	7.0	5
93PET1A	18.4	1.3	1	1	3.2	11	1	1	9.0	5	1.4	0.9	11.3	5	3	1	3	8.6	1	7.0	7.0	7.0	5
2CPU2A	11.6	1.9	1	3	2.3	11	3	1	7.0	5	2.0	0.8	6.6	5	5	3	3	6.6	1	6.0	6.0	6.0	1
2CAM1A	33.4	1.3	3	3	2.5	11	3	3	6.5	5	1.6	0.6	7.3	5	5	3	3	6.4	3	6.0	6.0	6.0	1
2FUT4A	23.9	1.3	3	1	2.4	7	3	3	9.0	5	1.6	0.7	8.2	5	5	3	5	5.2	3	6.0	6.0	6.0	3
2PAL2A	23.0	1.4	3	1	2.8	7	3	3	7.1	5	1.8	0.9	10.4	5	3	3	5	7.7	1	5.5	5.5	5.5	3
2PAL3A	22.3	1.1	5	1	1.8	7	3	5	8.5	5	1.3	0.5	9.1	5	3	3	5	7.8	1	7.0	7.0	7.0	3
2MAR1A	10.8	1.9	1	3	2.3	11	1	7	6.9	5	2.4	0.8	8.9	3	5	1	3	7.5	1	7.0	7.0	7.0	1
2TAP4A	12.5	1.2	3	1	2.2	7	3	3	5.4	5	1.2	0.5	12.4	5	3	3	5	7.7	3	6.0	6.0	6.0	1
2TAP3A	19.6	1.1	3	1	2.8	7	3	3	7.3	5	1.3	1.1	11.7	5	3	3	5	6.1		6.0	6.0	6.0	3
2BAL1B	29.9	1.6	3	1	3.4	7	3	3	14.4	5	1.7	0.7	8.4	7	3	3	5	9.1		6.0	6.0	6.0	3
2MAL2A ^w	35.0	1.5	3	1	3.3	7	3	3	15.0	5	2.2	1.6	10.5	7	1	1	5	9.8	1	6.0	6.0	6.0	3
2COC9A	20.8	1.3	3	1	2.5	7	1	3	9.1	5	1.6	0.9	9.1	3	3								

^zCharacteristic:

1) Number of leaves

2) Petiole diameter (mm)

3) Pubescence of leaflet abaxial side: 1 = dense, 5) sparse

4) Leaflet orientation: 1 = apical, 7 = admedium

5) Leaflet width (cm)

below foliage

6) Leaflet form: 1 = oblong, 11 = obovate very wide

7) Color of leaflet adaxial side: 1 = clear green, 7 = dark green

8) Leaflet brightness: 1 = very bright, 7 = opaque

9) Length of petiole (cm)

10) Leaflet apex: 1 = obtuse, 9 = emarginated

11) Stolon diameter (1) (mm)

12) Stolon length (cm)

13) Stolon length to first node (cm),

14) Vegetative habit: 1 = very weak, 9 = very vigorous

15) Plant growth habit: 1 = erect, 5 = prostrate

16) Rachis branching: 1 = high or 3 = low

17) Inflorescence position: 1 = over, 5 = below foliage

18) Calyx length (cm)

19) Presence of pollen (1): 1 = yes, 3 = no, or 5 = both

20) Number of petals

21) Number of sepals

22) Number of bracteoles

23) Type of calyx: 1 = adhered, 3 = free, or 5 = reflex

^xAccession not evaluated for inflorescence and flower.^wAccession with less than 4 plants evaluated.^yVariable not considered in multivariate analysis.

(Soquimich, Santiago), a commercial 18N–18P–18K fertilizer was applied weekly through the irrigation system during the first 3 weeks of September, at a rate of 0.9 g·L⁻¹. Plants were drip irrigated according to needs established through a Class A evaporimeter. Morphological characteristics (Table 1), were established through weekly observations on at least 4 plants per accession. Variables were analyzed through multivariate analysis using TREE software (SAS Institute, Cary, N.C.). Cluster analysis was used to determine distances through the average method and expressed as RMS (root mean square), using the criterion of RMS ≥ 0.8.

Results and Discussion

The multivariate analysis of morphological characteristics of vegetative organs and flowers determined nine clusters of accessions

(Fig. 1), with a mild relationship between the climatic characteristics and the zones of origin. Several accessions (3CAY5A, 3ONO1A, 3CUN1A, 2MAR1A, 3COR1A, 3CUR1A, and 97AMB1A), could not be assigned to a given cluster. 97AMB1A (collected in Ecuador), was the most different of the accessions considered; this accession was originally described by Garcilaso de la Vega in 1609 (Popenoe, 1921; Wilhelm and Sagen, 1974). Native Chilean strawberries were taken by the Spaniards from Chile to Perú and in 1557 to Ecuador; these plants have been productive for over four centuries without replanting and irrigation (Darrow, 1953; Wilhelm and Sagen, 1974). In the dendrogram (Fig. 1), this accession appears to be the most different, which agrees with the description of Popenoe (1921) when he visited Santiago and mentioned that “these plants appear quite vigorous and robust and markedly different from those observed in Huachi, Ecuador.” Considering that in this experiment conditions were homogeneous for all accessions, 97AMB1A presented an intermediate growth habit. Also, the accession 3CUR1A is shown as

Fig. 1. Dendrogram of *F. chiloensis* accessions derived from multivariate analysis of the characteristics of vegetative organs and flowers. It shows the normalized distance from the root of the average (RMS) of the different accessions and the groups with RMS > 8.

different from other white-fruited accessions, which coincides with the conclusions of Lavín et al. (2000).

Figure 1 also shows that most cultivated white-fruited accessions (*F. chiloensis* f. *chiloensis*) included in this analysis are separated from the red-fruited wild accessions (*F. chiloensis* f. *patagonica*), which appear in group nine or are isolated (such as 97AMB1A and 3CUR1A). This agrees with descriptions by Staudt (1962) and Lavín et al. (2000).

In the multivariate analysis of fruit characters (Fig. 2), all but four accessions were included in 6 clusters. The phenological characterization, based on the presence of flowers and fruits during the season, allowed the formation of four distinct groups. The most precocious accession was 3CUR1A, which started blossoming in the first week of October.

The main objective of the future breeding program will be focused on the creation of cultivars with large whitish fruits, similar to the traditional ones but with higher yield potential. The parents will be mainly chosen from the white cultivated accessions (*F. chiloensis* f. *chiloensis*) but some red fruited accessions (*F. chiloensis* f. *patagonica*) will be included, since even though they bear small fruit, they have some interesting characters, such as a longer flowering period. From the results presented, it is clear that some red fruited accessions are

Fig. 2. Dendrogram of *F. chiloensis* accessions derived from multivariate analysis of fruit characteristics. It shows the normalized distance from the root of the average (RMS) of the different accessions and the groups with RMS > 8.

genetically close to the white fruited ones (clusters 1 and 7, Fig. 1), so if they are crossed less variation should occur.

Literature Cited

- Darrow, G.M. 1953. Strawberries in Mexico, Central America, Colombia, and Ecuador. Ceiba 3:177-185.
- Lavín, A., A. Del Pozo, and M. Maureira. 2000. Distribución actual de *Fragaria chiloensis* (L.) Duch. en Chile. IBPGR Plan Genet. Resour. Nwsltt. 122:24-28.
- Popenoe, W. 1921. The frutilla, or Chilean strawberry. J. Hered. 12:457-466.
- Staudt, G. 1962. Taxonomic studies in the genus *Fragaria*, typification of *Fragaria* species known at the time of Linnaeus. Can. J. Bot. 40:869-885.
- Wilhelm, S. and J. Sagen. 1974. A History of the strawberry, p. 85-104. Univ. Calif. Div. Agr. Sci.