VIEWPOINT

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Few Cytoplasm Contribute to North American Strawberry Cultivars

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The cytoplasm of plants contains genetic information that is transmitted maternally. All progeny from a single female plant will share the same extra-chromosomal genes unless a mutation occurs. To date, the strawberry *(Fragaria* × *ananassa* Duch.) has not been analyzed to show the cytoplasmic contribution of different maternal founding clones to the gene pool of North American cultivars. This report summarizes the contribution played by the maternal founding clones to the cytoplasm. of the present North American cultivars.

The 134 cultivars of known parentage released in North America between 1960 and 1987 were used as the database, and the pedigree tables assembled by Sjulin and Dale (1987) were used as the basis for this study. The cytoplasm of each cultivar was traced by following pedigrees back to the original maternal parent or the last clone of known parentage.

Only 17 cytoplasm were identified in the 134 cultivars of known parentage (Table 1), considerably fewer than the 53 founding clones identified by Sjulin and Dale (1987). Three of the cytoplasm were traced to their native founding clones, while the others were traced to old cultivars whose origins could not be determined due to incomplete records. Therefore, there are almost certainly even fewer cytoplasm involved than 17. The exact number of founding cytoplasm could probably be inferred from assays of the mitochondrial and chloroplast DNA.

Cultivars with a single cytoplasm were sorted into 11 groups based on geographical origin (Sjulin and Dale, 1987) to see if the groups contained few or unique cytoplasm. The contribution of the cytoplasm varied among these groups. Those of 'Missionary' and 'Hudson Bay' are evenly distributed, each in six of the 11 groups, whereas the cytoplasm of 'Middlefield' (13/18 in California group), 'Chesapeake' (11/13 in southeastern group), 'Aberdeen' (11/12 in northeastern group), and 'Marshall' (nine/nine in northern everbearing group), and *F. virginiana* 'The Native Iowa' (six/seven in southeastern group) are restricted mainly to one group.

The contribution of cytoplasmic genes to the improvement of the strawberry has not been investigated in detail. Only a few studies showing differences between reciprocal crosses have been described (Barritt et al., 1982; Sjulin et al., 1986). June yellows is thought to be transmitted by cytoplasmic genes (Scott and Lawrence, 1975), and susceptible cultivars have included those with cytoplasm from five founding clones.

Steps should be taken to introduce new cytoplasm to avoid the increased risk of deleterious effects such as June yellows. With so few cytoplasm present, cultivars of widely differing germplasm may have identical cytoplasm. As the non-nuclear genes in the cytoplasm cannot be introduced by crossing, a program to extend the cytoplasm base of the crop should be considered.

Two strategies can and are being adopted by North American strawberry breeding programs to increase cytoplasmic diversity. These are to a) increase the number of cultivars with known different cytoplasm that are used as female parents, and b) introduce cytoplasm from wild *Fragaria* spp.

Probably the most promising of the two strategies is to introduce cytoplasm from wild *Fragaria* spp. Several collections of wild species recently have been announced, both

Table 1. All North American strawberry cultivars of known parentage released between 1960 and 1987, grouped according to their maternal founding clone.

Maternal founding clone	Cultivars
Missionary	American Sweetheart, Annapolis, Blomidon, Cataldo, Dabreak, Fresno, Glooscap, Mars, Micmac, Midway, Nisqually, Quinault, Rainier, Scott, Shuksan, Stoplight, Sunrise, Tangi, Tioga, Torrey, Vantage
Hudson Bay	Aliso, Aptos, Badgerbelle, Deep Red, Dover, Florida Belle, Gala, Garnet, Honeylump, Northland, Red Titan, Santana, Sequoia, Trumpeter, Ulrich, Veegem, Veestar, Wiltguard
Middlefield	Aiko, Bounty, Brighton, Cascade, Chandler, Cruz, Douglas, Fern, Hecker, Marlate, Parker, Salinas, Selva, Soquel, Toro, Tufts, Tustin, Vista
Chesapeake	Allstar, Apollo, Atlas, Guardian, Linn, Prelude, Redchief, Secord, Sentinel, Sumner, Titan, Tribute, Tristar
Aberdeen	Acadia, Citation, Cornwallis, Darrow, Earliglow, Governor Simcoe, Holiday, Jewel, Kent, Lester, Raritan, Veeglow
Marshall	Amazing, Autumn Surprise, Fantasy, Shortcake, Spring Beauty, Spring Giant, Sunburst, Temptation, Universal Red
Neunan	Benton, Fortune, Molalla, Nedspride, Olympus, Pajaro, Tillicum, Totem, Tyee
Early Jersey Giant	Candy Red, Gilbert, Locke Lake Ruby, Millay Everbearer, Red Giant, Royalty, Sweet Abundance, Sweet Surprise
F. virginiana 'The Native Iowa'	Arking, Cardinal, Comet, Delite, Earlibelle, Earlimiss, Rosanne
Ettersburg 450	Badgerglo, Honeoye, Vesper, Vibrant
Champion	Ourown, Porter's Pride, Protem, Tendersweet
F. chiloensis 'Cape Mendocino'	Cheam, Hood, Vale
Bubach	Centennial, Chief Bemidji
Markee	Alaska Pioneer, Canoga
Streamliner	Fort Laramie, Geneva
F. chiloensis 'Reedsport'	Columbia
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of *F. chiloensis* from California (Hancock and Bringhurst, 1979), Washington and Oregon (Crock et al., 1982), and British Columbia (Daubeny and Frazer, 1987), and *F. virginiana* from Minnesota (Stabler et al., 1987) and Ontario (Dale, 1988). However, about half the clones selected from these programs will be unavailable as female parents because they are pollen parents only.

The two strategies mentioned should be used to increase the cytoplasmic variation in North American strawberries. This can be achieved without diverting resources from efforts to increase nuclear genetic diversity by careful selection of female parents within existing breeding programs. However, more information is needed to determine the role played by cytoplasmic variation in the development of new strawberry cultivars.

Literature Cited

Barritt, B.H., R.S. Bringhurst, and V. Voth. 1982. Inheritance of early flowering in relation to breeding day-neutral strawberries. J. Amer. Soc. Hort. Sci. 107:733-736.

Crock, J.E., C.H. Shanks, Jr., and B.H. Barritt. 1982. Resistance in *Fragaria chiloensis* and *F.* × *ananassa* to the aphids *Chaetosiphon fragaefolii* and *C. thomasi.* HortScience 17:959-960.

Dale, A. 1988. Variation in wild strawberry in Ontario. Rpt. Commun. Hort. Res. for 1987. Canadian Hort. Council, Ottawa. p. 17.

Daubeny, H. and B.D. Frazer. 1987. The British Columbia *Fragaria chiloensis* collection. Rept. Commun. Hort. Res. for 1986. Canadian Hort. Council, Ottawa. p. 80.

Hancock, J.F., Jr., and R.S. Bringhurst. 1979. Ecological differentiation in perennial, octoploid species of *Fragaria.* Amer. J. Bot. 66:367-375.

Scott, D.H. and F.J. Lawrence. 1975. Strawberries, p. 71–97. In: J. Janick and J.N. Moore (eds.). Advances in fruit breeding. Purdue Univ. Press, West Lafayette, Ind.

Sjulin, T.M. and A. Dale. 1987. Genetic diversity of North American strawberry cultivars. J. Amer. Soc. Hort. Sci. 112:375-385.

Sjulin, T.M., J. Robbins, and B.H. Barritt. 1986. Selection for virus tolerance in strawberry. J. Amer. Soc. Hort. Sci. 11:458-464.

Stabler, M.M., J.J. Luby, and P.D. Ascher. 1987. Evaluation of repeat-flowering and sex expression in wild populations of *Fragaria virginiana.* HortScience 22:1076. (Abstr.)

Corrigendum

• In the article "Influence of Endocarp Thickness on Rose Achene Germination: Genetic and Environmental Factors", by Serge Gudin, Laurence Arene, André Chavagnat, and Camille Bulard *[HortScience* 25(7):786-788, July 1990], the text and numbers were not included on the x and y axes of Figs. 1 and 2. The authors' revised figures are as follows:

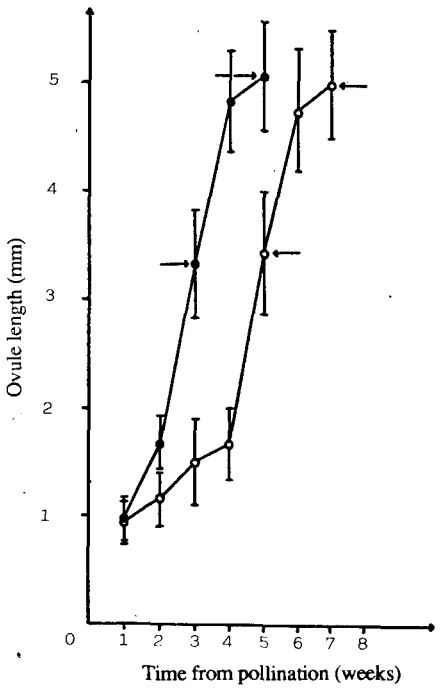

Fig. 1. Ovule length of 'Meiringa' × 'Meitulandi' (○) or × 'Pink Puff' (●) roses until embryos are "visible". For both curves, the first arrow signals the time when the difference between fecund and nonfecund ovules becomes noticeable; the second signals the time when embryos are visible.

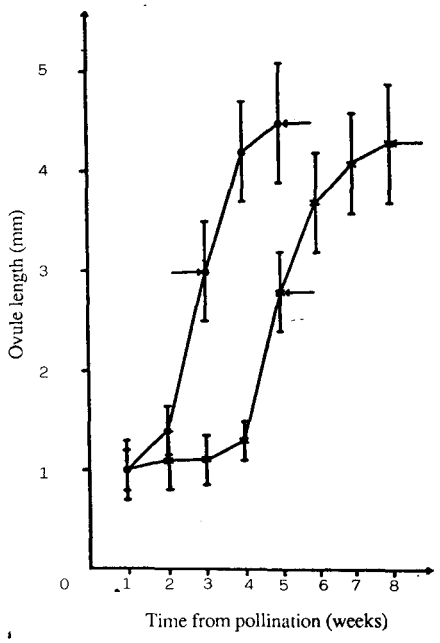

Fig. 2. Ovule length of no. 364-73. D × 'Jelrafloki' from May (●) or March (*) pollinations until embryos are "visible". For both curves, the first arrow signals the time when the difference between fecund and nonfecund ovules becomes noticeable; the second signals the time when embryos are visible.