Strawberry, *Fragaria virginiana* glauca from Uintah Mountains, Utah (left), similar to the one used in original hybridization leading to breeding of California day-neutrals (source of genes conditioning day-neutrality). 'Hecker' (right) is a third backcross derivative (1979 release).

# Hybridization in strawberries

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Polyploidy is important in strawberries, because only in the end products found in nature (octoploids *Fragaria chiloensis* and *F. virginiana*) were the necessary genes found, organized, and conserved in such a way as to make possible the relatively rapid breeding of the modern large-fruited strawberry cultivars. Lower ploidy levels are of interest, because they tend to be highly specialized to specific environments, and many of the traits they carry as a result may be useful in the cultivars of the future, if they can be introduced into the octoploids.

Only a small part of the rich germplasm pool available for strawberry breeding has been utilized thus far, and genetic accessibility has been the deciding factor in determining what has been used. The most accessible species have been American *F. chiloensis* and *F. virginiana*, ancestors of modern cultivated strawberries (*F.* X *ananassa*), since all are octoploids (2n = 8× = 56 chromosomes).

In interspecific hybridization at the octoploid level, *F. chiloensis* has been the source of many of the genes presently exploited in all important cultivars, including those governing disease resistance and those that condition ability to grow vigorously during the winter. The latter probably trace back to Etter's 'Fendalcino', a California *F. chiloensis* derivative and ancestor of 'Lassen', the cultivar upon which the southern California commercial strawberry industry was built.

*F. virginiana* has also been the source of many important genes, including those governing the ability to grow under rigorous environmental conditions. Recently, a new group of day-neutral cultivars has been derived directly from hybrids between 'Shasta' and an *F. virginiana* male plant from the Wasatch Mountains of Utah through backcrossing. The group includes the California cultivars 'Aptos', 'Brighton', and 'Hecker' and the USDA-Maryland cultivars 'Tribute' and 'Tristar', all released recently, Starting with specific target genes in wild octoploids, only three to four backcrosses are required to transfer a given trait into useful cultivars.

In developing interspecific hybrids with lower ploidy levels, genes from diploid (2n = 2× = 14), tetraploid (2n = 4× = 28), and hexaploid (2n = 6× = 42) *Fragaria* species can be transferred to the octoploid cultivars in more indirect ways. Only transfers involving diploids and, to a lesser extent, tetraploids will be discussed here.

Two approaches have been explored, and both are feasible. The first involves going to the next higher chromosome level, decaploid (2n = 10× = 70) through natural doubling of the chromosome number. This has been accomplished in a number of ways, including:

☐Hybridizing the octoploids with the diploids to produce pentaploids (2n = 5× = 35) and doubling the chromosome number with colchicine.

☐Intercrossing or self-pollinating the pentaploids, relying on the higher incidence of functional unreduced male and female gametes to yield decaploids.

☐Using natural tetraploids or induced tetraploids (from diploids) to hybridize with the octoploids to produce hexaploids (2n = 6× = 42), and in turn backcrossing the hexaploids to the octoploid, again relying on the high incidence of unreduced gametes in the hexaploids to yield decaploids.

☐Developing 16-ploids (2n = 16× = 112) by colchicine treatment of octoploid gametes in hybridization with the above-mentioned tetraploids.

The second approach uses 9-ploid (2n = 9× = 63) plants in backcrossing to octoploid cultivars, relying on the high probability that the 9-ploids will be very fertile, and virtually all of the gametes will result from normal reduction. The strategy is simply to select for the target gene or combination of genes from the diploid species and then, through backcrossing, incorporate those genes into the derivatives, finally, by eliminating undesirable chromosomes, arriving back at the octoploid level. The simplest way to generate 9-ploids in large numbers has been to backcross the pentaploids already mentioned to the desired octoploids, relying again upon the fact that most of the offspring of the pentaploids will be from unreduced gametes.

All or part of the uses of diploid and tetraploid species in hybridization with octoploids have been carried out with diploids *F. vesca*, *F. viridis*, *F. iinumae*, *F. nubicola*, and *F. yezoensis* and with the tetraploid *F. orientalis*. Much of the study has involved natural pentaploid and hexaploid hybrids between octoploid California *F. chiloensis* and diploid California *F. vesca* found along the California coast.

Intergeneric hybridization between *Fragaria* and *Potentilla* species offers many interesting possibilities. Two fertile colchicine-induced amphiploids have been reported, one a decaploid hybrid between octoploid *F.* X *ananassa* and *P. palustris* giving a 14-ploid (2n = 14× = 98) and the other a decaploid hybrid between octoploid *F. chiloensis* and diploid *P. glandulosa* (2n = 10× =70). The latter decaploid is of particular interest, because it can be crossed with the decaploid *F. chiloensis* and *F.* X *ananassa* x *F. vesca* hybrids, opening the way for possible transfer of *Potentilla* genes to octoploid strawberries via backcrossing with the resulting 9-ploid hybrid.

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