Breeding New Tetraploid Grape Varieties

By H. P. Olmo, *University of California, Davis, Calif.*

THERE are now several grape varieties grown or introduced commercially which we have found to be tetraploid. The Muscat Cannon Hall was found to be the tetraploid Muscat of Alexandria (3). Undoubtedly further search for varieties that show enlarged or "giant" characteristics will add to this list (Table I). I am indebted to Mr. Nagao Tsuchiya, Yamanashi-Ken, Japan, for furnishing cuttings of the Japanese varieties in 1938. Although not all of the varieties have been commercially proven, they have much larger berries and ripen earlier, in these respects being superior to the parent varieties from which they have arisen as spontaneous somatic mutants. However, of 20 tetraploid vinifera varieties observed for more than 4 years at Davis, the undesirable characteristics that may prevent commercial acceptance are: (a) Poor growth habit. The shoots have shorter internodes, resulting in too compact a vine. This results in sparse foliage cover of the fruit and is serious with varieties that sunburn, such as the tetraploid Flame Tokay and Muscat of Alexandria. The canes, shoots, and cluster stems are all very brittle, and there is considerable breakage of the vine from wind. The fruit requires more careful handling, and the keeping qualities are poor, as the cluster structure is more succulent and the berries are softer in texture. (b) Irregular and poorly set clusters. This is much more pronounced in some seasons than others, but most varieties set a smaller percentage of berries than the corresponding diploid (Table II). Some clusters may set compactly but others may remain straggly. (c) The total yield per vine is often less. Crop records on 15 vines of the tetraploid Thompson Seedless, averaged for the three years 1939 to 1941, showed 12.2 ± 0.8 (S.E.) pounds as compared to 21 ± 0.5 pounds for the diploid. This reduction in yield is in many tetraploids the result of fewer inflorescences per vine.

TABLE I—Tetraploid Grape Varieties Introduced or Grown Commercially*

Parent Variety (2X)	Tetraploid (4X)	Notes
Muscat of Alexandria	Muscat Cannon Hall	First described in England in 1835; grown only in European glasshouse trade.
Campbell	Early Giant	U. S. Plant Patent No. 42, November 8, 1932.
Campbell	Black King	Variety grown in Japan under this name.
Catawba	Otsubu Catawba	Variety grown in Japan under this name.
Concord	Wallis Giant	The same mutant known from California and Oregon.
Delaware	Benikawachi	Grown in Japan.
Koshu	Otsubu Koshu	Grown in Japan.
Niagara	Otsubu Niagara	Grown in Japan.

*Other tetraploid forms have recently been described (1, 6), but these have not been offered as having commercial possibilities.

It has been found impossible to generalize for grape tetraploids as a whole. For example, the tetraploids derived from interspecific hybrids such as the Niagara, Catawba, and Delaware do not have such an undesirable growth habit as most of the vinifera tetraploids. The longer internode length present in these hybrids is shortened somewhat, but

TABLE II—PER CENT SEEDED BERRY SET OF SOME DIPLOID AND THEIR CORRESPONDING TETRAPLOID VARIETIES WHEN SELF-POLLINATED (SEASON OF 1941)

Variety	Species Derivation	Diploid (2X)		Tetraploid (4X)	
		Flowers	Per Cent Set	Flowers	Per cent Set
Campbell	Labrusca × vinifera	1004	38	1635	32
Catawba	Labrusca × vinifera	826	58	538	29
Delaware	Complex?	471	44	520	40
Niagara	Labrusca × vinifera	1229	54	772	50
Cornichon*	Vinifera	5665	17	4651	21
Folle blanche*	Vinifera	2507	65	1515	44
Muscat of Alexandria*	Vinifera	9166	5	9295	9
Zinfandel*	Vinifera	4282	58	5188	22

*Data from Randall, T. R. (5), seasons of 1939 to 1941.

the resultant growth habit is as good as many commercial vinifera diploids. In fruitfulness the same situation applies: the 4X Niagara, for example, has produced well-filled clusters at Davis, and even though the set is smaller than the diploid, the increase in berry size offsets this defect, whereas the Catawba and Koshu tetraploids have often given very irregularly set clusters. Among the vinifera wine grapes we also see such differences, the Carignane tetraploid produces well-filled clusters rather consistently, but the Zinfandel tetraploid is often very straggly.

We must conclude, therefore, that the results of tetraploidization in any given grape variety cannot be predicted with certainty. This indicates that it is not the mere doubling of the chromosome number per se that produces the typical features of a given tetraploid variety, but it is the changed genetic balance that does so. Thus the genotype of the particular variety in which doubling occurs plays a large role. In a number of 4X vinifera varieties studied by Randall (5), he has reached the same conclusion regarding their fertility relationships. Thus the 4X Muscat of Alexandria is actually more fertile than the diploid from which it arose, whereas other varieties may show quite the reverse.

It would appear, therefore, that some of the desirable features of tetraploidy can be maintained and the defects eliminated by breeding and selection, despite the fact that we are essentially dealing with autotetraploids in the grape, even in those derived from species hybrids. Certainly a most promising field is to increase the heterozygosity by the crossing of unrelated tetraploids.

Crosses were first made at this station between the varieties Muscat of Alexandria (4X) and Thompson Seedless (4X) in 1936. In this population three seedlings were grown to fruiting age, two were determined to be pentaploids and the other triploid. From these results and the more extensive data accumulated by Randall (5), the use of tetraploids in breeding can therefore be advantageous in further increasing the chromosome number. We have also produced numerous triploids, that appear to have promise as rootstock varieties because of their great vigor (4, 5). The pentaploids have desirable growth habit, but studies of their fertility are not yet completed. This same cross was

repeated on a larger scale in 1937, and from the population 10 tetraploids were obtained with the range in chromosome number determined as 76 to 76 ± 4. These hybrids show markedly the effects of gene segregation, differing among themselves in growth habit and fertility despite the same approximate chromosome number. One tetraploid variety has the appearance of an extremely vigorous diploid, having produced canes measuring 20 feet in length in a single season, with leaves measuring 12 to 14 inches in width. The berry size of three seedlings is as large as the tetraploid parents, and in one even larger.

These preliminary results are mentioned only because the possibilities of breeding and selection among the tetraploid forms appears promising, with the possible outcome the production of varieties with much larger berries and with a vigor heretofore unknown amongst grapes. Large progenies now coming into bearing will allow us to present quantitative data of genetic interest.

SUMMARY

Some tetraploid grape varieties introduced or grown commercially are reported. These are creating interest because of their larger berry size and earlier ripening. Most tetraploid varieties have certain defects which prevent their commercial acceptability, among these is poor growth habit, irregular setting of fruit, and reduced yield. It is impossible to predict the effects of doubling the chromosome number of a given variety on its growth habit and fertility, and hence its possible commercial value.

The particular genotype of the original variety that undergoes duplication appears to determine the characteristics of the new tetraploid more than does the doubling of the chromosome number *per se*. Change in genotype brought about by crossing and selection amongst tetraploids will thus enable the breeder to produce new varieties having increased berry size, and other desirable features of the tetraploid condition and at the same time eliminate the defects such as reduced fertility and poor growth habit of the vine.

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