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Early maturity and seed abortion in tetraploid grapes

by

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Introduction

Tetraploids were produced in ten varieties of grapes by Dass and Mukherjee (1967). During the studies on five of them which came to fruiting, it was noted that the tetraploid bunches accumulated sugars and matured earlier than the diploids. Other data on the viability of seeds and the growth of ovules and the berries indicated that these features were related to early maturity. The relevant data from two varieties are presented and discussed here.

Materials and Methods

The growth of berries was recorded as mean of the diameter of five berries, at three day intervals, by means of a vernier caliper; the average was used for the graph.

Total soluble solids (TSS) were recorded by a hand refractometer, from two fruits picked at random from the bunch, and the average value was recorded every fourth day. — The seed growth was tested by floating and by X-ray photographs.

For studying the development of the ovules, five ovaries were collected at anthesis and 2, 4, 8, 15 and 25 days after anthesis, and were fixed in Craf fluid, dehydrated with alcohol-tertiary butyl alcohol mixture and embedded in wax. Sections were cut at 10 μ and stained by the iron haematoxylin method.

Results

Growth of berries

The data on measurement of berries in Pearl of Csaba and Madeleine angevine are plotted in Fig. 1. In both the diploid and the tetraploid, the curve was double sigmoid, and period I ended at about the same time. Period II, on the other hand, was distinctly shorter in the tetraploids. Period III commenced earlier and ended earlier in the tetraploids.

The curves of rates of growth show that in both the tetraploids these were distinctly higher than in the diploids in the second peak, i. e. period III. As to Madeleine angevine, however, there was little difference in first peak.

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Table 1

Development of total soluble solids (TSS) in diploid and tetraploid fruits

Days from anthesis	Pearl of Csaba				Madeleine angevine			
	2n		4n		2n		4n	
	TSS	increase in 3 days	TSS	increase in 3 days	TSS	increase in 3 days	TSS	increase in 3 days
44	8.5	—	12.5	—	10.0	—	13.0	—
47	9.5	1.0	14.9	2.4	11.0	1.0	15.0	2.0
50	11.3	1.8	16.7	1.8	11.9	0.9	16.2	1.2
53	13.0	1.7	18.2	1.5	12.8	0.9	17.0	0.8
56	14.1	1.1	19.4	1.2	13.6	0.8	17.6	0.6
59	15.0	0.9	20.0	0.6	14.3	0.7	18.0	0.4
62	15.7	0.7			14.7	0.4		
65	16.3	0.6			14.9	0.2		
68	16.7	0.4			15.0	0.1		
71	17.0	0.3						

Above data show that the berries of the tetraploids had higher TSS than those of the diploids at each stage of maturity, with greater periodical increments.

Maturity

All the tetraploids matured earlier during the year than the diploids. Earliness was most marked in Black Prince (23 days) and Pearl of Csaba (16 days), and was eight days in Madeleine royale, 5 days in Madeleine angevine and 4 days in Bharat Early.

Floating seeds

One striking feature was that practically all the seeds of the tetraploids were floating and non-viable. X-ray photographs showed them to be empty (Fig. 2). In one of the tetraploid bunches of Pearl of Csaba, a few seeds were well filled and weighed 41 mg each, whereas the bulk of the seeds, which were floaters, weighed only 25 mg per seed against the diploid average of 20 mg.

Development of ovules

The percentage of normal ovules at different stages is presented in Table 2.

Table 2

Percentage of normal ovules at different stages after anthesis

Days from anthesis	Madeleine angevine		Pearl of Csaba	
	diploid	tetraploid	diploid	tetraploid
0	100	95	90	85
2	80	70	55	50
4	65	50	45	45
8	70	40	35	35
15	65	25	45	40
25	67	25	42	42

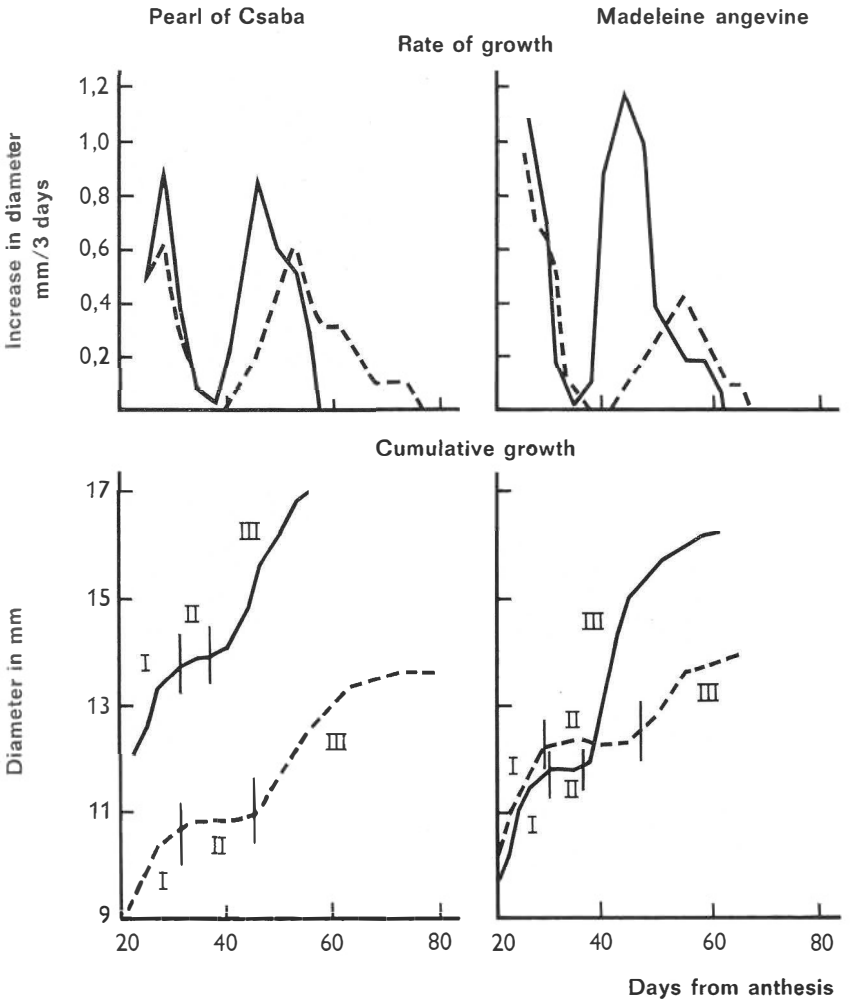

Fig. 1: Growth of berries in diploids and tetraploids. — — — — diploid, ——— tetraploid. I, II, III = Period I, period II, period III.

The average length of the ovule approximately indicates the time when its growth might have been arrested. In the variety Madeleine angevine, the percentage of normal ovules is nearly constant from the fourth day in the diploid whereas, in the tetraploid, it decreased progressively till the 15th day. In Pearl of Csaba, the reduction was progressive in both the diploid and the tetraploid. The fact to be noted is that by the 25th day after anthesis there is a percentage of normal ovules in the tetraploids. Yet, at maturity all the ovules are aborted. It was also noted that the arrested ovules showed no abnormalities like those described in Thompson Seedless and Corinth by Pearson (1932) and Stout (1936).

Discussion

From the cumulative growth curves (Fig. 1), it is to be seen that while period I is practically similar in both diploids and tetraploids, period II is shorter in tetraploids suggesting its relationship with earliness in maturity.

Period II coincides with the period of development of the embryo (NITSCH, 1953) in fruits having a double sigmoid growth. TUKEY (1933) related the shortening of period II to embryo abortion in early ripening cherries. He found a direct relation between the ripening dates and the duration of period II in several varieties of peaches, in all of which period I was identical. TUKEY (1936) also proved that drilling out embryos of cherry and peach about the end of period II, caused earliness. Arrest of the growth of embryos by growth substances also resulted in earliness in apricots and peach (CRANE *et al.*, 1960), fig (CRANE and BLONDEAU, 1951), and in grape (CLORE, 1965). It is therefore indicated that in grape with double sigmoid growth of fruits, arrest of embryo growth, as evidenced by the complete empty seededness has led to earliness.

Examination of the developing ovules showed that upto the 25th day, the seeds, which did not abort, developed normally showing no retardation of growth. Therefore, the shortening of period II cannot be attributed to any abnormality in period I as suggested by BRINK and COOPER (1941) in similar cases. It would appear, on the other hand, that there was an earlier onset of period III, shortening period II. If the embryos which appeared normal upto the 25th day were viable upto period II (which was between the 30th and 37th day from anthesis), as in the case of the embryos of early cherry varieties cultured by TUKEY (1933), it would be reasonable to infer that the earlier onset of period III was rather the cause than the result of suppression of the embryos.

OLMO (1934) was of the opinion that in the occurence of empty seeds, the abortion of the embryo was secondary and the cessation of the growth of embryo is a result of disturbance originating in the maternal tissues. It is, therefore, considered that the cause of the late suppression of embryos in the tetraploid grapes was due to the rapid development of berries in period III. The higher rate of growth of tetraploid berries during the second growth peak gave support to this view.

In grapes, period III growth is mainly due to osmotic diffusion of water, following the influx of sugar into the berry by the end of period II (COOMBE, 1960). The data on sugar accumulation (Table 1) show earlier accumulation of sugar in the tetraploids than in the diploids. There is also a close correspondence between the magnitude of the rates of growth and sugar accumulation, which are interdependent.

Hence, early maturity of tetraploids may be explained as follows. The first cycle of growth in the berries of both diploid and tetraploid is identical, and period II starts at the same time. Then the influx of sugar takes place, followed by osmotic attraction of water resulting in rapid expansion of size i. e., earlier onset of period III and rapid growth. It is more rapid in the tetraploids, because of their larger cell size. The relatively higher rate of growth in the tetraploids probably suppresses the development of embryo and results in empty seededness.

Both earliness and higher TSS have not been mentioned by DERMEN and SCOTT (1962) in their survey of 65 tetraploid grape varieties. OLMO (1942) and FRY (1963) have noted earliness in tetraploid grapes. It would, therefore, be interesting to study the behaviour of these tetraploids for some more seasons and in other climatic regions, which is now in progress.

Summary

Five out of the ten tetraploid varieties of grapes produced at the Indian Agricultural Research Institute, New Delhi, came to fruiting. All of them matured earlier than their diploids. Detailed investigation in two of the varieties revealed that in the tetraploids, period II of the growth of berries was shortened, rates of period III growth were higher, TSS accumulated earlier and all the seeds were floating seeds (empty). It appeared that the late abortion of seeds resulting in empty seededness and earliness of maturity of bunch were associated with each other.

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