Chromosome Behaviour of a Spontaneous Autotetraploid Guava (*Psidium guajava*, L.)

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During the survey of guava orchards a typical guava tree has been found in Allahabad which deviates significantly from the other varieties of guava in some of the morphological features. In comparison to triploid and diploid varieties the tree is more spread up. The foliage of this plant is darker, larger and thicker. It blooms more or less throughout the year. Its ripe fruits are smaller and display few seeds on cutting. These salient morphological features have warranted a cytological study of the tree. Preliminary observations have been reported by Naitani and Srivastava (1966). This communication presents a detailed cytological findings.

Materials and methods

The tetraploid form of *Psidium guajava*, L was found in an orchard of Allahabad Agricultural Institute.

For mitotic studies root tips were treated, in .001 M solution of 8-hydroxy-quinoline for 3 hours at 14°C and fixed in 1:3:6 mixture of glacial acetic acid, chloroform and absolute alcohol. Afterwards it was transferred in a mixture of eight parts aceto-orcin and two parts N-Hydrochloric acid. It was gently warmed and squashed in 1% aceto orcin.

For meiotic studies floral buds were fixed in 1:3:6 mixture of glacial acetic acid, chloroform and absolute alcohol with a few crystals of ferric acetate. Anthers were squashed in 1% propiono-carmin. Photomicrographs were prepared from temporary slides at a magnification of 2325 ×. Drawings were prepared by bleaching of photomicrographs.

Observations

Cytological observations of mitotic preparations have revealed that the chromosome number of this form of *P. guajava* is $2n=44$ (Fig. 1).

During meiosis at diakinesis quadrivalents varying from 6 to 11 have been observed. In 78 cases 11 quadrivalents have been found (Fig. 2). In 12% cases 10 quadrivalents with a trivalent and a univalent have been noted. Four per cent PMC revealed 9 quadrivalents and 4 trivalents. In another 4% cells 6 quadrivalents with 10 bivalents and 3 nucleoli, with a pair of bivalents attached to a nucleolus have been observed. In 2% cases 7 quadrivalents and 8 bivalents have been seen

(Fig. 4).

Behaviour of the chromosomes during metaphase I have been observed from a large number of PMCs. Analysis of 50 PMCs is being given in Table 1.

Figs. 1-6. Autotetraploid *Psidium guajava*, L. 1, $2n=44$. 2, 11. quadrivalents at diakinesis. 3, $9_{IV}+4_{II}$ at diakinesis. 4, $7_{IV}+8_{II}$ at diakinesis. 5, $6_{IV}+9_{II}+2_I$ at M I. 6, $7_{IV}+1_{III}+5_{II}+3_I$ at M I.

The frequency of PMC showing 11 quadrivalents has been found to be very high i. e. 76 per cent. Eight per cent cases have revealed quadrivalents concomitant with 9 bivalents and 2 univalents (Fig. 5). A configuration of 7 IV+1 III+5 II+

Table 1.

Configurations				No. of PMC	Percentage
IV	III	II	I		
11		7	2	38	76
7	1	5	3	3	6
7		10		3	6
6		9	2	1	2
6		21	2	4	8
				1	2
Total				50	

Mean number of quadrivalent per cell	=9.80	Percentage of cells enclosing quadrivalent	=98.00
Number of trivalent per cell	=0.06	Percentage of cells enclosing trivalent	= 6.00
Mean number of bivalent per cell	=2.06	Percentage of cells enclosing bivalent	=24.00
Mean number of univalent per cell	=0.50	Percentage of cells enclosing univalent	=22.00

3 I=44 (Fig. 6) has been found in 6% cells. Another 6% PMC revealed the configuration of 7 IV+7 II+2 I=44 (Fig. 7). The two univalents were just opposit to each other, showing that the univalents were the product of precocious disjunction of a bivalent. Two percent PMC have shown 6 quadrivalents along with 10 bivalents (Fig. 8). Beside these, 21 bivalents and two univalents were seen in 2% cases.

At anaphase I bivalents disjoined normally but in case of trivalents one of the component moved to one pole and the other two to the other pole. In a few cases the middle chromosome was left behind and remained as a laggard. In 57.3% cases the distribution of the chromosomes was 22: 22 (Fig. 9). In other cases the distribution was unequal (Fig. 10), often with varying number of laggards (Table 2).

Table 2

Distribution	22-22	23-21	24-20	20-5-19	20-3-21	22-1-21	22-1/2-1/2-21
No. of cells	55	8	7	7	6	8	5
Percentage	57.3	8.3	7.3	7.3	6.2	8.3	5.2

About 5% cases have displayed the distribution of 22 and 21 chromosomes with one divided laggard (Fig. 11). In most cases the laggards appeared to have reached to their respective poles. Though in rare cases they did not reach the poles and remained more or less at the equator (Fig. 12).

At metaphase II usually 22 chromosomes have been observed at each equator (Fig. 13), but variations in the distribution of chromosomes have also been observed. About 6% cases have shown a distribution of 23 and 21 chromosomes. Seven per cent PMC revealed 24 chromosomes at one equator and 20 chromosomes at the other equator.

At anaphase II usually the distribution of chromosomes was 22: 22: 22: 22

Figs. 7-15. 7, $7_{IV}+7_{II}+2_I$ at M I. 8, $6_{IV}+10_{II}$ at M I. 9, 22:22 distribution at A I. 10, 24:20 distribution at A I. 11, division of a laggard. 12, stray chromosome at T I. 13, 22 and 22 chromosomes at M II. 14, normal distribution at A II. 15, spindle fusion at A II.

(Fig. 14), but certain variations have been observed such as a distribution of 22: 21: 21: 20 with 1 chromosome lying away from one spindle and 3 laggards in another spindle. In 7.5% cases a distribution of 23: 23: 21: 21 has been observed. About 7% PMC have shown the distribution of 24: 24 and 20: 20 chromosomes. Besides irregular distribution of chromosomes, in certain PMC spindle fusion at anaphase II has been observed (Fig. 15).

At telephase II in some cases 1-2 micronuclei have been observed. Pollen fertility was found to be 52.5%.

Discussion

Chromosome number of this form of *Psidium guajava*, L. has been found to be $2n=44$. The basic number of this genus being eleven (Atkinson 1947) this form of *P. guajava*, L. is a tetraploid. Very high frequency of PMC showing 11 quadrivalents and the somatic number of 44 chromosomes clearly reveals the autotetraploid nature of this form of guava. In *Psidium guajava*, L. diploid, triploid and tetraploid forms have been reported (Sharma and Majumdar 1957, Naithani and Srivastava 1966, Raman *et al.* 1969 and 1971). Polyploid forms may originate in either of two ways, firstly, by doubling of the chromosome number in the somatic tissue, secondly by formation of gametes containing the unreduced number of chromosomes. The genetical consequences of these two ways may be different. In the case of somatic doubling the resultant polyploid naturally contains a double complement of the chromosomes and factors present in the original form. Hence, there is no qualitative difference but a quantitative difference in factor content between the diploid and its derivative tetraploid form. On the other hand formation of gametes with more than the haploid complement of chromosomes may or may not have similar results to that of somatic doubling. It appears that somatic doubling has not played significant role in producing the autotetraploid *Psidium guajava*, L. Irregularities during meiosis of parents seems to have played greater role in the formation of this polyploid form. By the union of two unreduced gametes of diploid *P. guajava*, L. the tetraploid form appears to have evolved.

In the tetraploid form of *P. guajava*, L. besides multivalents univalents have been frequently observed. The univalents may have originated by any of the three ways. Firstly the chromosomes which have failed to pair at zygotene. In this case their orientation is at random at metaphase I. Secondly it may be one which pair to form a bivalent but whose two component chromosomes separated at diplotene because no chiasmata were formed between them. Univalents formed in this way orient near each other in the equatorial region. Thirdly, it is a product of precocious separation of a bivalent chromosome. Univalents thus evolved lie opposite each other in the equatorial region. There are two types of variation in univalent behaviour. Firstly, delayed equatorial orientation followed by division. Secondly, delayed equatorial orientation not followed by division. In the first case half univalent may follow either of the two course i. e. either they move to the poles and get access in time to be included in the telophasic nuclei or they remain in the cytoplasm. The half univalent may or may not divide during second division.

The tetraploid form of *P. guajava*, L. shows sterility to the extent of 47.5%. This high sterility may be attributed to three different causes. Firstly, irregular distribution caused by unequal disjunction of multivalents. Secondly, irregular distribution caused by meiotic abnormalities of a physiological nature presumed controlled genetically, and thirdly, genetic physiological sterility of an unexplained nature but not associated with meiotic irregularity. The relative importance of these causes varies with the autotetraploid *Psidium guajava* L.

Summary

The autotetraploid form of *Psidium guajava*, L. reveals highly irregular meiotic division. It shows multivalents, abnormal distribution of chromosomes at anaphase, equatorial disjunction of a laggard, spindle fusion during second meiotic division, formation of stray chromosome and micronuclei. Mode of origin of this polyloid and its sterility have been discussed.

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