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CYTOGENETIC STUDIES OF THE F1 HYBRID *SOLANUM INDICUM* L. × *S. MELONGENA* L. AND ITS AMPHIDIPLOID[1]

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SUMMARY

The F_1 hybrid (*S. indicum* × *S. melongena*) resembled the wild parent and exhibited hybrid vigour. In spite of normal meiosis, it was partly sterile with 48.9% stainable pollen. Its sterility is attributed to cryptic structural hybridity.

The amphidiploid (*S. indicum* – *melongena*) obtained through colchicine treatment was fully fertile. It showed a low multivalent formation during meiosis and it is classified as a segmental allopolyploid.

The practical value of the hybrid in eggplant breeding has been indicated.

INTRODUCTION

The results of the cytogenetic studies on the eggplant (*Solanum melongena*) and its related species are quite meagre. *S. indicum*, a prickly shrub-like plant found wild in forests and hilly tracts, is one of the related species of the eggplant occurring in India (BHADURI, 1951). SWAMINATHAN (1949) and MITAL (1950) who attempted hybridization between *S. melongena* and *S. indicum* reported incompatibility between them. NASRALLAH and HOPP (1963) obtained a sterile hybrid. However their report did not contain any data on the meiotic behaviour of the hybrid or the cause of sterility.

The results of studies on the F_1 hybrid *S. indicum* × *S. melongena* and its derived amphidiploid are presented in this paper.

MATERIALS AND METHODS

A local cultivar of *S. melongena* (purple striped) and *S. indicum* collected at Anamalai hills in South India formed the material for study.

The F_1 seedlings were treated with 0.4% colchicine solution to obtain amphidiploid. The emerging seedlings were carefully pulled out and the shoot portions were kept immersed in colchicine solution in an inverted position for 6 h. The roots were kept moist by wrapping them up in moist cottonwool. After treatment, the seedlings

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were thoroughly washed in distilled water and transplanted in pots. After a period of about 3 weeks in shade, they were planted in the main field.

For meiotic studies, the floral buds were fixed in 3:1 absolute alcohol and propionic acid saturated with ferric chloride and smeared with propiono-carmine (SWAMINATHAN et al., 1954). The pollen was stained in 1:1 acetocarmine and glycerine.

The F_1 hybrid (*S. indicum* × *S. melongena*) was obtained by using *S. indicum* as the pistillate parent. The reciprocal cross was not successful. The ploidy level of the colchicine-treated F_1 plants was checked by counting the chromosomes in the pollen mother cells. One of them was identified as an amphidiploid. Observations on morphological characters, meiosis and pollen were carried out in the parents, F_1 and amphidiploid.

RESULTS

Morphology

The data on morphological characters are presented in Table 1.

The F_1 (*S. indicum* × *S. melongena*) was prickly, shrub-like and perennial in nature and resembled the wild parent *S. indicum* most. It exhibited marked heterosis in plant height with 85.5 cm exceeding the mid-parent value by 21.1 cm. For other characters such as leaf length, size of floral parts and number of flowers per inflorescence, the heterotic expression was only marginal.

The hybrid did not set fruit on selfing. A few fruits, however, were set under open pollination. It was easily backcrossed with *S. melongena* as the pistillate parent, while the reciprocal failed. Crosses with *S. indicum* were not successful in either way.

The open-pollinated fruits were borne in clusters and resembled those of *S. indicum* with green stripes turning red on maturity. They were slightly bigger in size than those of *S. indicum* (Fig. 1). The seeds of these fruits were viable and the resulting progenies segregated widely for plant size, prickliness and fruit shape and size. The fruits of the segregants closely resembled those of cultivars grown in the vicinity (Fig. 1). A similar type of segregation was observed in the progenies of the back cross with *S. melongena* parent (Fig. 1).

The amphidiploid (*S. indicum* – *melongena*) closely resembled the F_1, but it was initially less vigorous and slow in growth. It flowered about 3 months late as compared with the F_1. The gigantic size usually observed in polyploids was clearly absent in the amphidiploid. It was 23.5 cm shorter than the F_1, but approximated the mid-parent value. The number of flowers per inflorescence and the sizes of the floral parts were not appreciably different from those of the F_1.

The fruit set was profuse and borne in clusters. In contrast to the F_1, the amphidiploid set fruit even on selfing. The fruits resembled those of the F_1, with a slight increase in size (Fig. 1). The seeds were viable and yielded fertile progenies.

Meiosis

Parents. The chromosome number was $2n = 24$ in the parental species. The meiotic behaviour was normal in both the species. At diakinesis, 12 bivalents were formed, out of which one remained attached to the nucleolus. At metaphase I, all the 12

Table 1. Measurements of certain morphological characters of the parents, F_1 and amphidiploid (mean of 5 plants).

Characters	*S. indicum*	*S. melongena*	Midparent value	F_1	Amphidiploid*	
					mean	range
Plant height (cm)	70.4 ± 3.66	58.3 ± 4.77	64.35	85.5 ± 3.19	62.0	
Leaf length (cm)	9.8 ± 0.16	13.5 ± 0.19	11.65	12.0 ± 0.23	9.6	8.7 – 11.5
Pedicel length (cm)	0.8 ± 0.02	1.4 ± 0.04	1.10	0.9 ± 0.03	1.1	0.9 – 1.2
Corolla length (cm)	1.4 ± 0.03	2.0 ± 0.04	1.70	1.8 ± 0.04	1.9	1.7 – 2.2
Anther length (cm)	0.7 ± 0.01	0.7 ± 0.01	0.70	0.9 ± 0.01	0.9	0.8 – 1.0
Style lenth (cm)	1.2 ± 0.03	1.1 ± 0.01	1.15	1.4 ± 0.02	1.4	1.3 – 1.5
Number of flowers per inflorescence	9.7 ± 0.23	3.5 ± 0.12	6.60	7.1 ± 0.32	6.9	3 – 8
Fruit diameter (cm)	1.1 ± 0.01	4.8 ± 0.18	2.95	1.3 ± 0.01	1.6	1.4 – 1.7

* Measurements of the single available plant.

Table 2. Chromosome associations at diakinesis and metaphase I in the amphidiploid *S. indicum – melongena*.

	Diakinesis						Metaphase I					
	I	II	III	IV	number of cells	percentage of total cells studied	I	II	III	IV	number of cells	percentage of total cells studied
	–	24	–	–	10	21.7	–	24	–	–	9	16.9
	2	23	–	–	3	6.5	2	23	–	–	2	3.8
	–	22	–	1	11	23.9	–	22	–	1	9	16.9
	1	22	1	–	3	6.5	1	22	–	–	2	3.8
	–	21	2	–	1	2.2	–	20	1	2	17	32.0
	–	20	–	2	14	30.4	1	20	1	1	5	9.4
	1	20	1	1	1	2.2	–	19	2	1	2	3.8
	–	18	–	3	2	4.3	–	18	–	3	6	11.3
	1	18	1	2	1	2.2	–	17	2	2	1	1.9
Range:	0–2	18–24	0–2	0–3			0–2	17–24	0–2	0–3		
Mean:	0.24	21.57	0.15	1.04			0.20	20.88	0.24	1.32		

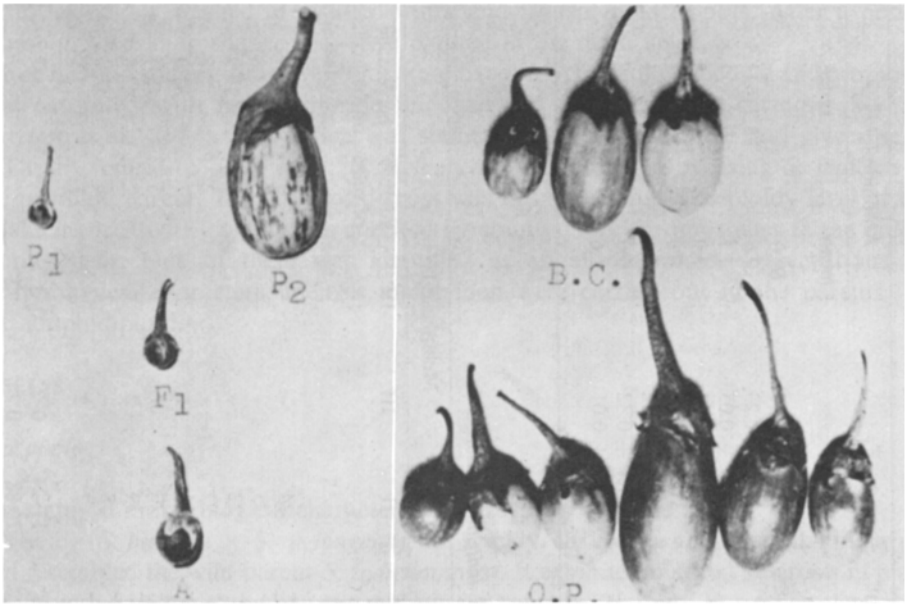

Fig. 1. Segregation for fruits (× ⅓ approx.) P_1 = *S.indicum*; P_2 = *S. melongena*; F_1 = *S.indicum* × *S.melongena*; A = Amphidiploid; B.C. = F_1 × *S.melongena*; O.P. = F_2 progenies derived from open pollinated F_1.

bivalents were normally oriented. Anaphase I and subsequent stages were regular.

F_1. There was complete pairing of the chromosomes into 12 bivalents at diakinesis. They were closely formed and mostly ring-shaped (Fig. 2a). Orientation of the bivalents at metaphase I and separation at anaphase I were observed to be regular (Fig. 2c), as in parents. No abnormalities were observed in subsequent stages.

Amphidiploid. The data on chromosome associations at diakinesis and metaphase I are presented in Table 2. At diakinesis, 24 bivalents were observed in 21.7% of the PMC's. The bivalents in the rest of the cells observed ranged from 18 to 23. The occurrence of quadrivalent ranging from 1 to 3 per cell was observed in 63.0% of PMC's (Fig. 2b). Univalents and trivalents were comparatively less frequent (19.6%). The highest association observed was 18 II + 3 IV, the average being 0.24 I + 21.57 II + 0.15 III + 1.04 IV. The association at methaphase I showed almost a similar trend, with a mean of 0.20 I + 20.88 II + 0.24 III + 1.32 IV per cell.

Subsequent stages of meiosis were mostly normal (Fig. 2d). At anaphase I, the disjunction of the chromosomes was equal and normal in 96% of the PMC's, while chromatid bridges and laggards were observed in the rest of them.

Pollen fertility. The data on pollen stainability and size are presented in Table 3. The percentage of stainable pollen was 96.6 for *S. indicum* and 96.3 for *S. melongena*. In the F_1, only 48.9% of the pollen was stainable, the rest of the grains being shri-

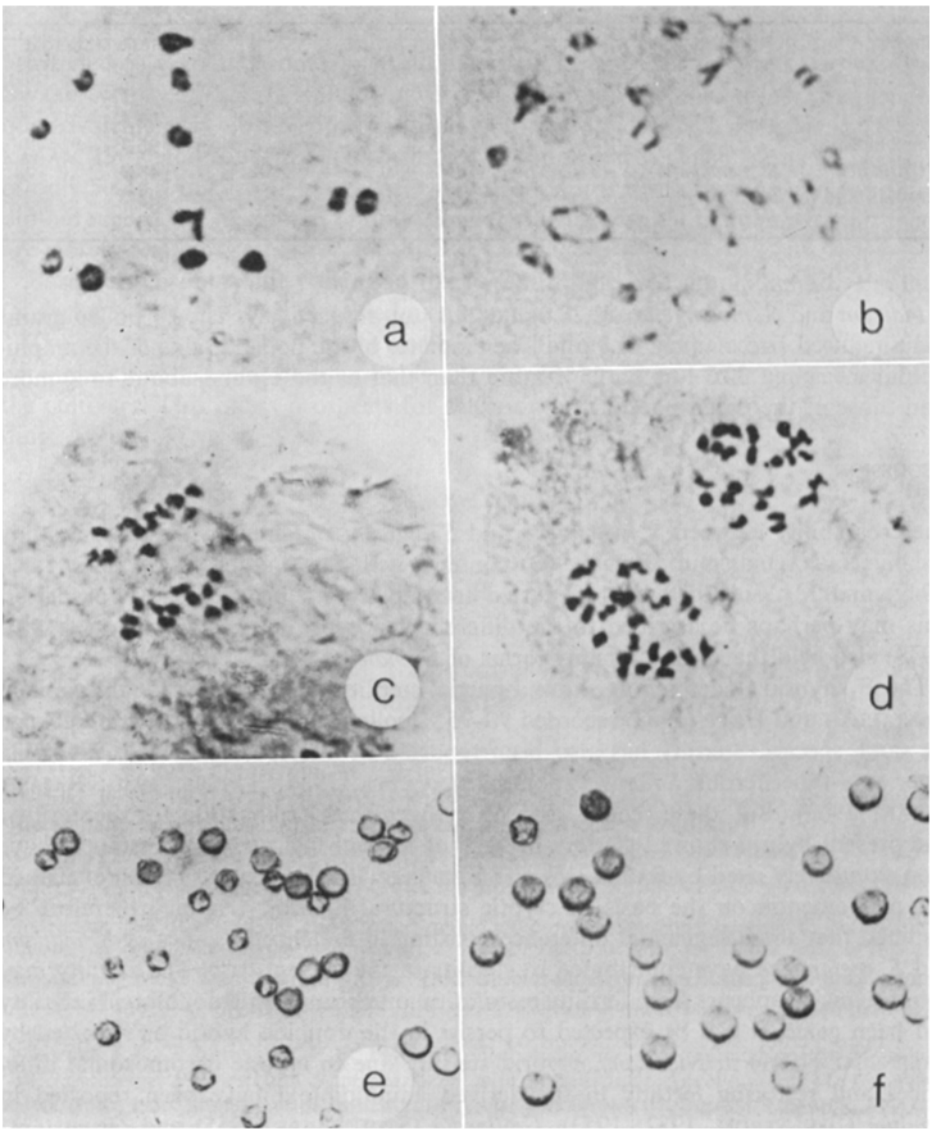

Fig. 2. a: Late diakinesis in F_1 showing 12 II (×1350); b: Diakinesis in amphidiploid showing 22 II + 1 IV (×1050); c: Anaphase I in F_1 showing 12/12 separation (×1050); d: Metaphase II in amphidiploid showing 24 + 24 (×1050); e: Pollen of F_1 (×150); f: Pollen of amphidiploid (×150).

velled and small (Fig. 2e). Only 20% of the stainable pollen grains were well filled. The amphidiploid contained 92.0% stainable pollen grains which were uniform in size and well filled, as in the case of the parents (Fig. 2f). The sizes of the stainable pollen grains of both the parents were almost equal: the diameters of the pollen grains of

Table 3. Pollen size and stainablility in the parents, F_1 and amphidiploid.

Plant	Mean pollen diameter (μm)	Percentage stainable pollen
S. indicum	28.9 ± 0.08	96.6
S. melongena	28.1 ± 0.11	96.3
F_1 (*S. indicum* × *S. melongena*)	25.8 ± 0.23	48.9
Amphidiploid (*S. indicum* - *melongena*	32.3 ± 0.23	92.0

S. indicum and *S. melongena* are 28.9 and 28.1 μm, respectively. The F_1 pollen grains had a reduced size, namely 25.8 μm. The diameter of the pollen grains of the amphidiploid measured 32.3 μm, so 25% more than that of the F_1 and about 14% more than those of the parents.

DISCUSSION

The crossability between *S. melongena* and *S. indicum* obtained in the present study and by NASRALLAH and HOPP (1963) conflicts with the findings of SWAMINATHAN (1949) and MITAL (1950), who reported incompatibility between the two species. This may perhaps be ascribed to the different genotypes in *S. indicum*. SANTAPAU (1948) also held that in India many forms of *S. indicum* occur.

The F_1 hybrid under report showed partial sterility with 48.9% stainable pollen. NASRALLAH and HOPP (1963) recorded 90–95% pollen sterility in the hybrid between the same species. Sterility has also been reported in interspecific hybrids involving other non-tuberiferous *Solanum* species (SARVAYYA, 1936; TATEBE, 1936; RAJASEKARAN, 1969). But these reports give no cytogenetical explanation for the sterility. The present hybrid showed sterility in spite of normal meiosis. Such instances have been extensively cited by SAX (1935) and STEBBINS (1945). STEBBINS (1950) explained this phenomenon on the basis of cryptic structural hybridity. It may therefore be assumed that small segmental differences existing in the chromosomes of *S. indicum* and *S. melongena* have contributed to sterility in the present case. The sterility may not be genic as appears from fertility restoration on chromosome doubling. If sterility had been genic, it can be expected to persist in the doubled hybrid as reported by GREENLEAF (1941) in *Nicotiana*. Hybrid sterility due to cryptic chromosomal differences and restoring fertility in the derived amphidiploid have been reported in *Lamium* (BERNSTROM, 1952; 1953), *Gaillardia* (STOUTAMIRE, 1955) and *Geum* (GAJEWSKI, 1954).

The F_1 hybrid failed to set fruit on selfing. On the contrary, good fruit set with viable seeds was obtained, when the amphidiploid was selfed. Similar findings have been reported for *Solanum bulbocastanum* (LIVERMORE and JOHNSTONE, 1940) and *S. chacoense* (SWAMINATHAN, 1951).

Though 12 bivalents were formed in the F_1, a maximum of only 3 quadrivalents was observed in the amphidiploid and about 20% of the PMC's showed complete bivalent formation. This low frequency of multivalents might be due to preferential pairing (DARLINGTON, 1937). Presumably, the parental chromosomes are similar

enough to pair in the F_1, yet they differ in small segments. Similar chromosome pairing in the F_1s and amphidiploids involving certain tuberiferous *Solanum* species has been attributed to cryptic chromosomal differences of the species involved (HOWARD and SWAMINATHAN, 1952). It should however be pointed out that a low frequency of quadrivalents was observed in induced autotetraploids of *S. melongena* (RAJASEKARAN, 1961) and *S. indicum* (RAJASEKARAN, unpublished) which formed a maximum of only 5 and 4 quadrivalents, respectively. Hence, it is not surprising that the amphidiploid recorded a maximum of only 3 quadrivalents even though the parental species are closely related.

Based on chromosome pairing in the F_1 and its derived amphidiploid, the latter (*S. indicum–melongena*) is classified as a segmental allopolyploid.

The progenies from back cross and open pollination segregated widely combining perenniality and cluster bearing habit of the wild parent and fruit shape and size of the cultivars. This offers prospects for selection of economic types in eggplant breeding.

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