https://doi.org/10.29321/MAJ.10.A02983

Madras agric. J 66 (8) : 495–502. Aug., 1979

The Cytomorphology of an Interspecific Hybrid in *Capsicum* *

N. SUNDARESAN [1] and P. CHANDRASEKARAN [2]

One way compatibility between the species of *Capsicum* viz. *Capsicum annuum* and *Capsicum frutescens* was realised. In spite of occurrence of post-fertilization barriers, hybrids could be grown to maturity in respect of some combinations of parents only. High sterility both genic and chromosomal in origin was evidenced. The differentiation between the parental species seems to rest upon genic or small structural differences in their chromosome components. The cytological behaviour of the hybrids points to the non-development of genic mechanisms which inhibit pairing of chromosomes in the F_1s.

Inspite of the constancy in chromosome number, attempts at interspecific hybridization of *Capsicum* have succeeded only in a few cases (Smith and Heiser, 1951 and 1957). Investigations on the nature of barriers to successful realisation of hybrids, causes of hybrid sterility and on the prospects and difficulties in artificial introgression have not been extensive or comprehensive. To fill up the lacuna in knowledge on the above aspects, a study was initiated involving hybridization of the cultivated *C. annuum* with those different genotypes of *C. frutescens* and the findings are presented below

MATERIAL AND METHODS

The cultivar K. 1 of *C. annuum* was crossed with three different genotypes of *C. frutescens* viz., AC 150 (Kerala), AC. 155 (Andhra) and AC. 156 (Tabasco-USA). Crosses were effected after hand emasculation of the flowers. There was total failure of fruit set when *C. annuum* was used as the female parent while the frequency of fruit set varied when the varieties of *C. frutescens* were employed as the ovule parent.

RESULTS AND DISCUSSION

Using K. 1 as the female and AC. 150, C. 155 and AC. 156 as pollen parents, 42, 36 and 38 cross pollinations were effected. None of these crosses set fruits as the crossed flowers dropped away on the 3rd or 4th day. In the reciprocal cross with *C. annuum* as the pollen parent, the percentage of fruitset in AC 150, AC. 155 and AC 156 was 16 6, 17.1 and 2 4 respectively. Plumpy and few papery seeds were found in fruits of AC. 150 and AC. 155 developing from cross pollinated ovar-

* Forms part of M. Sc. (Ag.) thesis approved by the Tamil Nadu Agricultural University, Coimbatore.

1. Assistant Professor, Dept. of Agrl. Botany. 2. Dean (Agri.), Tamil Nadu Agrl. University, Coimbatore-641003.

ies the percentage of germination being 53.6 and 50 respectively. In the case of AC. 156 only papery seeds were obtained which failed to germinate.

The hybrids obtained from the two crosses could be successfully raised to maturity. They were in general more vigorous than the parents, combining the attributes of the parental species to varying degrees.

Morphology

The hybrids were intermediate for most of the characters like height, pattern of branching, spread of plant, characteristics of flower and fruit. However, they exceeded both the parents in respect of length of petal and size of seed though the quantity of seed set was very much reduced. The F1s resembled the female parent *(C. frutescens)* in pigmentation of plant parts and also the deciduous nature of the fruit. But in respect to the shape of leaf, number of flowers per node and protrusion of style beyond the anther column, the hybrids resembled the male parent. The coefficient of variability indicated the variations between the parents as well as among the hybrids were comparable and showed the homogenous nature of the material.

TABLE I Chromosome Pairing in Hybrids at Metaphase - I

Conjugation	*C. frutescens* (AC. 150) × *C. annuum* (AC. 21)		*C. frutescens* (AC. 155) × *C. annuum* (AC. 21)	
	Frequency	Percentage	Frequency	Percentage
12 II	48	75.8	18	51.4
11 II + 2 I	12	18.5	7	20.0
10 II + 4 I	–	–	2	5.6
8 II + 8 I	–	–	1	2.9
2 III + 9 II	1	1.5	–	–
1 IV + 10 II	2	3.1	3	8.6
1 III + 10 II + 1 I	2	3.1	3	8.6
1 IV + 8 II + 4 I	–	–	1	2.9
	65	100.0	35	100.0
MEAN	0.061 IV + 0.06 III + 11.6 II + 0.34I		0.11 IV + 0.09 III + 11.11II + 1.06 I	

TABLE II Chromosome pairing at Diakinesis in Parents and hybrids

Parents and Hybrids	I		II		III		IV		Chiasmata		No. of cells studied	Pollen fertility %
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean		
C. frutescens (AC 150) (female)	0-2	0,4	11-12	11,9	-	-	-	-	19-22	20.9	30	92,0
C. annuum (male)	0-2	0,4	11-12	11,8	-	-	-	-	19-22	20,1	30	98,7
C. frutescens (AC 150) × *C. annuum* (AC 21)												
a) Plant No. 5	0-2	0,24	9-12	11,4	0-2	0,08	0-1	0,16	16-22	19,7	25	36.4
b) Plant No. 6	0-2	0,35	10-12	11,7	0-1	0,05	-	-	18-21	19,5	20	30,2
c) Plant No. 10	0-2	0.45	10-12	11,7	0-1	0.05	-	-	18-21	19.5	20	34.2
C. frutescens (AC 155) (female)	0-2	0.4	11-12	11,8	-	-	-	-	19-22	20,7	30	95.0
C. frutescens (AC 155) × *C. annuum* (AC 21)												
a) Plant No. 1	0-8	1,2	8-12	11.1	0-1	0,1	0-1	0,1	12-21	18.9	20	39,0
b) Plant No. 3	0-4	0,86	8-12	11.6	0-1	0.06	0-1	0.13	17-20	18.9	15	37.6

Cytology

The parental materials showed regular bivalent formation, normal orientation at Metaphase-I. Rarely precocious separation of a bivalent was noticed (Fig. I 1-4). The meiosis in the F1 of *C. frutescens* (AC. 150) × *C. annuum* presented 12 bivalents at Metaphase-I (Table I). Occasionally, however, higher associations of trivalents and quadrivalents occured in a very low frequency (Fig. I 5-8). The mean number of chiasmata per cell compared at diakinesis showed a reduction ranging from 19.5 to 19.7 in the F1s compared to 20.1 to 20.9 in the parents (Table II). The disjunction of chromosomes at Anaphase-I was normal in 35% of cells while in rest unequal distribution could be found besides laggards. The number of laggards noticed at Anaphase-II was more, than at Anaphase-I (Table III and IV).

The meiosis in the F1 of *C. frutescens* (AC. 155)) × *C. annuum* was abnormal, quadrivalent and trivalent associations being formed in frequencies of 11.5 per cent and 8.6 per cent respectively. Normal distribution of chromosomes at Anaphase I and II was not observed in all the pollen mother cells, the laggards contributing to the abnormality. Mostly tetrads are formed and in addition a low frequency of pentads was also observed (Fig. I.11).

TABLE III Anaphase – I Separation in Hybrids

Separation	*C. frutescens* (AC. 150) × *C. annuum* (AC. 21)		*C. frutescens* (AC. 155) × *C. annuum* (AC. 21)	
	Frequency	Percentage	Frequency	Percentage
12 – 12	14	35	13	32.5
12–1–11	10	25	23	57.5
11–2–11	16	40	4	10.0
Total	40	100	40	100.0

The pollen sterility indicated a level of fertility in the hybrids as 36.4 per cent whereas in the parents the values ranged from 92 per cent to 98.7 per cent. Thus, in the hybrids sterility was fairly high. The fruitset in the hybrid was found to be 16.6 per cent, while the seed contents on an average was only six.

The failure of fruitset when *C. annuum* was used as the female parent and success in the hybridization in the reciprocal crosses could be largely attributed to the one way compatability between the two species. Instances of a similar case were reported in *Solanum* (Nasarallah and Hopp, 1963; Krishnappa and Chennaveeriah,

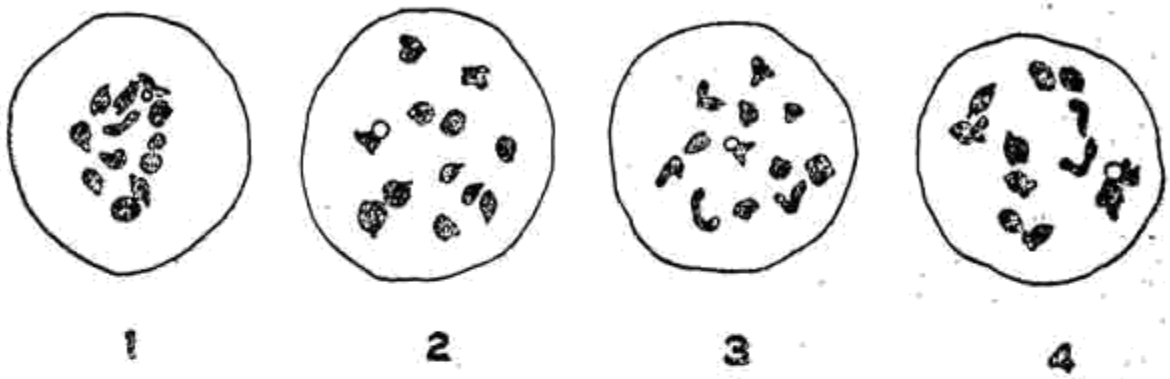
1964; Babu Rao, 1965 and Rajasekaran, 1969). The failure in cross pollinations was due to the pre-fertilisations barrier as revealed by non-germination of pollen in the stigma of *C. annuum*. In cases where fruit set was not hampered as in crosses with the varieties of *C. frutescens* the development of plumpy seeds was not uniform, thereby indicating different intensities of post-fertilization barrier. The reproductive isolation of the species is due to the self pollination found in nature. Genetic mechanisms also cause incompatility in fertilization and failure of development of embryo in cases of successful fertilization in artificial pollinations. The barrier to hybridization has been developed to varying degrees as evidenced from the variation in the percentage of realisation of hybrids in different matings. The successful realisation of hybrids between *C. frutescens* and *C. annuum* would imply that the development of isolation barrier has been incomplete. Genetic differentiation of the parent is well evidenced from the phenotype of the hybrids as well as in the low fertility of pollen. Zygotic sterility also seemed to prevail. The distribution of sterility factors to the gametes and the dishormonious gene combinations in the zygote render the hybrids to suffer from reasonable levels of seed fertility.

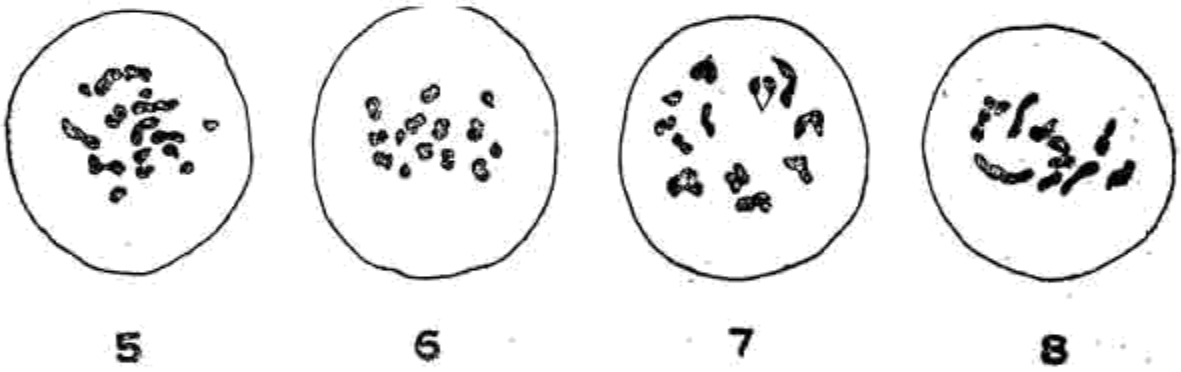
Sterility, chromosomal in origin is also brought about by multivalent associations of chromosomes and the production of gametes with unbalanced chromosome numbers. The average chromosome association of 0.06_{IV} +

TABLE IV Anaphase – II Separation in Hybrids

Separation	*C. frutescens* (AC. 150) × *C. annuum* (AC. 21)		*C. frutescens* (AC. 155) × *C. annuum* (AC. 21)	
	Frequency	Percentage	Frequency	Percentage
Normal	10	25	14	35.0
1 laggard	2	5	11	27.5
2 laggards	18	45	7	17.5
3 laggards	6	15	4	10.0
4 laggards	4	10	2	5.0
5 laggards	–	–	2	5.0
Total	40	100	40	100.0

MEIOSIS IN PARENTS & HYBRIDS





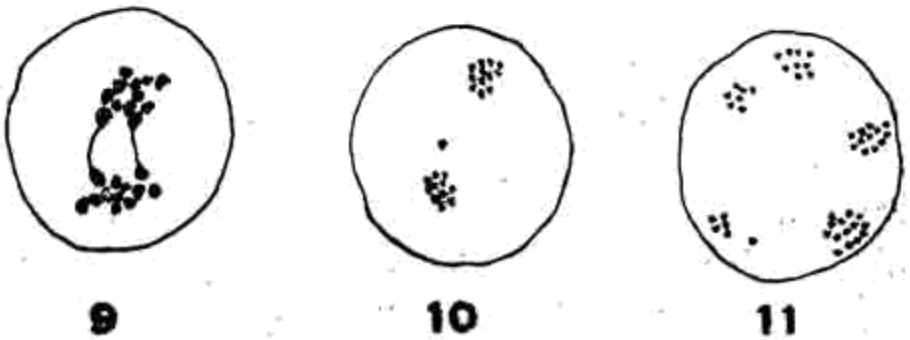


Fig. 1 Meiosis in Parents and Hybrids

(1–4) Diakinesis in parents –
1. *Capsicum annuum* (AC. 21)
2. *C. frutescens* (AC. 150)
3. *C. frutescens* (AC. 155)
4. *C. frutescens* (AC. 156)

(5–8) Metaphase in Hybrids –
5. *C. frutescens* (AC. 155) × *C. annuum* (8 II + 8 I)
6. *C. frutescens* (AC. 150) × *C. annuum* (10 II + 4 I)
7. *C. frutescens* (AC. 150) × *C. annuum* (1 III + 10 II + 1 I)
8. *C. frutescens* (AC. 155) × *C. annuum* (1 IV + 10 II)

(9–11) Telophase in Hybrids –
9. Telophase I in *C. frutescens* (AC. 155) × *C. annuum* (12–12 separation)
10. Telophase I in *C. frutescens* (AC. 150) × *C. annuum* (11–12 distribution with one laggard)
11. Telophase II in *C. frutescens* (AC. 155) × *C. annuum* (pentad formation)

$0.06_{III} + 11.6_{II} + 0.34_{I}$ and $0.11_{IV} + 0.09_{III} + 11.11_{II} + 1.06_{I}$ in the two hybrids (Table I) also showed that 11 chromosomes out of the 12 of one parental set are homozygous to the complement of the second parental species. The trivalents could possibly arise as a result of precocious disjunction of the quadrivalent. The bivalents observed are mostly rod-shaped, pointing to the segmental homology being confined to terminal ends of the chromosomes. The exchange of segments by the chromosomes of the two species render the gametes inviable and the reproductive potential of cryptic structural hybrids has been almost nil; as shown in the case of hybrid *Primula floribunda* × *P. verticellata*. The parental species of *Capsicum* seems to be differentiated both by genic and small structural differences in their chromosome complements. The association of four chromosomes can be assumed on the basis of pairing between two bivalents each of which resulting from intergenomal pairing, as haploids of *Capsicum* have been reported to form a maximum of six bivalents.

The senior author thanks Dr. S. Sivasubramanian, Associate Professor of Agricultural Botany, Kaveripattinam for the help rendered in the conduct of the experiments and Dr. R. Sethupathi Ramalingam, Associate Professor of Agricultural Botany, A. R. S., Aliyarnagar for providing the seed materials.

REFERENCES

BABU RAO, L. 1965. Cytomorphological studies on certain interspecific hybrids of non tuberiferous *Solanum* species. Unpub. M. Sc. (Ag.) Dissert. Submitted to the Madras University.

KRISHNAPPA, D. G. and M. S. CHENNAVEERAIAH. 1964. Breeding behaviour in non tuber bearing *Solanum* species. Mag. Karnatak Univ., Dharwar. 68-74.

NASRALLAH, M. I. E. and R. J. HOPP. 1963. Inter specific crosses between *S. melongena* (Egg plant) and related *Solanum* species. *Proc. Amer. Soc. Hort. Sci.* **83** : 571-74.

RAJASEKARAN S. 1969. Cytogenetic studies on the Inter-relationship of some common *Solanum* species occuring in South India. *Annamalai Univ. Agrl. Res. Ann.* **1** : 42-48.

SMITH, P. G. and C. B. HEISER, Jr. 1951. Taxonomic and genetic studies on the cultivated peppers *Capsicum annuum* L. and *capsicum frutescens*. Amer. J. Bot. **38** : 362-68.

SMITH, P. G. and C. B. HEISER, Jr. 1957. Breeding behaviour of peppers. *Proc. Amer. Soc. Hort. Sci.* **70** : 286-90.