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Wide crosses and chromosome behaviour in Sesamum

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Abstract: Sesame, one of the major oil seed crops produces very good quality oil and tolerates drought, but it suffers from poor yield, susceptibility to many pests and diseases, capsule dehiscence etc. Improvement of sesame has been approached by utilizing many conventional and modern breeding methods to alleviate these problems nevertheless, wide hybridization between the cultivated and wild related sesame species has been identified as an effective tool to introgress desirable genes from wild species to the cultivated sesame. The wild *Sesamum* species so far identified are having three different chromosome numbers *viz.* 2n: 26, 32 and 64 and they are highly differentiated genetically. Wide hybridization among wild species, diploid and tetraploid cultivated sesame has been attempted by many to assess the cross compatibility, performance of tetraploids, F_1s and amphidiploids and the genome analysis based on the chromosome behaviour in meiosis of diploid, tetraploids, inter specific hybrids and amphidiploids synthesized b[illegible]e treatment and they are reviewed in this paper.

Key words: Wide crosses, Chro[illegible]ies, Genome

...duction

Sesame *(Sesamum indicum* L.) the queen ...eeds belongs to the family *Pedaliaceae.* ...ong the genera come under this family and *...amum* is an important genus, which consists many species distributed in Tropical Africa, ...dagascar, Tropical Australia and few of the ...rn Islands of Malaysian Archipelago. There ...siderable uncertainty in enumerating species ...*esamum.* Index Kewensis has so far listed species perhaps 34 of them are wild (Nayar ... Mehra 1970), and some of these species ...considered as synonymous. Stapf (1906) ...Joshi (1961) reported 37 sesame sp., and ...1961) stated that both annual and perennial ...ies are included in the genus *Sesamum* ...has three chromosomal groups *viz.* 2n:26, ...and 64 (Table 1).

Though many of them are wild species, ...are also being utilized economically. The ...wing cultivated and wild *Sesamum* sp. of ...nomical importance are given in Table 2.

...tification of species

Sesamum was described by Linnaeus in ...era Plantarum and was of the opinion that ...*dicus* and *S. orientale* were two different, DeCondolle (1986) reported that *S.orientale* ... variety of *S. indicum.* The generic name *Sesamum* was taken by Hippocrates from the Arabic word "Simsim". Workers like Enlicher (1839, 43) Decondolle (1819) and Stapf (1906) Beruhardi (1985) have revised the genus dividing in the sub genera and sections based on the morphology of the leaves (simple and tripartite) and seeds (wringed and non winged). *Sesamum orientale* (2n: 26) was separate species, but later De Condolle (1819) suggested that both of them were same species. He also reported that *Sesamum edule, Sesamum lutium, Sesamum oliferum, Sesamum africanum, Sesamum fertidum* and *Sesamum occidentalis were* identical. Hooker (1985) and Gamble (1921) stated that only three species *viz. S. indicum L. S. prostratum* Retz and *S. laciniatum* Klein were in India. Hilterbrant (1932) opined that Africa was the origin of *Sesamum* sp. since large number of wild species available in that continent. Appalla Naidu (1953) identified a wild sp. at Hyderabad and named it as *S. ekambaramii* but Ramanujam and Joshi (1954) later reported this sp. as *S. alatum.*

Stapf (1906) was of the opinion that *Sesamum alatum (2n* : 26) (Plate I-2) and *Sesamum capense* (2n: 26) were two distinct species but later they were considered as synanim. Abraham (1945) identified the *Sesamum grandiflorum* in Kerala. Bruce (1953) after a detailed study

Table 1. Species of *Sesamum*

S.No.	Name of the species	Chromosome Number (2n)	Distribution
1.	*S. alatum* Thonn	26	Tropical Africa
2.	*S. angolense* Welw	32	Tropical Africa
3.	*S. angustifolium* Engl.	32	Tropical Africa
4.	*S. antirrihinoides* Welw	Not known	Tropical Africa
5.	*S. auriculatum* Pres	Not known	Crete
6.	*S. baumii* Stapf.	Not known	Africa
7.	*S. biapiculatum* Dewild	Not known	Congo
8.	*S. brasiliense* vell	Not known	Brazil
9.	*S. caillei* A.Cheval	Not known	Guinea
10.	*S. calycinum* Welw	Not known	Tropical Africa, Australia, India
11.	*S. capense* Burm	26	Tropical Africa India and Australia
12.	*S. digitaloides* Welw.	Not known	Tropical Africa
13.	*S. dinterii* Schinz	Not known	Tropical Africa
14.	*S. gibbosum* Bremek	Not known	Tropical Africa
15.	*S. grandiflorum* Schinz	26	India
16.	*S. hendelotti* Stapf	Not known	Tropical Africa
17.	*S. indicum* Linn	26	India
18.	*S. laciniatum* klen	32	India
19.	*S. latifolium*	Not known	East Africa
20.	*S. lepidotum* schinz	Not known	Tropical Africa
21.	*S. digitaloides*	Not known	Tropical Africa
22.	*S. macranthum* oliver	Not known	Tropical Africa
23.	*S. malabaricum* Burm	Not known	India
24.	*S. marlothii* Engl.	Not known	Africa, East Indies, Australia
25.	*S. microcarpum* Engl.	Not known	Tropical Africa
26.	*S. mombazense* widem	Not known	Tropical Africa
27.	*S. occidentale* Regl. & Heer	64	Tropical Africa
28.	*S. pedaloides* Retz	Not known	Tropical Africa
29.	*S. prostratum* Schum and Thonn	32	India
30.	*S. radiatum* Schnm & Thonn	64	Ceylon
31.	*S. repense* Engl. & Gilg	Not known	Tropical Africa
32.	*S. rigidum* A. Peyr.	Not known	Tropical Africa
33.	*S. sabulsam* A.cheval	Not known	India
34.	*S. somalense* Chior	Not known	Africa
35.	*S. schenckii* Aschers	26	India, South Africa, East Indies
36.	*S. schinzianum* Aschers	Not known	Tropical Africa, East Indies
37.	*S. talbottii* wernham	64	Nigeria
38.	*S. thonnerii* witdem	64	Tropical Africa
39.	*S. trifolium* Mill	64	India
40.	*S. tryphyllum* welw	64	Tropical Africa, East Indies, Australia

Table 2. Uses of Sesamum species

Sesamum indicum	Oilseed, oil and variety of other uses
Sesamum alatum *Sesamum angustifolium* *Sesamum radiatum*	Vegetable in Africa
Sesamum prostratum	Medicinal plant
Sesamum angolense	Medicinal plant for skin diseases
Sesamum angustifolium	
Sesamum angolense *Sesamum radiatum* *Ceratotheca sesamoides*	Ornamental plant Oil soap making
Sesamum indicum *Sesamum radiatum*	Green manure

concluded that *Sesamum schenckii* (2n: 26) *S.grandiflorum* (2n: 26) and *Sesamum gibbosum* were the same. He also stated that *S. angolense* (2n: 32) *and Sesamum macranthesis* were identical. Later *Sesamum baumii and Sesamum angustifolim* were also reported to be synonym.

Karyotype studies

Morinaga *et al.* (1929) reported the somatic chromosome number of *S. indicum as* 2n:26 Nohara (1934) and Suguira (1936) and Richharia (1936) identified the haploid number in the sp as n:13. Raghavan and Krishnamoorthy (1947) who examined the karyotype of *Sesamum indicum* have indicated that the chromosomes had terminal centromers. Kobayashi (1949) classified three groups of chromosomes *viz.* A, B and C based on their arm length and it varied from 1.25 to 1.85 μ. Mukherjee (1959) classified *the Sesamum indicum* chromosome into 2 types and also identified 2 pairs of chromosome with secondary constrictions. He recorded the arm length ranged from 1.6 - 3.6 μ.

Secondary Association

It is an important phenomenon by which the closeness of chromosome, their probable source of origin and basic chromosome number can be understood. Kumar and Abraham (1941) observed two types of secondary associations *viz.* 2(3) + 2(3) + 3(l) and 1(3) + 4(2) + 2(l) suggesting the basic chromosome number of *Sesamum* sp. as x = 7.

Wide crosses

A good number of attempts have been made to assess the relationship among the wild species of the genus *Sesamum* and also between the genera *Sesamum, Martynia and Ceratotheca* with the help of inter specific and intergeneric crosses. Though many of the crosses were failed to produce 'capsules with viable F_1 seeds, some of the crosses were successful, and viable F_1 hybrids were obtained. Particularly the interspecific crosses between the Indian cultivated species *S. indicum* and the two wild species of India *viz. S. laciniatum and S. prostratum* which were identified as resistant parents for phyllody the micoplasma like disease offered scope to study the progenies developed through amphidiploids. The details of the interspecific crosses attempted among various cultivated and wild species with different chromosome numbers are furnished in Table 3.

The cross between *S. indicum and S. prostratum* was successful while the reciprocal cross failed to set seed (Sundaram 1968). The F_1 hybrid with 2n:29 was highly sterile with all possible irregular movements of 29 chromosomes in meiosis indicating the wide genetic diversity between these two species. It ranged from 29 I to occasional IIs and IIIs revealing a few segmental homology as well as autosyndetic paring. The anaphase I was also highly irregular and had more irregular cells formed instead of tetrads at the end of meiosis, which caused high pollen sterility even to the tune of 100%. The F_1 was treated with colchicine and the

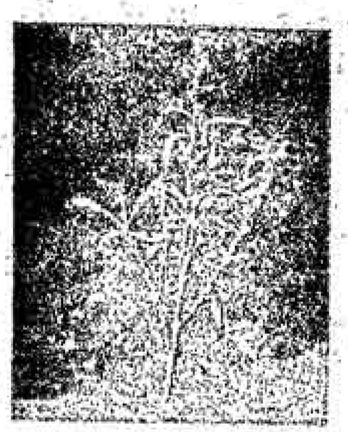
Table 3. Interspecific crosses of *Sesamum* sp.

Particulars of crosses			
Between 2n : 26 chromosome species			
S. indicum (2n:26)	*S. grandiflorum* (2n:26)	F_1 sterile, but fertility restored at maturity and F_2s raised	Abraham (1945)
S. indicum (2n:26)	*S. alatum* (2n:26)	Capsules developed but seeds nonviable fruit set normal seeds, F1 viable	Kedarnath (1954) Amirtha Devaratnam (1965) Sundaram (1968) Subramanian (1972) Amala Joseph Prabakaran (1992)
S. alatum (2n:26)	*S. indicum* (2n:26)	Capsule set normal-seeds non viable Viable seeds	Kedarnath (1954) Amirtha Devaratnam (1965) Subramanian (1972) Ramalingam *et al.* (1992) Kirija (1992)
S. indicum (2n:26)	*S. malabaricum* (2n:26)	Fertile hybrids	John *et al.* (1950)
S.indicum (2n:26)	*S.capense* (2n:26)	Shrivelled and inviable seeds	Amirtha Devaratnam (1965) Sundaram (1968)
S. indicum (2n:26)	*S. mulayanum* (2n:26)	F1 hybrids viable and resembled wild parent	Biswas and Mitra (1990)
Between 2n : 32 Chromosome species			
S. laciniatum (2n:32)	*S. prostratum* (2n:32)	F_1 fertile and viable F_2 segregants	Ramanathan (1950) Kedarnath (1954) Sundaram (1968)
S. angolense (2n:32)	*S. latifolum* (2n:32)	F_1 sterile	Nagamura and Sato (1958)
S. prostratum (2n:32)	*S. latifolium* (2n:32)	F_1 sterile	Joshi (1961)
S. prostratum (2n:32)	*S. latifolium* (2n:32)	F_1 sterile	Joshi (1961)
Between 2n : 26 and 2n : 32 Chromosome species			
S. indicum (2n:26)	*S. prostratum* (2n:26)	Viable seeds - F_1 sterile - Amphidiploid fertile	Ramanujam (1942) Abraham (1945) Raghavan and Krishnamoorthy (1947) Ramanathan (1950) Kedarnath et al. (1959) Sundaram (1968)

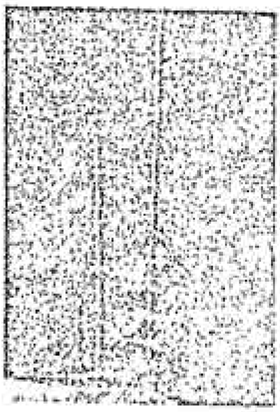
S. prostratum (2n:32)	*S. indicum* (2n:26)	Nonviable seeds	Kedarnath et al. (1959) Sundaram (1968)
S. indicum (2n:26)	*S. laciniatum* (2n:32)	Viable seeds - F_1 sterile - Amphidiploid fertile	Ramanathan (1950) Kedarnath *et al.* (1959) Aiyyadurai *et al.* (1962) & (1965)
S. laciniatum (2n:32)	*S. indicum* (2n:26)	No seed set	Amirtha Devaratnam (1965) Kirija (1992) Subramanian and Chandrasekaran (1977) Biswas and Mitra (1990)
S. laciniatum (2n:32)	*S. indicum* (2n:26)	No seed set	Subramanian and Chandrasekaran (1977) Biswas and Mitra (1990)
	Between 2n:64 Chromosome species		
S. radiatum (2n:64)	*S. occidentale* (2n:64)	Good capsule and seed set ; F_1 meiosis normal and F_2 segregation normal with high fertility	Ramanathan (1950) Kedarnath (1954) Subramanian (1975)
S. occidentale (2n:64)	*S. radiatum* (2n:64)	Good capsule and seed set ; F_1 meiosis normal and F_2 segregation fertile with high fertility	
F_1 (*S. radiatum* x S.occidentale) (2n:64)	*S. occidentale* (2n:64)	Good capsule and seed set ; meiosis regular	Subramanian (1975)
F_1 (*S. radiatum* x S.occidentale (2n:64)	*S. radiatum* (2n:64)		
	Between 2n : 26 and 2n : 64 Chromosome species		
S. indicum (2n:26)	*S. occidentale* (2n:64)	Rarely developed capsules had shrivelled and inviable seeds	Ramanathan (1950) Amirtha Devaratnam (1965) Sundaram (1968) Subramanian (1972)
S. indicum (2n:26)	*S. radiatum* (2n:64)	Capsules set; but no seeds	Garu (1934) Patel (1936) Dhawan (1946) Mazzani (1952) Subramanian (1972)
S. alatum (2n:26)	*S. occidentale* (2n:64)	Ill developed capsules	Subramanian (1972)
S. schinizianum	*S. indicum* (2n:26)	Shrivelled seeds	Shi (1993)

	Between 2n : 32 and 64 Chromosome species		
S.occidentale (2n:64)	*S.laciniatum* (2n:32)	Non viable seeds, rarely germinated seedling died after sometime	Ramanathan (1950) Subramanian (1972)
S.laciniatum (2n:32)	*S.occidentale* (2n:64)	No capsule formation	Ramanathan (1950) Subramanian (1972)
S.occidentale (2n:64)	*S.prostratum* (2n:32)	Seeds no viable	Ramanathan (1950) Dadlani (1956) Joshi (1961)
S.radiatum (2n:64)	*S.laciniatum* (2n:32)	No capsule set-if set had small shrivelled seeds	Nayar and Mehra (1970) Subramanian (1972)
S.laciniatum (2n:32)	*S.radiatum* (2n:64)	Ill developed capsule	Ramanathan (1950) Subramanian (1972)
S.radiatum (2n:64)	*S.prostratum* (2n:32)	Non viable seed	Nayar & Mehra (1970)
S.radiatum	*S.angolense*	Hybrid 17II+ 14I	Nagamura and Sato (1958)
	Between 4n : 52 and 2n : 26 Chromosome species		
S.indicum (4n:52) (Tetraploid)	*S.indicum* (2n:26)	Seed set Triploid plants obtained (3n:39)	Mazzani and Mitchelletti (1953) Srivastava (1956) Subramanian (1972)
	Intergeneric crosses *Between 2n : 32 Chromosome species*		
S.laciniatum (2n:32)	*Martynia annua* (2n:32)	Ill developed capsules and seeds	Subramanian (1973)
	Between 2n : 58 Chromosome species		
S.lacinientale (2n:58)	*S.indicatum* (2n:58)	F_1 hybrid fertile	Varisai Muhammed and Stephen Dorairaj (1968) Sundaram (1968)
	Between 32 and 58 Chromosome species		
S.indicatum (2n:58)	*Ceratotheca sesamoides* (2n:32)	F_1 mostly sterile with 1-3 IIIs	Kedarnath (1954)
	Between 2n : 64 and 32 Chromosome species		
S.radiatum (2n:64)	*Martynia annua* (2n:32)	Ill developed capsules	Subramanian (1973)
S.occidentale (2n:64)	*Martynia annua* (2n:32)	Ill developed capsules	Subramanian (1973)

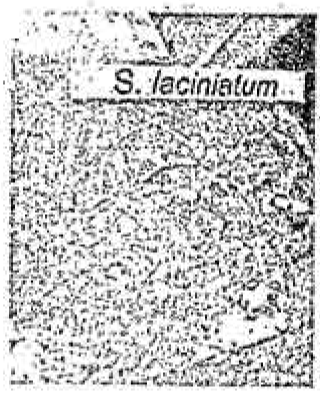
Sesamum species (Plate – I)



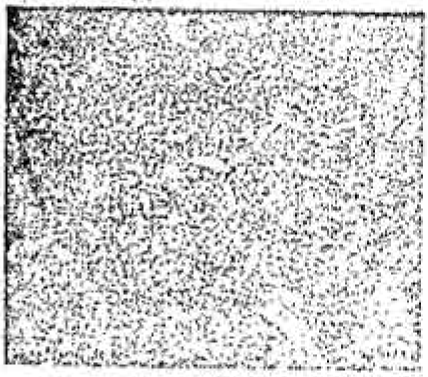
Sesamum indicum (2n = 26)
(Diploid)



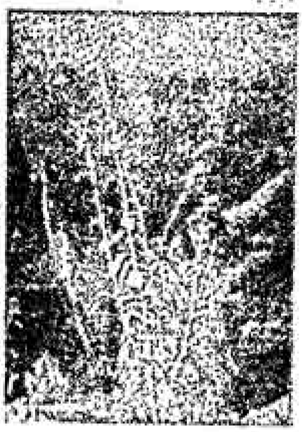
Sesamum alatum (2n = 26)



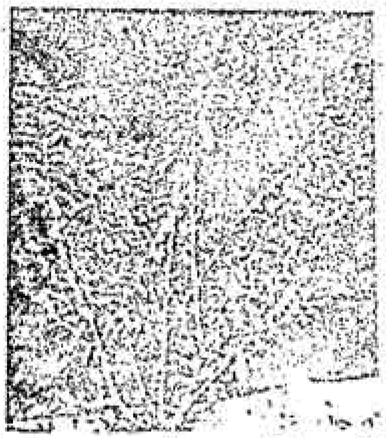
Sesamum laciniatum (2n = 32)



Sesamum lacinientale (2n= 58)
(Amphidiploid)



Sesamum occidentale (2n = 64)



Sesamum radiatum (2n = 64)

PLATE - II

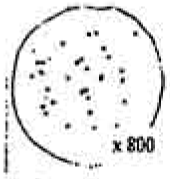
Sesame

Chromosome behaviour in Parents and Hybrids

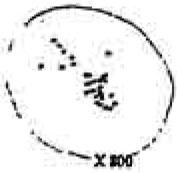
S. indicum (2n = 26)
M I. 13 II s

S. laciniatum (2n = 32)
A I. 32/32 separation

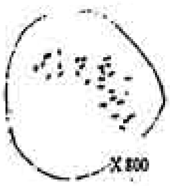
F1 Hybrids
Sesamum indicum x *S. laciniatum*
(2n = 39)



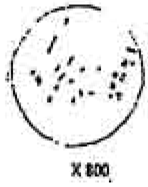
Early M I 27 I + 1 II



M I 14 I + 6 II + 1 III



Non oriented 29 II in early M I

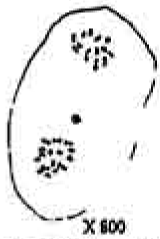


Scattered 29 I s in Diakinensis (late)

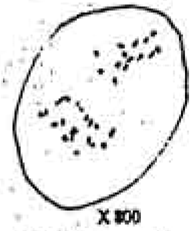
PLATE - III

F1 Hybrid

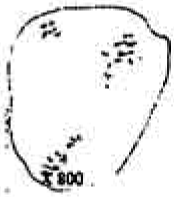
(*S. Indicum* / *S. laciniatum*)
(2n = 29)



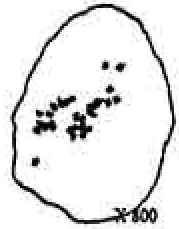
A I. 13 /16 Separation



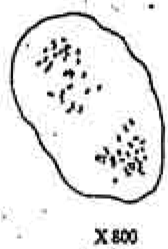
AI 15 /14 separation



Amphidiploids
(*S. indicum* x *S. lanciniatum*)
(2n = 58)



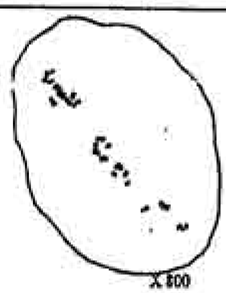
Diakinesis 29 II s



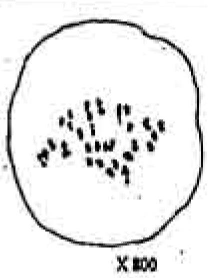
A I. 29 / 29 separation

PLATE - IV

Chromosome behaviour

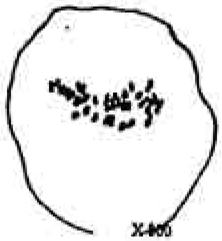


S. radiatum (2n = 64) M I 32 II



S. Occidentale (2n = 64)
Late Diakinesis 32 II s

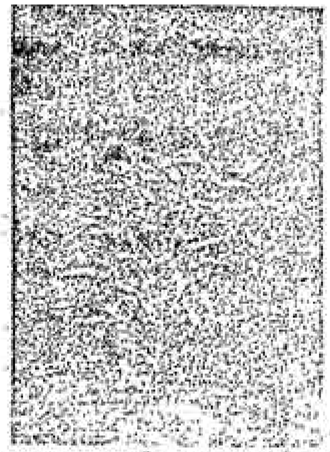
F1 Hybrid *S. radiatum* x *S. occidentale*



Early MI 32 II s

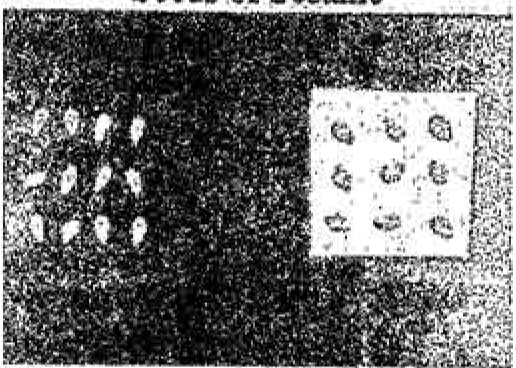
Autotetraploid Sesame (PLATE - V)

Colchicine treated (C_0)Sesame



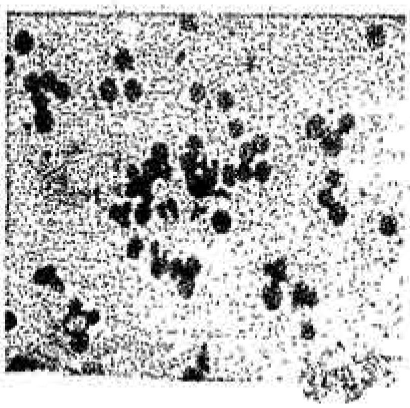
Sesamum indicum ($4n = 52$)
(C_1Tetraploid)

Seeds of Sesame

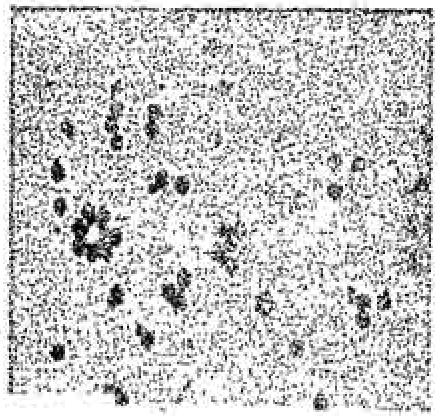


Diploid Tetraploid

Pollen grains of Sesame



Tetraploid



Diploid

chromosome number was doubled. The amphidiploid thus, obtained was named as *S. indicatum* (2n: 58) (Kedaranath *et al.* 1959) it was highly fertile with 29 II regularly formed.

S. indicum x *S. prostratum*
(2n : 26) ↓ (2n : 32)
F_1 2n : 29
(Sterile)
(Chromosome doubling)
Amphidiploid *(Sesamum indicatum)*
2n:58
29_{II}
(Fertile)

Kedarnath *et al.* (1959) attempted back crosses between the amphidiploid and both the parents separately and could get sequiploids with 2n:42 (Di-indicum monoprostratum) and 2n:45 (Di-prostratum monoindicum) chromosomes. Though they were highly resistant to Phyllody, the plants were mostly with wild characters of uneconomic importance.

S. indicatum x *S. indicum*
(2n : 58) ↓ (2n : 26)
(29) (13)
2n : 42
(Di-indicum monoprostratum)

S. indicatum x *S. prostratum*
(2n : 58) ↓ (2n : 32)
(29) (16)
2n : 45
(Di-prostratum monoindicum)

The cross between *S. indicum* (2n:26) and *S. laciniatum* (2n:32) had similar behaviour. The F_1 was highly sterile due to the misbehaviour of all '29' chromosomes, the occasional IIs and IIIs obtained, have indicated the slight homology between a few segments of the two genomes and autosyndetic paring (Ramanathan, 1950, Amirdha Devaratnam 1965 and Subramanian 1972). The F_1 hybrid responded well to colchicine treatment and the chromosome number had been doubled. The resultant amphidiploid was named as *S. lacinientale* (2n:58) (Ramanathan, 1950) but failed to produce progenies through back cross (Subramanian, 1972) (Plate I to 111).

S. indicum x *S. laciniatum*
(2n : 26) (2n : 32)
(13) ↓ (16)
F_1 : 2n:29 sterile
↓
Chromosome number doubled
↓
Amphidiploid (*S.lacinientale)*
2n: 58
29_{II}
(Fertile)

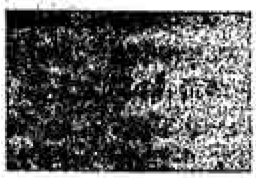
The two synthesized amphidophloids *Sesamum lacinientale (2n* 58) and *S. indicatum* (2n:58) were hybridized and F_1S and F_2S (Mary Juliet, 1994) F_3 (Kavitha, 1995) and F_4 (Jaisankar, 1996) were studied and their variances for different characters have been reported. Similarly di-indicum and mono laciniatum plants identified with C_5 progenies *of S. lacinientale* (2n:58) when back crossed with *S. indicum,* plants with 2n:26 and 34 were obtained (Kavitha 1995). Plants with 2n:34 were again crossed with *S. indicum (2n:26)* and plants with 2n:26 and 38 chromosomes were segregated (Jaisankar, 1996). The plants with 2n:26 revealed $8_{II} + 10_I$ and $10_{II} + 6_I$ association. Anaphase I was highly irregular. The seeds of plants with 2n:38 chromosomes when raised, produced plants with 2n:40, which showed $15_{II} + 10_I$ and $16_{II} + 8_I$ association and the anaphase separation was highly irregular. The plants were sterile indicating the transgression of genes between *S. indicum* and *S. laciniatum* (Bindu, 1997).

In 1992, Amala tried to develop male sterile source by crossing *S. indicum* with six wild sp. and she was successful in getting a hybrid between *S. alatum* and *S. indicum* (CO 1) and fertile F_1 first time with normal chromosomal behaviour in meiosis.

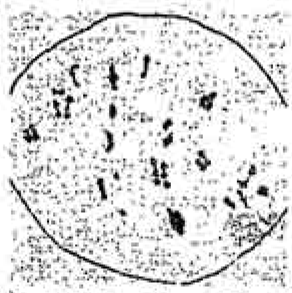
Kavitha (1998) developed male sterile plants through back crossing F_1 hybrids of *S. malabaricum (*2n: 26) and *S.indicum* (2n:26) the cytoplasmic male sterile lines were found to be stable. The sesame genotypes Si 1525

PLATE - VI
Autotetraploid Sesame
Chromosome behaviour (Plate – III)
(Meiosis)

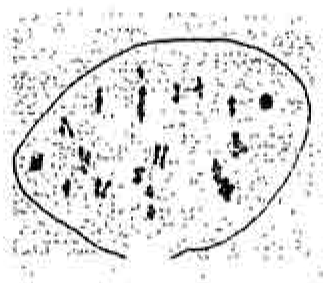
M I showing $2_{IV} + 22_{II}$ with precocious chromosome separation



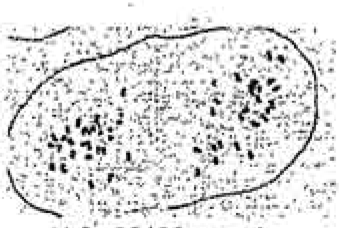
M I end A I beginning ($4_{iv} + 1_{III} + 15_{II} + 3_{I}$) Already separated chromosome



Early M I. $2_{IV} + 2_{III} + 18_{II} + 2_{I}$



Early MI. $3_{IV} + 3_{III} = 15_{II} + 5_{I}$ with secondary nucleolus



A I. 26 / 26 separation

between these two taxonomically similar species were intra specific rather than inter specific and the variations found in the two species might be due to changes in the genes involved.

Richharia (1937) also observed that pollen grains of *Martynia annua* had good germination in the styles of *S. indicum.* Srinivasan (1942) obtained in viable seeds in the cross between *S. indicum* x *M. diana.* Subramanian (1995) reported that the pollen grains of selfed plants of *S. indicum* (cv. TMV 2) entered the ovary after 6 hrs of pollination and in the inter generic crosses, the pollen grains of *Martynia annua* when pollinated on the stigmatic surface of *S. laciniatum* (24:32) *S. radiatum* (2n:64) and *S. occidentale* (2n:64) individually the pollens germinated with out inhibition and grew in the styles and entered the ovary but the pollinated flowers dropped after 4 or 5 days of hybridization in all crosses.

and SVPRI were identified as restores and a dominant gene was found to determine the pollen fertility restoration.

Subramanian (1975) who attempted hybridization between *Sesamum radiatum* (2n:64) and *S. occidentale* (2n :64) got successful F_1 hybrids on both way crosses . The F_1 hybrids were highly fertile and in meiosis 32_{II} were regularly formed with 32/32 regular separation in anaphase I (Plate IV). Pollen stainability was 100%. Kedarnath (1954) who also obtained fertile hybrids between these two species said that morphological determination progressed sufficiently and the genetic barrier has been slow. Subramanian (1975) inferred that the crosses

Induced autotetraploids

Induction of autotetraploids in cultivated *Sesamum indicum* (2n:26) was reported by many authors, by using (1) Pre-soaked seeds (2) Germinated seeds (3) Growing parts in plant and (4) Auxilliary buds.

Riccharia and Persai (1940) were the first to induce autotetraploids in sesame by soaking the seeds in 0.06% colchicine for 2 hours. The tetraplods produced had $0\text{-}5_{IV}$ Langham (1942) was successful in getting autotetraploids by treating the auxilliary bud with 0.5% colchicine and other growing parts with 0.4% colchicine. According to Kobayashi and Shimamura (1952) 0.2-0.5%. colchicine was effective in doubling the chromosome in sesame. The autotetraploids had slow growth in the initial stage and become vigorous in the later stage. They recorded a maximum of 13_{IV} with regular separation in the anaphase I. Mazzani and Mitchelletti (1953) observed $5\text{-}10_{IV}$ and the remaining chromosomes had associated only as IIs. They showed irregular separation in anaphase I. Mazzani (1954) also noticed that the pollen number in tetraploids was reduced.

Srivastava (1956) suggested that 0.06 to 0.1% colchicines treatments for 4 hours was optimum to get polyploids in sesame. He also observed one mixoploid in C_1. According to Subramanian (1972) treating young seedlings with 0.4% colchicine successfully doubled the chromosomes in TMV 2 Sesame (Plate V). Heole served that the autotetraploids had slow growth in the initial stage and become vigorous in the later stages. The morphological observations in both C_0 and C_1 sesame in general indicated that the leaves were dark green in colour and become thick and leathery. The flowers, pistil filament and pollen grains were larger in size compared to diploid. The capsules were reduced in length but become broader. In meiosis he recorded $2\text{-}3_{IV}$ and $15\text{-}19_{II}$, with low frequency of IIIs and regular anaphase separations (Plate IV). Thiyagarajan (1974) was of the opinion that 10 days old seedlings were more responsive to colchinine treatment, survival and doubling of chromosomes in TMV 3 sesame. He also suggested that 0.4% cochinine was effective in doubling chromosome in Sesame. He recorded a mean chromosome association of $5.8_{IV} + 0.27_{III} + 13.6_{II} + 0.79_{I}$ in TMV 2 and $5.6_{IV} + 14.67_{III}$ in TMV 3 sesame. Failure for the expected 13IV formation in the tetraploids was attributed to the physiological disturbances during the process of synopsis in meiotic cells which caused weak chiasma formation and desynapsis (Dryansagar and Sudhakaran, 1970). Thiyagarajan (1974) also observed gradual reduction in quadrivalent's number in subsequent generations. It was reduced from $5.8_{IV}(C_1)$ to 3.9_{IV} (C_2) due to its tendency towards diploidization. The C_1 pogeny showed 40-61% pollen stainability.

Triploids

A natural triploid was identified among the C_1 progenies of TMV 2 tetraploid plants by Subramanian (1977). Triploids were taller than diploids with less branches; less vigorous and poor fertility. Capsules were smaller with reduced size and mostly empty. A few capsules had developed seeds with number ranging from 1-2. The seeds were small but plumpy. The triploids showed Is (2-4), IIs (8-14) and IIIs (3-7). The maximum chromosome association was $2_I + 8_{II} + 7_{III}$ (17. 1 %) while the minimum association was $4_I + 13_{II} + 3_{III}$ (8.5%). The mean chromosome association was $3_I + 9.6_{II} + 5.6_{III}$. The anaphase I was highly irregular due to unequal separation of III s and Is. The pollen fertility was 13.3% (Subramanian, 1977).

Trisomic

A trisomic plant (2n:27) was identified from the progenies of triploid (3n: 39) sesame (Subramanian 1977). This had less number of branches, flattened main stem, small narrow linear leaves and terminal cluster of flower buds. The side branches produced flowers equal in size to that of diploid but developed small sized capsules with 3-5 tiny seeds. The cytological studies revealed that 60% of the cells showed. $13_{II}+_{I}$ and in the rest it was $1_{III} + 12_{II}$ association. Anaphase I had 14/13, 12/13, 11/15 and 13/13 separation with laggards. The laggard also divided and resulted in 14/14 separation.

Monosomics in Diploid and Tetraploid Sesame

Thiyagarajan (1974) has studied the aneuploids obtained from the tetraploid as well as diploid *sesamum* sp. The TMV 2 tetraploid monosomic (2n:52-1) had reduced branching larger sized leaves but they were thinner with light green. The reduced capsule number and seeds developed in the capsules were elongated with dull white colour. It showed a mean chromosome association of $2.67_{IV} + 0.33_{III} + 19_{II} + 1_{I}$. Twenty five and 75% of the cells studied showed IIIs and Is respectively. The anaphase separation was mostly 25/25 with one chromosome lagging and few cells also showed 25/26 separation. The pollen fertility ranged from 50-80%.

Another TMV 3 diplomonosomic (2n:26-1) was identified by Thiyagarajan (1974). This was very poor in vigour but profusely branched with many primaries and secondaries. Leaves were small and narrow, flowers were also small with anther size reduced much, they were shrivelled, capsules were reduced in their size and had rarely seedset. The few seeds collected were medium in their size dark brown in colour. The chromosome association was $12_{II} + 1_I$ the anaphase I separation had 12/12 separation with a legging chromosome. In some cells univalents also divided, separated in to chromatids and moved to opposite poles. The pollen stainability was 2.25%. The maximum chromosome association of $13_{II} + 1_I$ was observed in 61% of the cells studied, the rest showed an association of $12_{II} + 1_{III}$. The Anaphase I had 14/13 separation in 42% of cells, laggards ranged from 1-4 (13/13 and 11/15) were also recorded. Division of Is resulted in 14/14 distribution. The pollen stainability was 44.8%. Out of 100 seeds collected from this plant, 22 have established. Among them 3 were trisomic (2n 26+1), one tetrasomic (2n26+2) and the remaining were disomics (2n:26).

Tetrasomic

This tetrasomic plant, (2n:26 + 2) was short; with moderate branching; flowers small with light pink tinch; anthers were six as that of six stigmatic branches; capsule formation was affected much and reduced in number and size. The seed set was also poor occasionally had a few and small sized seeds. The mean chromosome association was $0.25_{III} + 13.35_{II} + 0.55_I$; 45% of cells showed IIs and 35% cells showed IIIs, IIs and Is. Anaphase I separation was 14/14 (Thiyagarajan 1974).

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