academicJournals

Vol. 10(9), pp. 911-918, 26 February, 2015
DOI: 10.5897/AJAR2014.8592
Article Number: BF4300651010
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Study of reproductive compatibility and morphological characterization of interspecific hybrids in *Sesamum* sp.

B. Meena Kumari* and K. Ganesamurthy

Department of Oilseeds, Centre for Plant Breeding and Genetics Tamil Nadu Agricultural University, Coimbatore, India.

Received 6 February, 2014; Accepted 17 December, 2014

In the present study, three wild species of sesame, *Sesamum alatum*, *Sesamum malabaricum* and *Sesamum radiatum* and one wild variety of *Sesamum indicum*, that is, *S. indicum* var. *yanamalaiensis* were crossed with eight cultivated varieties of *S. indicum* L. in both direct and reciprocal forms. All the wild species exhibited different degrees of cross compatibility with cultivated *S. indicum*. There was no crossed seed set in the direct and reciprocal crosses involving cultivars of *S. indicum* (2n = 26) with *S. radiatum* (2n = 64) and with *S. alatum* (2n = 26). The crosses involving *S. malabaricum* and *S. indicum* var. *yanamalaiensis* having the same chromosome number (2n = 26) as in the cultivated sesame genotypes were fairly successful in producing high percentage of crossed capsules with well filled seeds. The morphology of four wild species along with the cultivated species of sesame and the interspecific hybrids derived were compared. The wild species utilized in the present study differed significantly from the cultivated in branching pattern, leaf pubescence, flower size, color of corolla and anther, size, shape and color of extra floral nectary, capsule size, and shape, texture and size of the seed. All the successful interspecific hybrids showed predominance of wild characters than cultivated *S. indicum*.

Key words: Sesame, wild species, cross compatibility, morphological characterization.

INTRODUCTION

Sesame is known to be the most ancient oilseed crop dating back to 3050-3500 B.C. (Bedigian and Harlan, 1986) because of its ease of extraction, great stability, and drought resistance. It is also considered to be important because of its nutritional and antiaging features of high quality vegetable oil with oil content ranging from 50 to 60% (Chayjan, 2010). The sesame oil is highly resistant to oxidative deterioration due to the presence of antioxidants such as sesamin and sesamolin (Erbas et al., 2009) and also has high percentage of unsaturated

*Corresponding to author. E-mail: meenacpbg_17@yahoo.co.in.

fatty acids (Yermanos et al., 1972). Though sesame is having all these benefits, the productivity is limited due to low seed yield (Ashri 1989; Pham et al., 2010), frequent occurrence of diseases (El-Bramawy, 2006) and stress factors (Sarwar et al., 2007). Therefore, breeding efforts have mainly concentrated on increasing the seed yield of sesame. One of the important ways for increasing seed yield is utilization of diverse sources, especially the wild species for the exploitation of heterosis as well as to impart biotic and abiotic stress resistance. Hence an attempt was made to study the crossability between the four wild and cultivated species of sesame and to evaluate the hybrid vigour expression in the interspecific crosses.

MATERIALS AND METHODS

The experimental materials comprised of three wild species of sesame, *Sesamum radiatum* (2n = 64), *Sesamum alatum* (2n = 26), *Sesamum malabaricum* (2n = 26) and one wild form of *Sesamum indicum,* that is, *S. indicum* var. y*anamalaiensis* (2n = 26) as reported by Devarathinam and Sundaresan (1990) with eight cultivated varieties of *S. indicum* (Figure 1). This includes CO 1, PYR 1, SVPR 1, VRI 1, VRI(Sv) 2, TMV 3, TMV 4 and TMV 7. The wild species were collected from the Species Garden maintained at Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, India. The varietal seeds were obtained from the Department of Oilseeds, TNAU, Coimbatore. The seedlings were raised in earthern pots during Summer, 2010. During flowering, the crossing was effected by utilizing the wild species as both male and female parents. This was done by emasculating the female flower buds (removing the corolla with four stamens) in the previous day evening. The just opened male flowers were collected from the respective parents on the following day morning and pollination was done between 6:30 to 8:30 AM. For this, the 1/3rd of the corolla was removed to expose the stamen outside, which was then smeared on the stigma of the emasculated flower. A small paper tag was tied at the base of the pollinated flowers for easy identification of crossed capsules at the later stage. The entire crossing block was raised in the glass house to avoid insect pollination. The seeds were collected from the crossed capsules and the F_1 generation was raised with the parents, in two replications with each entry in two rows of 5 m length and spacing of 15 × 30 cm during Kharif, 2010. All the recommended package of practices was adopted.

RESULTS AND DISCUSSION

Compatibility relationship

Based on the crossing data, it was evident that all the wild species exhibited different degrees of cross compatibility with cultivated *S. indicum*. The details about direct and reciprocal crosses attempted between the cultivars and the wild species are presented in Table 1. From the data on number of flowers pollinated, number of capsules set and number of hybrid seeds obtained, the crossability between the wild species and cultivated varieties were brought out. The overall cross compatibility relationship is given in Table 2.

Between *S. indicum* (2n = 26) and *S. alatum* (2n = 26)

Though *S. indicum* and *S. alatum* are having the same chromosome number, capsule and seed setting was not observed in both direct and reciprocal crosses of *S. alatum* with eight cultivars of *S. indicum*. Kedharnath (1954) could obtain only shriveled and non-viable seeds in *S. indicum* and *S. alatum* combination and presumed an early abortion of young embryo. Similar attempts were made by Amirtha Devarathnam (1965), Sundaram (1968) and Subramanian (1972) who also failed in producing viable hybrids between these two species. Even though these two species are having the same chromosome status (2n = 26), it is probable that a strong mechanism operates, due to which, hybrid seeds were not obtained.

Between *S. indicum* (2n = 26) and *S. radiatum* (2n = 64)

The direct crosses recorded the capsule setting with the maximum of 6.80% in *S. radiatum* × TMV 7 and minimum of 1.02% in *S. radiatum* × VRI 1. There was no seed set in any of the eight direct crosses between *S. radiatum* and *S. indicum*. The reciprocal cross between *S. indicum* and *S. radiatum* was not successful due to the premature dropping of crossed capsules. Hence, no capsule set and seed set was observed in the reciprocal crosses. Earlier studies involving these species also revealed the failure of these crosses (Dhawan, 1946; Ramanathan, 1950; Amirtha Devarathnam, 1965; Subramanian, 1972; Prabakaran, 1992; Vikas, 2006). The failure was attributed to very early collapse of the hybrid endosperm and the subsequent starvation of proembryo, as observed by Dhawan (1946) through embryological studies.

Between *S. indicum* (2n = 26) and *S. malabaricum* (2n = 26)

The crosses involving *S. indicum* cultivars and *S. malabaricum* both having the same somatic chromosome number (2n = 26) were fairly successful in producing good number of crossed capsules with well filled seeds. In the direct and reciprocal crosses effected between eight cultivars of *S. indicum* with *S. malabaricum*, successful capsule and seed setting was observed in all the 16 crosses (Figure 2). Only one crossed seed got germinated in the cross between *S. malabaricum* as female with *S. indicum* genotype SVPR 1, but the seedling was died subsequently in the two leaves stage, probably due to the abiotic factors. In the earlier description by John et al. (1950), *S. malabaricum* was referred as the variety of *S. indicum*, as *S. indicum* var. *malabaricum*, which was highly compatible with other genotypes of *S. indicum*. However, Prabakaran (1992)

Table 1. Details of crosses attempted between *S. indicum* and different species of *Sesamum.*

Crosses	Number of flowers pollinated	Number of capsules set	Percent of capsule setting	Mean no. of seeds per capsule	Remarks
Direct crosses					
S. alatum × SVPR 1	86	0	0	0	No capsule set
S. alatum × TMV 7	106	0	0	0	
S. alatum × VRI (Sv) 2	96	0	0	0	
S. alatum × CO 1	126	0	0	0	
S. alatum × TMV 3	98	0	0	0	
S. alatum × TMV 4	94	0	0	0	
S. alatum × VRI 1	98	0	0	0	
S. alatum × Paiyur 1	106	0	0	0	
S. malabaricum × SVPR 1	84	5	5.9	6.7	Capsule set, and viable seeds
S. malabaricum × TMV 7	143	10	6.9	25.7	
S. malabaricum × VRI (Sv) 2	126	7	5.6	18.9	
S. malabaricum × CO1	132	6	4.6	14.5	
S. malabaricum × TMV 3	102	5	4.9	12.2	
S. malabaricum × TMV 4	136	7	5.2	10.9	
S. malabaricum × VRI 1	127	10	7.9	15.2	
S. malabaricum × Paiyur 1	138	7	5.1	17.9	
S. i. var. *yanamalaiensis* × SVPR 1	105	46	43.8	14.7	Capsule set, and viable seeds
S. i. var. *yanamalaiensis* × TMV 7	121	56	46.3	14.5	
S. i. var. *yanamalaiensis* × VRI(Sv) 2	138	72	52.2	17.9	
S. i. var. *yanamalaiensis* × CO1	124	39	31.5	14.9	
S. i. var. *yanamalaiensis* × TMV 3	100	0	0	0	
S. i. var. *yanamalaiensis* × TMV 4	95	0	0	0	
S. i. var. *yanamalaiensis* × VRI 1	100	5	5.0	7.0	
S. i. var. *yanamalaiensis* × Paiyur 1	97	27	27.8	22.3	
S. radiatum × SVPR 1	94	5	5.3	0	Capsule set, but no viable seeds
S. radiatum × TMV 7	103	7	6.8	0	
S. radiatum × VRI (Sv) 2	135	6	4.4	0	
S. radiatum × CO 1	126	4	3.2	0	
S. radiatum × TMV 3	85	2	2.4	0	
S. radiatum × TMV 4	108	3	2.8	0	
S. radiatum × VRI 1	98	1	1.0	0	
S. radiatum × Paiyur 1	120	2	1.7	0	
Reciprocal crosses					
SVPR 1 × *S. alatum*	98	0	0	0	No capsule set
CO 1 × *S. alatum*	105	0	0	0	
TMV 3 × *S. alatum*	98	0	0	0	
TMV 4 × *S. alatum*	88	0	0	0	
TMV 7 × *S. alatum*	91	0	0	0	
Paiyur 1 × *S. alatum*	80	0	0	0	
VRI 1 × *S. alatum*	84	0	0	0	
VRI(Sv) 2 × *S. alatum*	112	0	0	0	

Table 1. Contd.

SVPR 1 × *S. malabaricum*	95	12	12.6	13.1	
CO 1 × *S. malabaricum*	126	4	3.2	26.9	
TMV 3 × *S. malabaricum*	106	1	0.9	44.5	
TMV 4 × *S. malabaricum*	97	2	2.1	25.7	Capsule set, and viable seeds
TMV 7 × *S. malabaricum*	135	6	4.4	55.1	
Paiyur 1 × *S. malabaricum*	114	7	6.1	14.0	
VRI 1 × *S. malabaricum*	125	7	5.6	22.3	
VRI(Sv) 2× *S.malabaricum*	138	11	7.9	39.4	
SVPR 1 × *S. i.* var. *yanamalaiensis*	99	14	14.1	12.2	
CO 1 × *S. i.* var. *yanamalaiensis*	137	6	4.4	35.2	
TMV 3 × *S. i.* var. *yanamalaiensis*	97	1	1.0	14.6	
TMV 4 × *S. i.* var. *yanamalaiensis*	89	1	1.1	0	Capsule set, and viable seeds
TMV 7 × *S. i.* var. *yanamalaiensis*	108	4	3.7	47.5	
Paiyur 1 × *S. i.* var. *yanamalaiensis*	99	5	5.0	6.34	
VRI 1 × *S. i.* var. *yanamalaiensis*	119	3	2.5	27.0	
VRI(Sv) 2 × *S. i.* var. *yanamalaiensis*	126	5	3.9	39.3	
SVPR 1 × *S. radiatum*	115	0	0	0	
CO 1 × *S. radiatum*	128	0	0	0	
TMV 3 × *S. radiatum*	105	0	0	0	No capsule set
TMV 4 × *S. radiatum*	117	0	0	0	
TMV 7 × *S. radiatum*	94	0	0	0	
Paiyur 1 × *S. radiatum*	100	0	0	0	
VRI 1 × *S. radiatum*	123	0	0	0	
VRI(Sv) 2 × *S. radiatum*	88	0	0	0	

Table 2. Cross compatibility between *Sesamumindicum* and other species of *Sesamum.*

S. indicum	***S. alatum***		***S. malabaricum***		***S. i.* var. *yanamalaiensis***		***S. radiatum***	
	DC	**RC**	**DC**	**RC**	**DC**	**RC**	**DC**	**RC**
SVPR 1	×	×	☑	✓	✓	✓	×	×
CO 1	×	×	✓	✓	✓	✓	×	×
TMV 3	×	×	✓	✓	×	✓	×	×
TMV 4	×	×	✓	✓	×	×	×	×
TMV 7	×	×	✓	✓	✓	✓	×	×
Paiyur 1	×	×	✓	✓	✓	✓	×	×
VRI 1	×	×	✓	✓	☒	✓	×	×
VRI(Sv) 2	×	×	✓	✓	✓	✓	×	×

DC – Direct cross, RC – Reciprocal cross, × - Cross failed to produce viable hybrids, ✓ - Cross in which viable hybrids produced, ☑ - Hybrid seedling not survived, ☒ - Seed not germinated.

referred this as the separate species of sesame as *S. malabaricum*. He reported that *S. malabaricum* had possessed distinct morphological features like longer duration, green stem with purple tinge, leathery leaves, purple corolla, highly rough testa as seen against the cultivated sesame. Also, *S. malabaricum* had shown partial capsule set when crossed with cultivated *S. indicum* (Prabakaran, 1992). The percentage of capsule setting ranged from 4.6% (*S. malabaricum* × CO 1) to 7.9% (*S. malabaricum* × VRI 1) in direct crosses. In reciprocal crosses, it was between 0.9% (TMV 3 × *S. malabaricum*) and 12.6% (SVPR 1 × *S. malabaricum*).

In direct crosses, the mean number of seeds per capsule was the lowest in *S. malabaricum* × SVPR 1 (6.7) and highest in *S. malabaricum* × TMV 7 (25.7). Similarly, the cross SVPR 1 × *S. malabaricum* recorded the lowest number of seeds per capsule (13.1) and the highest was recorded in TMV 7 × *S. malabaricum* (55.1) in reciprocal crosses.

Between *S. indicum* (2n = 26) and *S. indicum* var. *yanamalaiensis*(2n = 26)

The cross-compatibility between *S. indicum* and *S. indicum* var. *yanamalaiensis* both having the same chromosome number of 2n = 26 was confirmed both in direct and reciprocal form (Figure 2). But the capsule set and seed set was not observed in *S. indicum* var. *yanamalaiensis* with TMV 3 and TMV 4. The range of capsule setting was from 0 to 52.2% in *S. indicum var. yanamalaiensis* × VRI(Sv) 2. The seed setting was ranged from 0 to 22.3% (*S. indicum* var. *yanamalaiensis* × Paiyur 1) in direct crosses. In the cross *S. indicum* var. *yanamalaiensis* × VRI 1, crossed seed was obtained but the seeds were small and shriveled and hence not germinated.

In the reciprocal crosses, there was capsule set, but no seed set in TMV 4 × *S. indicum* var. *yanamalaiensis*. The range of capsule setting was from 1.0% (TMV 3 × *S. indicum* var. *yanamalaiensis*) to 14.1% in SVPR 1 × *S. indicum* var. *yanamalaiensis*. The seed setting was ranged from 0 (TMV 4 × *S. indicum var. yanamalaiensis*) to 47.5% (TMV 7 × *S. indicum* var. *yanamalaiensis*). Since the flowering of both parents had not coincided and hence, the pollination was attempted in the later stage of flowering. Due to this, the seed set was not observed in few of the direct and reciprocal crosses between *S. indicum* var*. yanamalaiensis* and cultivated varieties.

Morphological characterization of parents and interspecific hybrids

Parents

The morphology of four wild species and the cultivated species of sesame was compared and given in Table 3. The wild species utilized in the present study differed significantly from cultivated one in the branching pattern, leaf pubescence, flower size, color of corolla and anther, size, shape and color of extra floral nectary and capsules, texture and size of the seed. *S. alatum* was profusely branching with completely lobed basal leaves. The corolla color was maroon and glabrous with dark purple corolla lip. The anther was dark purple with purple colored extra floral nectary. The capsules were long and tapering with small and winged seeds. The branches of *S. malabaricum* were profuse with pubescent leaves. The corolla was pink and densely hairy with dark pink colored corolla lip. The calyx also had dense hairs with flower having purple anther. The glands were yellow colored and prominent. The capsules were medium sized and hairy. The seeds were also medium sized with rough testa.

S. indicum var. *yanamalaiensis* resembled cultivated *S. indicum* in most of the traits. It differed from cultivars in branching pattern, corolla and corolla lip color and in the size of yellow glands. The capsules were medium sized sparsely hairy with small black colored seeds with smooth testa as in the cultivated varieties. The wild species *S. radiatum* differed widely from *S. indicum*. The stem of *S. radiatum* was pubescent with more number of branches. The leaves were dark green, pubescent with serrated margins. The corolla was hairy, purple colored with dark purple corolla lip. The calyx was also pubescent with flowers having big, cream colored anther. The glands were dark colored with densely hairy capsules. The seeds were small with rough testa. These above mentioned specific traits were not observed in the cultivated *S. indicum* genotypes.

Inter-specific hybrids

The observed morphological characters of the direct and reciprocal crosses of wild with cultivated species are given in Table 4. The hybrids developed from the direct and reciprocal crosses involving *S. malabaricum* and *S. indicum* were similar in the expression of qualitative traits. But, the hybrids with *S. malabaricum* as the female parent had taken comparatively more days to germinate, when compared to their reciprocals. This difference was due to the maternal seed traits of the wild parent. The duration taken for germination of hybrids is much more than their cultivar parent.

The hybrids exhibited most of the phenotypic characters of wild parent, indicating the dominant nature of *S. malabaricum*. The direct crosses resembled the wild parent, *S. malabaricum* in branching pattern, leaf pubescence, corolla and corolla lip color, flower having calyx with dense hairs, and light purple colored anther. The nature and color of extra floral nectary resembled the wild parent. The capsules were very small with few seeds, which was medium sized black with rough testa. The crossed seeds had expressed dormancy as in the wild parent and many of the crossed seeds had not germinated for more than two months. The reciprocal crosses had also expressed similar traits as in direct crosses between *S. malabaricum* and *S. indicum*.

The F_1 hybrids involving the eight cultivars of *S. indicum* with *S. indicum* var. *yanamalaiensis*, were evaluated for their morphology and it was found that the 12 hybrids resembled the wild parent in branching pattern, corolla and corolla lip color. From this study, it was found that all the successful interspecific hybrids

Table 3. Morphological characteristics of *S. indicum* and their wild relatives.

Characters	***S. alatum***	***S. malabaricum***	***S. i. var. yanamalaiensis***	***S. radiatum***	***S. indicum***
Plant	Annual, erect, indeterminate	Annual, erect, indeterminate	Annual, erect, indeterminate	Annual, erect, indeterminate	Annual, erect, indeterminate
Stem	Green, glabrous, round shaped stem	Green, sparsely hairy, short and straight hair, square shaped stem	Green, glabrous, square shaped stem	Green, sparsely hairy, short and straight hair, round shaped stem	Green, glabrous, square shaped stem,
Branches	Alternate, basal, few branches	Alternate, basal, more primary and secondary branches	Alternate, basal, profusely branching	Alternate, basal, profusely branching,	Alternate, basal, few primary and secondary branches
Leaves	Green, glabrous, opposite, horizontal angled, basal leaves deeply lobed, upper leaves linear and entire.	Green, pubescent, alternate, flat, entire at top and lobed at bottom, horizontal angled, ovate	Green, glabrous, alternate, flat, entire, horizontal angled, lanceolate	Dark green, glabrous, opposite, acute angled, ovate and serrated margins	Green, glabrous, alternate, flat, horizontal angled, ovate at bottom, lanceolate at top,
Infloerescence	One flower per axil	One flower per axil	One flower per axil	One flower per axil	One flower per axil
Calyx	Glabrous, greenish purple calyx tip	Densely hairy, short and straight hairs, green calyx tip	Glabrous, green calyx tip	Medium hairy, short and straight hairs, green calyx tip	Glabrous, green calyx tip
Corolla	Maroon colored, sparsely hairy	Purple colored, densely hairy	Light purple colored, glabrous	Light violet, densely hairy	White colored, glabrous,
Corolla lip color	Dark maroon	Dark purple	Purple	Dark purple	White
Anther	Dark purple anther, light green filament	Purple anther, light purple filament	Cream colored anther, White filament	Light yellow anther, white filament	Cream colored anther, white filament
Style	Greenish purple medium style	White colored, short style	White colored, medium style	Green colored, Medium style	White colored, medium style
Extrafloral nectary	Small, purple colored	Medium, yellow colored	Small, yellow colored	Medium, dark purple colored	Small, yellow colored
Capsules	Tapered at apex, sparsely hairy, mono- capsular, long beak, four loculed, completely shattering	Broad oblong, medium hariy, mono-capsular, short beak, four loculed, partially shattering	Broad oblong, sparsely hairy, mono-capsular, short beak, four loculed, partially shattering	Narrow oblong, densely hairy, mono- capsular, short beak, four loculed, partially shattering	Broad oblong, sparsely hairy, mono capsular, short beak, four loculed, partially shattering
Seeds	Small sized, rough seed coat, dull black, winged	Medium, rough seed coat , dull black, rough testa.	small, black, smooth testa.	Medium sized, bright black, rough seed coat	Medium, different colored, smooth testa
Dormancy	Very high	High	Low	Medium	Low

Table 4. Morphological characteristics of interspecific hybrids.

Characters	***S. malabaricum* × *S. indicum***	***S. indicum* × *S. malabaricum***	***S. i. var. yanamalaiensis* × *S. indicum***	***S. indicum* × *S. i. var. yanamalaiensis***
Plant	Annual, erect, indeterminate	Annual, erect, indeterminate	Annual, erect, indeterminate	Annual, erect, indeterminate
Stem	Green, sparsely hairy short and straight hair, square shaped stem	Green, sparsely hairy short and straight hair, square shaped stem	Green, sparsely hairy, short and straight hair, square shaped stem,	Green, sparsely hairy, short and straight hair, square shaped stem,

Table 4. Contd.

Branches	Alternate, basal, profusely branching	Alternate, basal, profusely branching	Alternate, basal, profusely branching	Alternate, basal, profusely branching
Leaves	Green, densely hairy, horizontal angled, entire at top and slightly lobed at bottom	Green, densely hairy, alternate, flat, entire at top and lobed at bottom	Green, glabrous, alternate, flat, entire, horizontal angled, lanceolate, slightly lobed at bottom	Green, glabrous, entire at top and slightly lobed at bottom, horizontal angled, lanceolate,
Infloerescence	One flower per axil	One flower per axil	One flower per axil	One flower per axil
Corolla	Purple, densely hairy	Purple, densely hairy	Light purple, medium hairy	Light purple, sparsely hairy
Corolla lip color	Dark purple	Dark purple	Purple	Purple
Calyx	Green, dense, short and straight hairs	Green, dense, short and straight hairs	Green, sparse, short and straight hairs	Green, sparse short and straight hairs
Anther & style	Light purple anther, medium style	Light purple anther, medium style	White anther, medium style	White anther, medium style
Extrafloralnectary	Medium, yellow colored	Medium, yellow colored	Small, yellow colored	Small yellow colored
Capsules	Small, medium hairy, shattering monocapsular, four loculed,	Small, medium hairy, shattering monocapsular, four loculed,	Medium, sparsely hairy, monocapsular, four loculed, shattering	Medium, sparsely hairy, monocapsular, four loculed, shattering
Seeds	Medium, dull black, rough testa	Medium, dull black, rough testa	Small, black, smooth testa	Small, black, smooth testa
Dormancy	High	Medium	Low	Low

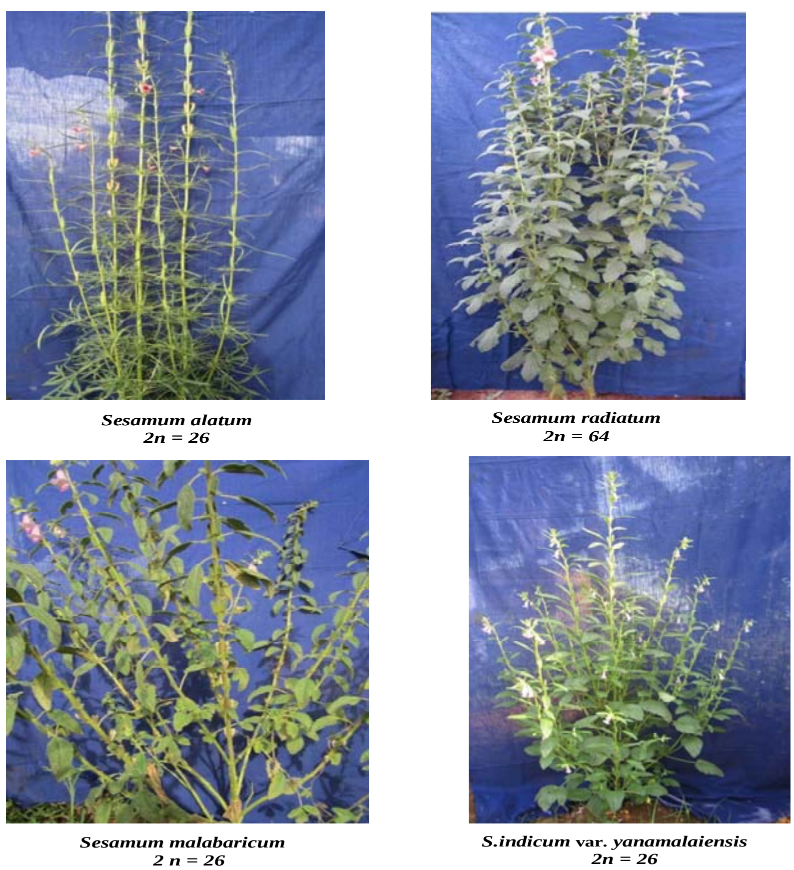

Figure 1. species of sesame.

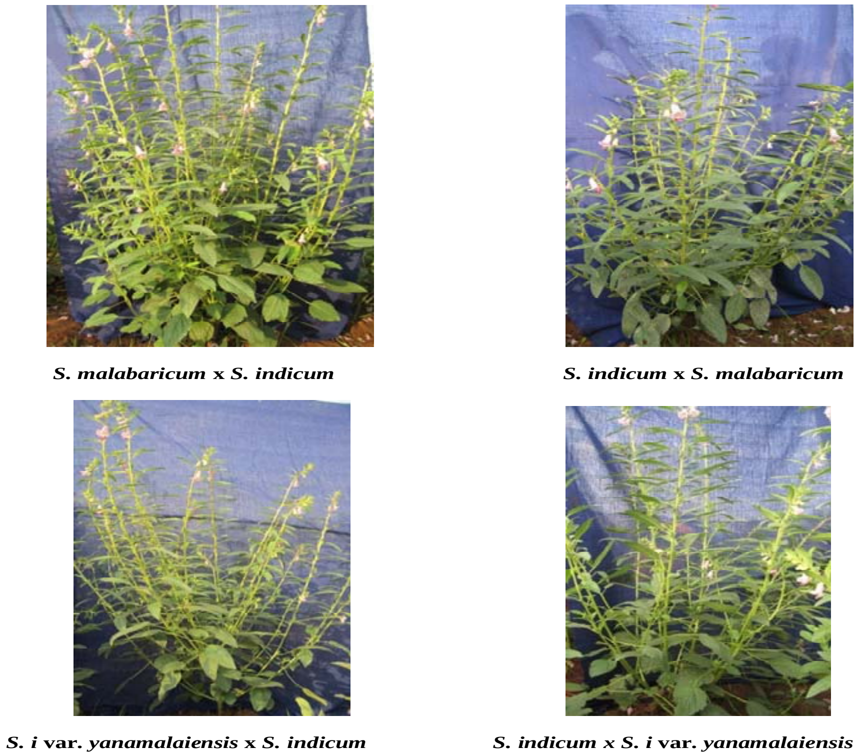

Figure 2. crossed species of sesame.

showed predominance of wild characters than cultivated *S. indicum*. The wild species *viz.*, *S. malabaricum* and *S. indicum* var. *yanamalaiensis* could be effectively utilized for the transfer of essential traits from wild to cultivated through conventional breeding program.

Conflict of Interest

The authors have not declared any conflict of interest.

REFERENCES

Amirtha Devarathnam A (1965). Studies on interspecific hybridization in Sesamum with special reference to hybrid *S. indicum L.* × *S. laciniatum* Klein and its amphidiploids. M.Sc. (Ag.) Thesis (Unpubl.) Madras Univ.

Ashri A (1989). Oil crops of the world - Sesame, McGraw-Hill, New York, pp. 375-387.

Bedigian D, Harlan JR (1986). Evidence for cultivation of sesame in the ancient world. Econ. Bot. 40:137-154.

Chayjan RA (2010). Modeling of sesame seed dehydration energy requirements by a soft-computing approach. Aust. J. Crop Sci. 4:180-184.

Devarathinam AA, Sundaresan N (1990). A new wild variety of sesamum: *Sesamum indicum* (L.) var. *sencottai* as ADR and NS. compared with *S. indicum* (L.) var. *yanamalai* ADR and MS. and *S. indicum*(L.). J. Oilseeds Res. 7: 121-123.

Dhawan NL (1946). Interspecific hybridization in *Sesamum.* M.Sc. (Ag.) Thesis, Indian Agricultural Research Institute, New Delhi.

El-Bramawy MAS (2006). Inheritance of resistance to Fusarium wilt in some sesame crosses under field conditions. Plant Protect. Sci. 42:99-105.

Erbas M, Sekerci H, Gül S, Furat S, Yol E, Uzun B (2009). Changes in total antioxidant capacity of sesame (*Sesamum* sp.) by variety. Asian J. Chem. 21:5549-5555.

John CM, Narayana GV, Seshadri CR (1950). The wild gingelly of Malabar *Sesamum orientale* Linn. var. *malabaricum*. Madras Agric. J. 37:47-50.

Kedharnath S (1954). Personal communication to Joshi 1961. Sesamum. Indian Control Oilseeds Committee Report 109 p.

Pham TD, Nguyen TDT, Carlsson AS, Bui TM (2010). Morphological evaluation of sesame (*Sesamum indicum* L.) varieties from different origins. Aust. J. Crop Sci. 4:498-504.

Prabakaran AJ (1992). Identification of male sterile sources through wide hybridization and induced mutagenesis in sesame (*Sesamum indicum* L.). Ph.D., Thesis submitted to TNAU, Coimbatore.

Ramanathan K (1950). A note on the interspecific hybridization in sesamum. Madras Agric. J. 37:397-400.

Sarwar G, Haq MA, Chaudhry MB and Rabbani I (2007). Evaluation of early and high yielding mutants of sesame (*Sesamum indicum*L.) for different genetic parameters. J. Agric. Res. 45:125-133.

Subramanian M (1972). Cytogenetical studies on inter specific hybrids in *Sesamum* spp. M.Sc.(Ag.) Thesis (Unpubl.), Tamil Nadu Agricultural Univ., Coimbatore.

Sundaram N (1968). Inter specific hybridization in sesamum. M.Sc.(Ag.) Thesis (Unpubl.) Madras Univ., Tamil Nadu, India.

Vikas VK (2006). Studies on interspecific hybridization with particular reference to development of male sterility in sesame (*Sesamum indicum* L.).Ph.D. Thesis.University of Agricultural Sciences, Dharwad.

Yermanos DM, Hemstreet S, Saleeb W, Huszar CK (1972). Oil content and composition of the seed in the worldcollection of sesame introductions. J. Am. Oil Chem. Soc. 49:20-23.