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Crossability studies in genus *Abelmoschus*

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Abstract : The results of cross compatibility studies revealed that cultivated *A.esculentus* cultivars were found compatible both directly and reciprocally with *A. tuberculatus*, *A.tetraphyllus*, *A.caillei*, *A.manihot* (L.) Medikus, *A.manihot spp. manihot and A.manihot spp. tetraphyllus* while, *A. moschatus* was found incompatible on both ways with *A. esculentus.* The wild species *A. ficulneus* was found compatible but seed sterile with *A.esculentus* when later used as female parent however, *A.ficulneus* was found incompatible with *A.esculentus* when former used as female parent while, wild species *A.angulosus* was found compatible with *A.esculentus*, only when later used as female parent. In general, highest fruit set percentage, number of seeds per crossed fruit, crossability index and germination percentage was observed when *A.esculentus* was used as female parent while crossing with all wild species except *A.caillei*.

Keywords: Crossability, *Abalmoschus,* okra

Introduction

At present, all the cultivars and land races of okra succumb to major diseases and pests indicating the absence of resistance in cultivated *Abelmoschus esculentus* and a search for resistance should be invariably shifted to related species. Inter specific hybridization has been mostly used for the transfer of specific characters such as disease and pest resistances from related species to cultivated species. In genus *Abelmoschus*, the species *A.caillei* (Kousalya, 2005), *A.angulosus*, *A.tetraphyllus*, *A.manihot* (L.) Medikus, *A.manihot spp. tetraphyllus* and *A.moschatus* (Prabu,2005) were found highly resistant to YVMV while *A.caillei* and *A.moschatus* found immune to powdery mildew whereas *A.moschatus* and *A.tuberculatus* found highly tolerant to jassids and shoot and fruit borer respectively (Prabu,2005). However, the reports regarding the crossability of the above wild species with *Abelmoschus esculentus* were inconsistent or meagre. Therefore, the present investigation was undertaken to find out the cross compatibility for the possible transfer of disease and pest resistances from wild *Abelmoschus* to cultivated *A. esculentus*.

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Materials and Methods

The present investigation was undertaken at Department of Horticulture, MPKV, Rahuri. The source, accession numbers and chromosome number of wild and cultivated okra used for cross compatibility studies were given below.

The eleven wild lines of nine *Abelmoschus* species (*viz.*, *A. tuberculatus* –1, *A. tetraphyllus* –1 and 2, *A. ficulneus*-1, *A. moschatus*-1, *A. caillei*-1 and 2, *A. manihot* spp. *manihot*, *A. manihot* spp. *tetraphyllus, A. angulosus* and *A. manihot* (L.) Medikus) were selected for inter specific hybridization with eight cultivated *A. esculentus* cultivars (*viz.*, Pusa Sawani, Red Bhendi, Arka Abhay, Phule Utkarsha, Arka Anamika, Parbhani Kranti, Varsha Uphar and P-7).. Overall 100 crosses were attempted which includes both direct and reciprocal crosses. Synchrony in flowering in wild species and cultivated okra was obtained by sowing wild species 6 to 10 days prior to cultivated okra. Observations were recorded on percentage of fruit set and number of seeds per fruit in F_0 and maternal parent. The number of fruit set and the number of seeds per fruit were noted to work out the fruit setting per cent and crossability index. Per cent fruit set and crossability index were calculated.

The fruit set percentage, average seed number and germination in selfed cultivated *A.esculentus* cultivars and wild species was given in Table1.

Results and Discussion

Positive results were obtained in direct and reciprocal crosses between *A. esculentus* cultivars and *A. tuberculatus* (Table 2) *in* the present study. This was in agreement with the findings of Kuwada (1966). The direct and reciprocal crosses between Parbhani Kranti and *A.tuberculatus* recorded maximum fruit set, highest crossability index and germination percentage. Crosses

Source of wild *Abelmoschus* collections and cultivated *A. esculentus* cultivars used for cross compatibility studies

Sr. No.	Wild/cultivated	Accession No.	Source	Reported Chromosome Number
	Wild *Abelmoschus* species			
1	*A. tuberculatus*-1	EC-90471	N.B.P.G.R., Regional Station, Akola	2n=58
2	*A. tetraphyllus*-1	--	I.I.V.R., Varanasi	N.A.
3	*A. tetraphyllus*-2	IC-140980	N.B.P.G.R., Regional Station, Akola	2n=130
4	*A. manihot* spp. *tetraphyllus*	IC-276994	N.B.P.G.R., Regional Station, Thrissur	N.A.
5	*A. ficulneus*-1	IC-140986	N.B.P.G.R., Regional Station, Akola	2n=72
6	*A. moschatus*-1	--	I.I.V.R., Varanasi	N.A.
7	*A. caillei*-1	EC-305619	N.B.P.G.R., Regional Station, Thrissur	N.A.
8	*A. caillei*-2	AE-286-1	Department of Olericulture ,K.A.U., Thrissur	2n=184
9	*A. manihot* spp. *manihot*	IC-141015	N.B.P.G.R., Regional Station, Thrissur	N.A.
10	*A. angulosus*	IC-203832	N.B.P.G.R., Regional Station, Thrissur	2n=56
11	*A. manihot* (L.) Medikus	IC-141029	N.B.P.G.R., Regional Station, Thrissur	N.A.
	Cultivated *A. esculentus* cultivars			
1	Pusa Sawani	--	A.I.C.V.I.P., Rahuri	2n=130
2	Red Bhendi	--	A.I.C.V.I.P., Rahuri	2n=130
3	Arka Abhay	--	A.I.C.V.I.P., Rahuri	2n=130
4	Arka Anamika	--	A.I.C.V.I.P., Rahuri	2n=130
5	Parbhani Kranti	--	A.I.C.V.I.P., Rahuri	2n=130
6	Phule Utkarsha	--	A.I.C.V.I.P., Rahuri	2n=130
7	Varsha Uphar	--	A.I.C.V.I.P., Rahuri	2n=130
8	P-7	--	A.I.C.V.I.P., Rahuri	2n=130

Note: N.A. –Not Available

between *A. esculentus* and *A. tetraphyllus* were successfully made both directly and reciprocally by earlier workers [Jambhale (1980), Sheela (1986) and Sheela (1994)]. The present work was also in conformity with previous findings in respect of successful crossing on both ways between *A. esculentus* and *A. tetraphyllus* (Table 3). However, Prakash (1986) reported success only when *A.esculentus* used as female parent. From the two sources, *A.tetraphyllus*-2 found to be having better crossability with *A.esculentus* cultivars on both ways as compared to *A.tetraphyllus*-1. The direct and reciprocal crosses between Phule Utkarsha and *A.tetraphyllus*-2 recorded maximum fruit set, highest crossability index and germination percentage when compared with other crosses. The wild species *A. ficulneus* was found compatible but seed sterile with *A.esculentus* when later used as female parent (Table 4). However, *A.ficulneus* was found incompatible with *A.esculentus* when former used as female parent. The

Table 1. Fruit set percentage, average seed number and germination in selfed cultivated *A.esculentus* cultivars and wild species.

Parents	No. of flowers selfed	Fruit set per cent	Avg. no. of seeds in selfed	Seed germination per cent (for two seasons)
Cultivated okra cultivars (*Abelmoschus esculentus* (L.) Moench)				
Pusa Sawani	25	88.00	62.00	75.00
Red Bhendi	25	92.00	58.00	70.00
Arka Abhay	25	88.00	60.00	75.00
Phule Utkarsha	25	100.00	66.00	85.00
Arka Anamika	25	96.00	60.00	80.00
Parbhani Kranti	25	92.00	65.00	83.00
Varsha Uphar	25	96.00	68.00	90.00
P7	25	84.00	63.00	75.00
Wild Abelmoschus spp.				
A. tuberculatus – 1	25	84.00	18.00	80.00
A. tetraphyllus – 1	25	96.00	28.00	83.00
A. tetraphyllus – 2	25	100.00	29.50	88.00
A. ficulneus – 1	25	80.00	36.50	13.00
A. moschatus -1	25	92.00	75.00	75.00
A. caillei -1	25	96.00	65.00	95.00
A. caillei – 2	25	92.00	42.00	55.00
A. manihot spp.manihot	25	84.00	33.50	70.00
A. manihot spp.tetraphyllus	25	76.00	18.50	35.00
A. manihot (L.) Medikus	25	88.00	32.00	60.00
A. angulosus	25	72.00	35.68	20.00

Table 2. Cross compatibility studies between *A. esculentus* and *A. tuberculatus*

Crosses	No. of flowers crossed	Fruit set per cent	Avg. no. of seeds in crossed fruits	Crossability index (%)	Seed germination per cent (for two season)
Phule Utkarsha x *A. tuberculatus* -1	50	30.00	14.33	21.71	37.50
A. tuberculatus -1 x Phule Utkarsha	10	30.00	3.33	18.50	30.00
Parbhani Kranti *x A. tuberculatus* -1	50	32.00	17.69	27.21	38.75
A. tuberculatus -1 *x* Parbhani Kranti	15	30.30	3.50	19.44	32.00
Varsha Uphar x *A. tuberculatus*-1	40	30.00	10.00	14.70	33.75
A. tuberculatus-1 x Varsha Uphar	10	20.00	2.00	11.11	25.00

Table 3. Cross compatibility studies between *A.esculentus* and *A.tetraphyllus*

Crosses	No. of flowers crossed	Fruit set per cent	Avg. no. of seeds in crossed fruits	Crossability index (%)	Seed germination per cent (for two seasons)
Pusa Sawani x *A. tetraphyllus* – 2	50	66.00	33.38	53.83	76.88
A. tetraphyllus – 2 x Pusa Sawani	20	50.00	13.00	44.06	66.50
Red Bhendi x *A. tetraphyllus* -2	50	70.00	32.75	56.46	75.63
A. tetraphyllus -2 x Red Bhendi	15	46.66	12.50	42.37	55.00
Arka Anamika x *A. tetraphyllus* – 1	15	53.33	22.00	36.66	58.75
A. tetraphyllus – 1 x Arka Anamika	10	50.00	10.00	35.71	40.00
Arka Anamika x *A. tetraphyllus* -2	35	71.42	26.33	43.88	76.25
A. tetraphyllus -2 x Arka Anamika	15	33.33	12.00	40.67	53.20
Parbhani Kranti x *A. tetraphyllus* -1	30	56.66	29.33	45.12	68.21
A. tetraphyllus -1 x Parbhani Kranti	15	53.33	13.00	46.42	67.50
Parbhani Kranti x *A. tetraphyllus* -2	60	80.00	32.88	50.58	75.42
A. tetraphyllus -2 x Parbhani Kranti	25	56.00	14.00	47.45	46.45
Varsha Uphar x *A. tetraphyllus*-1	20	65.00	29.66	43.61	27.50
A. tetraphyllus-1 x Varsha Uphar	10	20.00	10.30	36.78	18.50
Varsha Uphar x *A. tetraphyllus* -2	50	68.00	31.48	46.29	70.63
A. tetraphyllus -2 x Varsha Uphar	20	35.00	12.00	40.67	50.50
P7 x *A. tetraphyllus* -1	20	55.00	31.00	49.20	74.55
A. tetraphyllus -1 x P7	10	40.00	12.50	44.64	66.40
P7 x *A. tetraphyllus*-2	25	64.00	27.83	44.17	70.63
A. tetraphyllus-2 x P7	10	40.00	11.00	37.28	60.75
Phule Utkarsha x *A. tetraphyllus* – 1	30	60.00	35.00	53.03	81.25
A. tetraphyllus – 1 x Phule Utkarsha	20	50.00	14.50	51.78	80.00
Phule Utkarsha x *A. tetraphyllus* -2	50	84.00	36.00	54.54	77.08
A. tetraphyllus -2 x Phule Utkarsha	25	75.00	15.33	51.96	58.50
Arka Abhay x *A. tetraphyllus* -2	50	68.00	33.66	56.10	54.38
A. tetraphyllus -2 x Arka Abhay	20	60.00	15.00	50.84	46.50

Table 4. Cross compatibility studies between *A.esculentus* and *A. ficulneus*

Crosses	No. of flowers crossed	Fruit set per cent	Avg. no. of seeds in crossed fruits	Crossability index (%)	Seed germination per cent (for two seasons)
Phule Utkarsha x *A. ficulneus* -1	15	46.66	26.00	39.39	0.00
A. ficulneus -1 x Phule Utkarsha	10	55.00	0.00	0.00	0.00
Parbhani Kranthi x *A. ficulneus* -1	15	53.33	24.00	36.92	0.00
A. ficulneus -1 x Parbhani Kranthi	15	60.00	0.00	0.00	0.00
Varsha Uphar x *A. ficulneus* -1	20	55.00	27.00	39.70	0.00
A. ficulneus -1 x Varsha Uphar	20	60.00	0.00	0.00	0.00

major causes of hybrid inviability might be due to non-compatibility of the parental chromosomes, cytoplasmic genic interactions and non compatibility between embryo and the surrounding tissue called somaplastic sterility (Stebbins, 1958). In the present studies (Table 5), *A. moschatus* was found incompatible with *A. esculentus* on both ways. Crosses with *A. moschatus* produced shrivelled and non-viable seeds indicating involvement of post-zygotic sterility during inter specific hybridization. Similar results were obtained by Sheela (1986). In this incompatibility, zygote formation might be prevented by failure or ineffectiveness of pollen growth or failure of fertilization (Allard, 1990). However, Gadwal *et al.* (1968) obtained viable hybrids of this species with *A. esculentus* through embryo culture technique. Pushaparajan (1986) also reported that *A. moschatus* is reproductively isolated from the other species was in conformity with the present findings. According to Hamon and Charrier (1983) also, the species which differed most from other *Abelmoschus* species was *A. moschatus*. The crosses between *A.esculentus* cultivars and *A.angulosus* were found

successful only when *A.esculentus* cultivars were used as female parent in the present study (Table 6). Maximum fruit set, highest crossability index and germination percentage was obtained when Phule Utkarsha used as female parent. Samarajeewa *et al.* (1999) reported that when *A.angulosus* was used as the female parent incompatibility was observed resulting in failure of embryo formation. In such case, embryo rescue was successful to raise viable hybrids. When the cultivated type was used as female parent, progeny plants were produced without incompatibility difficulties.

The crosses between *A. caillei* and *A. esculentus* (Table 7) were found successful on both ways. Successful crossing between these two species was also reported by Hamon and Hamon (1991). Maximum fruit set, average number of seeds per crossed fruits and highest crossability index were observed when *A. caillei*-2 was used as female parent. Sheela (1994) reported that the reciprocal differences in compatibility of the crosses involving *A. esculentus* and *A. caillei* can be attributed to the higher ploidy status of *A. caillei* as compared to *A. esculentus* which provided better embryo endosperm balance as per Kalloo (1998). Chacko *et al.* (1996) also reported higher degree of crossability in the cross *A. caillei* x *A. esculentus*. However, highest germination was noticed in the crosses where *A. esculentus* was used as female parent. This might be due to hard seed coat of *A. caillei* seeds which failed to germinate. Kousalya (2005) however, reported maximum germination in the cross between *A. caillei* and *A.esculentus*.

The direct and reciprocal crosses between *A. esculentus* cultivars and *A. manihot* spp. *manihot* were found successful in the present study (Table 8). This was in conformity with the findings of Jambhale (1980) while Sujatha (1983) reported success when *A.esculentus* used as female parent. The direct and reciprocal crosses between Parbhani Kranti and *A.manihot spp.manihot*

Table 5. Cross compatibility studies between *A.esculentus* and *A. moschatus*

Crosses	No. of flowers crossed	Fruit set per cent	Avg. no. of seeds in crossed fruits	Crossability index (%)	Seed germination per cent (for two seasons)
Phule Utkarsha x *A. moschatus* -1	15	60.00	0.00	0.00	0.00
A. moschatus -1 x Phule Utkarsha	10	30.00	0.00	0.00	0.00
Parbhani Kranthi x *A. moschatus* -1	10	70.00	0.00	0.00	0.00
A. moschatus -1x Parbhani Kranthi	10	40.00	0.00	0.00	0.00
Varsha Uphar x *A. moschatus* -1	10	70.00	0.00	0.00	0.00
A. moschatus -1x Varsha Uphar	10	30.00	0.00	0.00	0.00

Table 6. Cross compatibility studies between *A.esculentus* and *A. angulosus*

Crosses	No. of flowers crossed	Fruit set per cent	Avg. no. of seeds in crossed fruits	Crossability index (%)	Seed germination per cent (for two seasons)
Phule Utkarsha x *A. angulosus*	10	70.00	18.00	27.27	18.50
A. angulosus x Phule Utkarsha	10	40.00	0.00	0.00	0.00
Parbhani Kranti x *A. angulosus*	20	65.00	14.66	22.55	16.67
A. angulosus x Parbhani Kranti	10	30.00	0.00	0.00	0.00
Varsha Uphar *x A. angulosus*	10	50.00	15.00	22.00	14.00
A. angulosus x Varsha Uphar	10	30.00	0.00	0.00	0.00

Table 7. Cross compatability studies between *A.esculentus* and *A.caillei*

Crosses	No. of flowers crossed	Fruit set per cent	Avg. no. of seeds in crossed fruits	Crossability index (%)	Seed germination per cent *
Pusa Sawani x *A. caillei* – 2	40	65.00	31.38	50.61	43.75
A. caillei –2 x Pusa Sawani	30	83.33	35.29	84.02	32.50
Red Bhendi *x A. caillei* -2	25	44.00	28.33	48.84	56.25
A. caillei – 2 x Red Bhendi	20	60.00	14.50	34.52	10.42
Phule Utkarsha x *A. caillei* -1	30	66.66	31.16	47.21	76.25
A. caillei -1 x Phule Utkarsha	10	70.00	37.00	56.92	70.00
Phule Utkarsha x *A. caillei* -2	40	60.00	34.25	51.89	28.75
A. caillei –2 x Phule Utkarsha	40	80.00	34.42	81.95	25.00
Parbhani Kranti x *A. caillei* -1	15	73.33	30.00	46.15	51.25
A. caillei -1 x Parbhani Kranti	10	70.00	33.00	50.76	50.50
Parbhani Kranti x *A. caillei* -2	35	51.42	37.80	58.15	28.33
A. caillei-2 x Parbhani Kranti	35	80.00	35.50	84.52	32.38
Varsha Uphar x *A. caillei* -1	10	60.00	32.00	47.00	62.22
A. caillei -1 x Varsha Uphar	10	60.00	30.00	46.15	50.75
Varsha Uphar x *A. caillei* -2	35	57.14	32.30	47.50	42.08
A. caillei-2 *x* Varsha Uphar	40	80.00	30.44	72.47	36.38

recorded maximum fruit set, number of seeds per fruit, highest crossability index and germination percentage. Inter-specific hybridization of *A. esculentus* with *A. manihot* spp. *tetraphyllus* on both ways was successfully undertaken by Prakash (1986) and Sindhu (1993). The present findings also endorse the findings of the previous workers. Among direct and reciprocal crosses between *A.esculentus* cultivars and *A.manihot spp.tetraphyllus* (Table 9), the crosses between Phule Utkarsha and *A.manihot spp.tetrphyllus* recorded maximum fruit set, highest crossability index and germination percentage. The direct and reciprocal crosses between *A.manihot* (L.) Medikus and *A.esculentus* cultivars were found successful (Table 10). Similarly, Jambhale (1980) and Sindhu (1993) reported success in both direct and reciprocal crosses between these two species. However, Teshima (1933) observed that *A. esculentus* and *A. manihot* crossed only when the former was used as female parent. In an inter-specific breeding programme between *A. esculentus* and *A. manihot*, Sujatha (1993) observed high degree of pollen fertility (33.4 to 64.5 per cent) in the hybrids, but there was hardly any seed set. The seeds if formed were shrivelled and very small in size. In the direct crosses, Varsha Uphar x *A.manihot* (L.) Medikus while, in reciprocal cross *A.manihot* (L.) Medikus x Parbhani Kranti recorded maximum fruit set, number of seeds per crossed fruit, highest crossability index and germination percentage.

From the present findings, it was observed that maximum fruit set percentage, number of seeds per crossed fruit, highest crossability index and germination percentage was observed when *A.esculentus* used as female parent while crossing with wild species viz., *A.manihot* (L.) Medikus, *A.angulosus ,A.manihot spp.manihot, A.manihot* spp *tetraphyllus and A.tuberculatus,* This is in line with findings of Jambhale (1980). However, Sheela (1994) observed reciprocal crosses registered higher compatibility than the direct crosses while crossing between *A.esculentus* and *A.tetraphyllus* while Cherian (1986) observed that there are no reciprocal differences in the crosses between *A.esculentus* and *A.manihot*. Lowest fruit set, average number of seeds per fruit and crossability index was observed in crosses between *A. esculentus cultivars* and *A. tuberculatus and A.esculentus cultivars and A. angulosus.* The low seed set and recovery of shrivelled seeds in the crossed fruits may be due to partial or complete failure of the endosperm owing to genetic imbalance. In certain hybrids the abnormal development of the endosperm will cause the hybrid seed fails to

Table 8. Cross compatibility studies between *A.esculentus* and *A. manihot spp.manihot*

Crosses	No. of flowers crossed	Fruit set per cent	Avg. no. of seeds in crossed fruits	Crossability index (%)	Seed germination per cent (for two seasons)
Pusa Sawani *x A. manihot spp.manihot*	50	58.00	32.50	52.41	67.50
A. manihot spp.manihot x Pusa Sawani	20	15.00	14.00	41.79	65.00
Red Bhendi *x A. manihot spp.manihot*	50	62.00	36.00	62.00	64.38
A. manihot spp.manihot x Red Bhendi	20	20.00	12.00	35.82	45.50
Phule Utkarsha x *A. manihot spp.manihot*	60	71.66	37.28	56.48	71.25
A. manihot spp.manihot x Phule Utkarsha	20	25.00	15.00	44.77	65.00
Arka Anamika x *A. manihot spp.manihot*	35	60.00	26.90	44.83	61.25
A. manihot spp.manihot x Arka Anamika	10	20.00	12.50	37.31	49.31
Parbhani Kranti *x A. manihot spp.manihot*	70	74.28	44.40	68.30	75.63
A. manihot spp.manihot x Parbhani Kranti	25	40.00	18.00	53.73	70.00
Varsha Uphar *x A. manihot spp.manihot*	60	70.00	43.85	64.48	63.33
A. manihot spp.manihot x Varsha Uphar	20	30.00	16.00	47.76	51.50

Table 9. Cross compatibility studies between *A.esculentus* and *A. manihot spp.tetraphyllus*

Crosses	No. of flowers crossed	Fruit set per cent	Avg. no. of seeds in crossed fruits	Crossability index (%)	Seed germination per cent (for two seasons)
Pusa Sawani x *A. manihot spp.tetraphyllus*	20	60.00	18.00	29.00	60.75
A. manihot spp.tetraphyllus x Pusa Sawani	10	30.00	5.00	27.02	45.36
Red Bhendi x *A. manihot spp.tetraphyllus*	30	50.00	26.50	45.68	57.32
A. manihot spp.tetraphyllus x Red Bhendi	10	20.00	3.00	16.21	16.66
Phule Utkarsha x A. *manihot spp.tetraphyllus*	60	63.33	32.13	48.68	63.12
A. *manihot spp.tetraphyllus* x Phule Utkarsha	20	35.00	7.00	37.83	47.14
Arka Anamika x *A. manihot spp.tetraphyllus*	20	55.00	21.50	35.83	56.31
A. manihot spp.tetraphyllus x Arka Anamika	10	20.00	4.00	21.62	12.50
Parbhani Kranti *x A. manihot spp.tetraphyllus*	40	62.50	28.16	43.32	61.04
A. manihot spp.tetraphyllus x Parbhani Kranti	10	30.00	5.50	29.72	11.76
Varsha Uphar x *A. manihot spp.tetraphyllus*	40	62.50	27.94	41.08	60.42
A. manihot spp.tetraphyllus x Varsha Uphar	10	20.00	3.00	16.21	16.66

Table 10. Cross compatibility studies between *A.esculentus* and *A. manihot* (L) Medikus

Crosses	No. of flowers crossed	Fruit set per cent	Avg. no. of seeds in crossed fruits	Crossability index (%)	Seed germination per cent (for two seasons)
Pusa Sawani x *A. manihot* (L.) Medikus	25	52.00	14.66	23.64	28.50
A. manihot (L.) Medikus x Pusa Sawani	10	20.00	7.00	21.87	14.28
Phule Utkarsha x *A. manihot* (L.) Medikus	20	70.00	25.25	38.25	52.13
A. manihot (L.) Medikus x Phule Utkarsha	10	30.00	10.00	31.25	20.00
Arka Anamika x A. *manihot* (L.) Medikus	20	60.00	15.00	25.00	39.59
A. *manihot* (L.) Medikus x Arka Anamika	10	20.00	8.00	25.00	12.50
Parbhani Kranti x *A. manihot* (L.) Medikus	30	63.33	23.50	36.15	59.64
A. manihot (L.) Medikus x Parbhani Kranti	10	40.00	11.50	35.93	32.00
Varsha Uphar x *A. manihot* (L.) Medikus	20	75.00	28.50	41.91	64.13
A. manihot (L.) Medikus x Varsha Uphar	10	20.00	8.00	25.00	25.00

develop. The complete or partial failure of the endosperm in the hybrids usually interferes with the nourishment of the developing embryo (Allard, 1990). Sindhu (1993) reported lower fruit set may be attributed to the variation in chromosome number in the parental species. In the present study, it was observed that seed germination was found maximum in crosses between *A. esculentus* cultivars and *A. tetraphyllus*. Babu and Dutta (1990) also have contributed towards maximum seed germination. reported 76.42 per cent pollen fertility in the inter-specific hybrid between *A. esculentus* and *A. tetraphyllus.* Therefore, high pollen fertility in these crosses might be contributed to maximum seed germination.

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