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DEVELOPMENT OF INTERSPECIFIC HYBRID ROOTSTOCKS USING CUCURBITA*MOSCHATA* DUCH EX. POIR AND CUCURBITA *MAXIMA* LINES

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ABSTRACT

In recent years, vegetable grafting has emerged as a rapid tool in tailoring plants to adapt to climate resilient growing conditions. Utilization of grafting technique is increasing mainly in commercial cucurbitaceous vegetables *viz.,* watermelon, cucumber, bitter gourd and muskmelon. These vegetables are preferably grafted with interspecific hybrid rootstocks for their seedling vigor, high degree of resistance against biotic and abiotic stresses. Moreover, the hybrid rootstock increases the yield of respective scions. To harness the potentiality of rootstocks, an attempt has been made to develop interspecific hybrid rootstocks by using 48 *Cucurbita moschata* and four *Cucurbita maxima* lines and hybridization was attempted through Line x Tester mating design. These 52 genotypes were collected from various diverse agro climatic regions of India and World Vegetable Centre, Taiwan, raised by following proper isolation distance and selfed to maintain the genetic purity. Using 48 *Cucurbita moschata* genotypes as lines and four *Cucurbita maxima* genotypes as testers, 192 interspecific hybrids were developed, out of which only 16 hybrids were fertile and in rest of the hybrids, cross incompatibility was observed. Among the lines, CMo 28, CMo 43 and CMo 44 were highly cross compatible with different *Cucurbita maxima* testers. Among the testers, CMa 49 and CMa 52 were highly cross compatible with different *Cucurbita moschata* lines. Among the fertile hybrid rootstocks, CMo 44 × CMa 52, CMo 28 × CMa 52 and CMo 43 × CMa 51 were identified as promising ones and used for graftingstudies.

Keywords: Interspecific hybrid rootstocks, pumpkin*, Cucurbita moschata,* winter squash and *Cucurbita maxima*

INTRODUCTION

Globally, the benefits of using grafted vegetable seedlings are increasing and it is recognized as reliable alternative tool to mitigate various biotic and abiotic factors which hamper the vegetable production as compared with conventional breeding strategies (Bahadur *et al.,* 2015; Muhammad *et al.,* 2016; Ashok Kumar and Kumar Sanket, 2017; Bie*et al.,* 2017; Pugalendhi *et al.,* 2019). Grafting technique in vegetable crops are currently being adopted extensively in Japan, Korea, China, Taiwan, USA, Spain, Italy and France (Lee *et al*., 2010; Karaca *et al*., 2012), while it is yet to be attempted on a commercial scale in India. Intra-specific and interspecific grafting is practiced in cucurbitaceous vegetables, the latter (grafting of cucurbitaceous vegetables onto different species of the same genus) being most common in commercial cucurbitaceous vegetables including bitter gourd, cucumber, watermelon and muskmelon to manage various biotic and abiotic factors.

Rootstocks play a vital role in sustainable yield improvement and protection of crop plants from various biotic and abiotic factors when it is grown under sub-optimal growing condition (Muhammad *et al.,* 2017 a, b; 2018). Moreover, the choice of rootstock also influences the success of grafting in most of the vegetable crops (Belen Pico *et al.,* 2017). Breading of suitable rootstocks helps to sustain the vegetable cultivation under suboptimal growing conditions (Gregory *et al*., 2013; Rouphael *et al*., 2017) than that of parental rootstock. The commercially cultivated cucurbitaceous vegetables were predominantly grafted onto interspecific hybrid rootstocks developed by crossing *C.moschata and C.maxima* lines (Colla*et al.,* 2010; Edelstein *et al.,* 2017) which has variable degree of compatibility (Paris and Kabelka, 2009) and are resistant to various biotic and abiotic stresses. Bigdelo *et al.* (2017) stated that *Lagenaria* and interspecific hybrid rootstocks are globally used for watermelon grafting and the later was found to be more vigorous with increased fruit weight and yield. Interspecific F_1 hybrid (*C.moschata x C.maxima*) rootstocks provided non-specific but efficient protection to wide range of soil borne diseases and tolerance to some abiotic stresses (Paris and Kabelka, 2009; Colla*et al*., 2010; Karaagac and Balkaya, 2013). Similarly, Keinath and Hassel (2014) and Zhou *et al.*(2014) stated that *Fusarium* wilt incidence were predominantly reduced when grafting watermelon scions with interspecific hybrid rootstocks besides yield improvement (Belen Pico *et al.,* 2017). Vigorous interspecific hybrid rootstock mitigated late season wine decline and improved the water uptake in watermelon (Davis *et al*., 2008; Jifon and Crosby, 2008). An increased resistance to verticillium wilt was also noticed in watermelon when grafted with interspecific hybrid rootstocks (Buller *et al.,* 2013). Interspecific hybridization paves an effective way to create new genotypes which combines favorable traits from different parents to combat various biotic and abiotic stresses (Zhang *et al.,* 2012).

Several attempts have been made among the cucurbit species *viz., Cucurbita pepo, C.maxima, C.mixta and C. moschata.* However, crossing barrier has been reported among these species including cross incompatibility, hybrid in viability, hybrid sterility and hybrid breakdown (Whitaker and Davis, 1962;Depei, 2000;Yongan*et al.*, 2002a). Bemis and Nelson (1963) recorded hybrid inviability in interspecific hybridization among ten *C ucurbita* spp. Where in abnormal seed development inspite of normal fruit set was observed. However, 23 interspecific crosses produced viable seedsand F_1 hybrid plants in the same study. Similarly, Korakot*et al.* (2010) observed hybrid inviability when attempting hybridization between *C. moschata x C.maxima*lines. However, Bingdong (1996) and Yongan*et al.* (2002b) observed cross compatibility among *C.moschata x C.maxima*lines and *C.argryosperma* x *C.maxima*lines.Yongan*et al.* (2002b) stated that, number of normal seeds per fruit is an index which determines the cross compatibility among the Cucurbitaspecies. Similarly, Karaagac and Balkaya (2013) attempted interspecific hybridization among *C.maxima*and *C.moschata*lines and obtained three promising interspecific hybrid combinations for further rootstock breeding.

Moreover, interspecific rootstock breeding work is prevalent in China, Japan, Korea and Turkey and they are well-known inrootstock breeding. However, still there has a meager report on rootstock breeding in *Cucurbita*spp. in India. Considering this, interspecific rootstock breeding research was attempted with *C.moschata* lines and *C.maxima*testers to identify a new compatible cross combination to mitigate *Fusarium* wilt and root knot nematode infestation in watermelon.

MATERIALS AND METHODS

This study was carried out during the January 2017 to June 2019 in the Department of Vegetable Science, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. Forty eight *C.moschata* lines and four *C. maxima* lines were collected across various parts of India and from The World Vegetable Centre, Taiwan. Before attempting interspecific hybridization, the collected *C.moschata* and *C.maxima* genotypes were selfed to obtain homozygous inbred lines. Based on the plant vigour, hypocotyl characters and seed yield, forty eight *C.moschata* lines and four *C. maxima* lines were used as female and male parents respectively and interspecific hybridization was attempted through Line x Tester mating design.

The field experiments were conducted at the experimental farm located at 11^0 N latitude, 77°E longitudes and an altitude of 426.26 m above sea level. The soil in the experimental area was sandy loam with pH of 6.5 to 7.5.Trenches of 30 × 30cm were dug at 2.5 x 2.5m apart and seeds were sown at a depth of 2 cm. Recommended cultural practices and plant protection measures were followed as per the production protocol.

Selfing: All *C. moschata* lines and *C. maxima* lines were selfed for three generations to maintain genetic purity. Pollen was collected from selected male flowers of the same plant dusted on the female flower of the same plant, and covered again until the fruit set. Seeds were collected from selfed fruits and the seeds were used to grow the crops for the crossing work tocarry out interspecific hybridization.

Interspecific hybridization: Crossing block was raised to produce interspecific hybrid seeds using forty eight *C. moschata* lines (lines) and four *C.maxima* lines (testers) in a Line × Tester mating system. The experiment was laid out in randomized Block Design (RBD) with three replications. Male flowers of testers (*C.maxima* lines) andfemale flowers of lines (*C.moschata* lines) were bagged separately with butter paper cover one day prior to anthesis. The next day morning, pollen grains are collected from bagged male flowers of testers and dusted on bagged female flowers of all lines between 6.00 to 8.00 A.M. Dusted female flowers were again covered with butter paper cover and labeled with the cross combination and pollination date. Paper covers were removed after fruit set. Seeds were extracted from fully ripened fruit (60-75 days after pollination), dried and stored in paper covers for further study. Finally, number of viable crosses, fruit set number (number of seeds per fruit), fruit set percentage, seed weight (g) and seed yield per fruit (g)were recorded. In addition to the above, physical seed traits *viz.,* seed length, width and thickness were measured for 100 seeds of all cross combinations. Seed weight was measured and recorded in air dried seeds and standard germination test was done with randomly selected seeds of each cross combinations with three replications (individual replication represented 100 seeds). Seed germination rate was measured as the peak germination percent/peak count day (ISTA, 2004).The data pertaining to the physical and seed parameters *viz.,* Seed length (mm), seed width (mm), seed thickness (mm), total number of seeds/ fruits, total number of ill filled seeds/fruit, total number of normal seeds/fruits, seed yield per fruit (g) and seed germination rate (%) was analysed with STAR-(Statistical Tool for

Agricultural Research) Software package (version 2.0.1) developed by IRRI, Philippines. Statistical evaluation of the aforementioned detailed variables was subjected to ANOVA analysis (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Forty-eight *C. moschata* lines and four *C. maxima* testers, were used to develop 192 interspecific cross combinations (Table 1). There was significant difference were noticed among the inter specific cross combinations. After hybridization, fruit setting was examined in each cross. Among the 192 interspecific crosses, only 40 interspecific cross combinations were fertile and produced fruits (Table 2). The flowers in the rest of the cross combinations were wilted and dried within three to seven days after pollination and finally fruit set was not observed. This indicates the cross incompatibility in the particular cross combinations as a result of incomplete fertilization due to insufficient growth of pollen tube to reach the ovule and inability of male gamete to unite with egg cell (Liu *et al.,*2004; Marta *et al.,*2004). Yongan*et al.* (2002a) and Karaagac and Balkaya (2013) also noticed cross incompatibility barrier among *C. moschata* and *C. maxima* lines while attempting interspecific hybridization

The fruit set percentage was worked out for the compatible fortyinterspecific cross combinations (Table 2). Among the forty interspecific cross combinations, CM44 x CM 52 recorded the highest fruit set percentage (66%) and highest number of fruits with normal seeds followed by CMo 43 x CMa 51 (50%) and CMo 44 x CMa 49 (50%). The lowest value (8.33 %) for the same trait was noticed in CMo 7 x CMa 49 and CMo 41 x CMa 50 followed by CMo 13 x CMa 51 (10%). Concomitant to this finding, Cheng *et al.* (2002) observed 40 to 50 percent seed set among *C.moschata x C.maxima* lines.

Fruits that developed from interspecific cross combinations were harvested after-ripening and sorted into two groups; those containing seeds with an embryo and those which were parthenocarpic/ or fruits without seeds. Among 40 different interspecific cross combinations,24 interspecific cross combinations produced abortive seeds (Table 3). Seed abortion in interspecific crosses are mainly due to the arrested development of embryos due to either the abortion of embryos at early levels (Ashley, 1972) or from the degeneration of the endosperm (Brink and Cooper, 1944; Cooper and Brink, 1944). Embryo/endosperm abortion is caused by abnormal cell division of zygote or slow endosperm development, which causes an incompatibility with embryo growth in most of the plant species (Nowack*et al.*, 2010). Results of the present study in corroboration with the findings of Kwack and Fujieda (1987), who reportedthat seed abortion in interspecific crosses of Cucurbita attributed to the abnormalities in pollen tube growth, fertilization, and/or incompatibility between embryo and endosperm after normal fertilization.The findings are in line with earlier report of Yongan*et al.*(2002a) and Karaagac and Balkaya (2013). Remaining 16 interspecific cross combinations producednormal seeds as a result of normal pollen tube growth which favours optimum fruit development with more number of normal seeds (Crane, 1969).

The data revealed that seed dimensions *viz.,* seed length, width and thickness had direct effect on seed weight and seed yield per fruit (Table 4). The average seed length of 16 interspecific cross combinations ranged from 10.82 mm to 18.51 mm.The highest seed length (18.51 mm) was achieved in CMo 23 x CMa 52 followed by CMo 28 x CMa 52 (17.66 mm) cross combinations. With respect to seed width, the cross combinations, CMo 44 x CMa 52 followed by CMo 28 x CMa 52 recorded the highest value (9.37mm and 9.28mm) and CMo 9 x CMa 49 (7.09 mm) recorded the lowest value for the same trait. Seed thickness of the aforementioned cross combinations ranged between 1.53 mm (CMo 41 x CMa 52) to 3.53 mm (CMo44 CMa 52). Observations on seed dimensionsshowed significant difference among interspecific cross combinations and their findings arecorroborate with the finding of Karagac and Balkaya (2013).

Production of highest number of normal seeds per fruit is a preferable trait in hybrid seed production which increases the quality seed yield and ultimately it reflected on revenue. Among the 16 interspecific cross combinations, CMo 20 x CMa 49 (568 seeds/fruit) followed byCMo 44x CMa 52 (552 seeds/fruit) and CMo 23 x CMa 52 (545 seeds/fruit) was found to be best for the production of highest number of normal seeds per fruit (Table 5). This result indicates thatcompatibility between *C. moschata*and*C.maxima* lines. The interspecific cross combinations CMo 25 x CMa49 (24 seeds/fruit) andCMo 41 x CMa52 (146 seeds/fruit) registered lowest values for the same trait. Theseresultsare in corroboration with the finding of Cheng *et al.* (2002). Theinterspecific cross combination, CMo23 x CMa 52 (112.5 g/fruit) followed by CMo 44 x CMa 52 (99.5 g/fruit) have registered the highest value for seed yield per fruit (Table 5). Seed germination rate is considered as an important and desirable parameter in interspecific hybridization, though seed number per fruit and seed yield is high. Substantial difference was noticed among the 16interspecific cross combinations for the above trait. The interspecific hybrid *viz.,* CMo 44 x CMa 52 (83.81%), CMo 28 x CMa52 (81.60%) andCMo43 x CMa51 recorded the highest germination rate than other cross combinations. Theseobservationswere concomitant with the reports of Karagac and Balkaya (2013).

Utilization of interspecific hybrid rootstocks for grafting with watermelon, cucumber, melons and bitter gourd (King *et al.,* 2010; Lee *et al.,* 2010) urge the vegetable breeder to widely adopt interspecific hybridization in cucurbitaceous vegetables. Among the several cross-pollination studies made, only few particular crosses of these two species (*Cucurbita moschata* and *Cucurbita maxima*) yield desirable number of viable seeds. The percentage of seed set among the cross combination was about 8.33 to 66.6 % and the percentage was different with different cultivars/varieties of these species. They exhibited wide range of crossing barriers such as failure of pollen tube growth (known as presyngamic barrier) and breakdown of embryo development (known as postsyngamic barrier). To improve the seed set percentageandyield, Ara *et al.* (2013) and Karaagac and Balkaya (2013) selected parental lines (*Cucurbita moschata* and *Cucurbita maxima*) based on the plant vigour, hypocotyl diameter, seed yield and compatibility and attempted interspecific hybridization. In the present study, we attempted similar approach to develop interspecific hybrid rootstocks.

From this study, it could be concluded that the interspecific hybrid combination s*viz.,* CMo 44 x CMa52, CMo 28 x CMa52 and CMo43 x CMa51were found to be the most promising based on the seed yield and seed germination rate. These three inter specific cross combinations were further tested for soil borne disease resistant traits and used as rootstock for grafting with commercial cucurbitaceous vegetables *viz.,* watermelon, cucumber and bitter gourd. These interspecific hybrid rootstocks helpin exploitation of grafting techniques in aforementioned commercial cucurbitaceous vegetables to achieve the targeted yield under diverse production system in a sustainable way.

Table 1. Results of interspecific hybridization in *C. moschata x C. maxima* lines.

Female parents ♀	**Number of flowers crossed**				**Number of fruit set**			
	Male parents (♂)				**Male parents (♂)**			
	CMa 49	**CMa50**	**CMa51**	**CMa52**	**CMa 49**	**CMa50**	**CMa51**	**CMa52**
CMo 1	6	7	6	6	0	0	0	0
CMo 2	8	5	5	7	0	0	0	0
CMo 3	5	11	7	4	0	0	0	0
CMo 4	7	5	9	5	0	0	0	0
CMo 5	6	4	8	6	0	0	0	0
CMo 6	8	7	8	9	0	0	0	0
CMo 7	12	8	6	8	1	1	1	0
CMo 8	6	6	5	8	0	0	0	0
CMo 9	10	4	6	7	4	0	0	0
CMo 10	6	8	6	10	0	0	0	0
CMo 11	9	5	5	7	0	0	0	0
CMo 12	12	4	6	10	0	0	0	0
CMo 13	9	11	10	11	0	3	1	0
CMo 14	5	4	5	6	0	0	0	0
CMo 15	14	10	8	8	3	0	1	1
CMo 16	6	7	5	5	0	0	0	0
CMo 17	4	8	8	6	0	2	0	0
CMo 18	5	8	8	7	0	1	0	0
CMo 19	7	4	4	8	0	0	0	0
CMo 20	12	7	8	6	2	2	0	0
CMo 21	5	8	7	6	0	0	0	0
CMo 22	5	7	12	5	0	0	0	0
CMo 23	9	6	6	8	0	1	1	3
CMo 24	12	8	12	6	0	2	0	0
CMo 25	8	5	5	7	5	0	0	0
CMo 26	7	7	10	6	0	0	0	0
CMo 27	6	10	6	5	0	0	0	0
CMo 28	4	7	7	6	0	0	1	2
CMo 29	6	5	5	6	0	0	0	0
CMo 30	8	8	6	5	0	0	0	0
CMo 31	9	8	4	7	3	2	1	0
CMo 32	7	6	7	6	0	0	0	0
CMo 33	5	3	4	5	1	0	0	0
CMo 34	5	9	6	6	0	0	0	0

CMo 35	6	8	6	7	0	0	0	0
CMo 36	7	7	5	6	1	0	0	0
CMo**37**	4	7	10	6	0	0	0	0
CMo 38	3	6	6	4	0	2	0	0
CMo39	4	3	4	4	0	1	0	0
CMo 40	5	4	6	5	0	1	0	0
CMo 41	7	12	12	8	2	1	0	2
CMo 42	4	4	6	3	0	0	0	0
CMo 43	7	9	6	8	1	1	3	3
CMo44	8	5	5	6	4	2	0	4
CMo 45	5	3	3	4	0	0	0	0
CMo 46	4	6	6	5	0	0	0	0
CMo 47	3	5	5	4	0	0	0	0
CMo 48	6	5	6	6	0	0	1	1

Table 2. Fruit set percentage of C. *moschata x C. maxima* interspecific hybrids.

Sr. No.	Cross combinations	Number of fruit set	Fruit set percentage	Number of fruits with normal seeds
1	CMo 7 x CMa 49	1	8.33	0
2	CMo 9 x CMa 49	4	25.0	4
3	CMo 15 x CMa 49	3	40.0	3
4	CMo 20 x CMa 49	2	16.6	2
5	CMo 25 x CMa 49	5	12.5	1
6	CMo 31 x CMa 49	3	33.3	3
7	CMo 33 x CMa 49	1	20.0	0
8	CMo 36 x CMa 49	1	14.2	0
9	CMo 40 x CMa 49	2	28.5	2
10	CMo 41 x CMa 49	1	14.2	1
11	CMo 44 x CMa 49	4	50.0	4
12	CMo 7 x CMa 50	1	12.5	0
13	CMo 13 x CMa 50	3	27.2	0
14	CMo 17 x CMa 50	2	25.0	0
15	CMo 18 x CMa 50	1	12.5	0
16	CMo 20 x CMa 50	2	28.5	0
17	CMo 23 x CMa 50	1	16.6	0
18	CMo 24 x CMa 50	2	25.0	0
19	CMo 31 x CMa 50	2	25.0	0
20	CMo 38 x CMa 50	2	33.3	0
21	CMo 39 x CMa 50	1	33.3	0
22	CMo 40 x CMa 50	1	25.0	0
23	CMo 41 x CMa 50	1	8.33	1
24	CMo 43 x CMa 50	1	11.1	0
25	CMo 44 x CMa 50	2	40.0	0
26	CMo 7 x CMa 51	1	16.6	0
27	CMo 13 x CMa 51	1	10.0	0
28	CMo 15 x CMa 51	1	12.5	0
29	CMo 23 x CMa 51	1	16.6	0
30	CMo 28 x CMa 51	1	14.2	0
31	CMo 31 x CMa 51	3	25.0	2
32	CMo 43 x CMa 51	1	50.0	1
33	CMo 48 x CMa 51	1	16.6	0
34	CMo 15x CMa 52	1	12.5	1
35	CMo 23 x CMa 52	3	37.5	3
36	CMo 28 x CMa 52	2	33.3	2
37	CMo 41x CMa 52	2	25.0	2

38	CMo 43 x CMa 52	3	37.5	0
39	CMo 44 x CMa 52	4	66.6	4
40	CMo 48 x CMa 52	1	16.6	0

Table 3. Summary of *C. moschata x C. maxima* interspecific cross combinations.

Female parents ♀	Male parents (♂)			
	CMa 49	**CMa50**	**CMa51**	**CMa52**
CMo 1	x	x	X	x
CMo 2	x	x	X	x
CMo 3	x	x	X	x
CMo 4	x	x	X	x
CMo 5	x	x	X	x
CMo 6	x	x	X	x
CMo 7	ab	ab	Ab	x
CMo 8	x	x	X	x
CMo 9	499^{y}	x	X	x
CMo 10	ab	x	X	x
CMo 11	ab	x	X	x
CMo 12	ab	x	X	x
CMo 13	x	ab	Ab	x
CMo 14	x	x	X	x
CMo 15	$317^{y}12^{z}$	x	Ab	236^{y}
CMo 16	x	x	X	x
CMo 17	x	ab	X	x
CMo 18	x	ab	X	x
CMo 19	x	x	X	x
CMo 20	$601^{y}43^{z}$	ab	X	x
CMo 21	x	x	X	x
CMo 22	x	x	X	x
CMo 23	x	ab	Ab	$598^{y}53^{z}$
CMo 24	x	ab	X	x
CMo 25	24^{y}	x	X	x
CMo 26	x	x	X	x
CMo 27	x	x	X	x
CMo 28	x	x	Ab	375^{y}
CMo 29	x	x	X	x
CMo 30	x	x	X	x
CMo 31	$461^{y}13^{z}$	ab	478^{y}	x
CMo 32	x	x	X	x
CMo 33	ab	x	X	x
CMo 34	x	x	X	x
CMo 35	x	x	X	x
CMo 36	ab	x	X	x
CMo**37**	x	x	X	x
CMo 38	x	ab	X	x
CMo39	x	ab	X	x
CMo 40	$207^{y}3^{z}$	ab	X	x
CMo 41	$342^{y}1^{z}$	$533^{y}2^{z}$	X	423^{y}
CMo 42	x	x	X	x
CMo 43	x	ab	253^{y}	ab
CMo44	401^{y}	ab	X	575^{y}
CMo 45	x	x	X	x
CMo 46	x	x	X	x
CMo 47	x	x	X	x

CMo 48	x	x	Ab	ab

X: Absence of fruit set; y: number of normal seeds/fruit; z: number of ill filled seeds; ab=all seeds were aborted

Table.4. Seed dimension characteristics of successful interspecific cross combinations of*C. moschata x C. maxima* lines.

S.No	Successful inter specific cross combinations	Seed length (mm)	Seed width(mm)	Seed thickness (mm)
1.	CM 9 x CMa 49	10.82	7.33	2.16
2.	CM15 x CMa 49	12.70	7.09	2.56
3.	CM 20 x CMa 49	15.34	7.98	3.01
4.	CM 25 x Cma 49	13.71	7.41	2.09
5.	CM 31 x CMa 49	17.36	8.76	3.44
6.	CM 40 x Cma 49	15.68	7.47	2.88
7.	CM 41 x Cma 49	14.70	7.94	2.36
8.	CM 44 x Cma 49	15.12	7.63	2.21
9.	CM 41 x CMa 50	16.66	8.73	3.24
10.	CM 31 x CMa 51	17.01	8.47	3.31
11.	CM43 x Cma 51	14.30	8.22	2.90
12.	CM 15 x Cma 52	15.82	9.17	2.91
13.	CM23 x Cma 52	18.51	8.71	2.88
14.	CM 28 x Cma 52	17.66	9.28	3.13
15.	CM 41 x Cma 52	15.90	8.48	1.53
16.	CM 44 x Cma 52	16.45	9.37	3.53
	Mean	15.48	8.25	2.75
	SEd	1.95	1.57	1.55
	CD (0.05)	3.90	3.17	3.10

Table.5. Seed characteristics of successful interspecific cross combinations of *C. moschataxC. maxima* lines.

S.No	Successful inter specific cross combinations	Total number of seeds/ fruit	Total Number of ill filled seeds/fruit	Total Number of normal seeds/fruit	Seed yield per fruit (g)	Seed germination rate (%)
1.	CM 9 x CMa 49	499	0	499	32.5	12.40
2.	CM15 x CMa 49	329	12	317	50.5	69.60
3.	CM 20 x CMa 49	644	43	601	69.5	9.20
4.	CM 25 x Cma 49	24	0	24	1.50	12.65
5.	CM 31 x CMa 49	474	13	461	33.7	11.30
6.	CM 40 x Cma 49	210	3	207	31.0	64.30
7.	CM 41 x Cma 49	343	1	342	36.5	19.50
8.	CM 44 x Cma 49	401	0	401	36.0	71.30
9.	CM 41 x CMa 50	535	2	533	89.0	73.60
10.	CM 31 x CMa 51	478	0	478	79.2	16.30
11.	CM43 x Cma 51	253	0	253	19.0	77.20
12.	CM 15 x Cma 52	236	0	236	71.30	0.00
13.	CM23 x Cma 52	651	53	598	112.5	50.18
14.	CM 28 x Cma 52	375	0	375	49.5	81.60
15.	CM 41 x Cma 52	423	0	423	69.0	0.0
16.	CM 44 x Cma 52	575	0	575	99.5	83.81
	Mean	403.12	7.93	395.18	55.01	37.68
	SEd	28.5	13.7	26.63	32.10	5.13
	CD (0.05)	57.0	27.4	54.25	64.22	10.24

CMo 44 × CMa 52 **CMo 28 × CMa 52**

CMo 43× CMa 51

Fig.1. Seeds of three interspecific hybrid rootstocks

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