

DEVELOPMENT AND CHARACTERIZATION OF INTRASPECIFIC HYBRIDS DERIVED FROM *CUCUMIS MELO* L.

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Abstract

An intraspecific hybridization programme among *Cucumis* species involving eight genetically diverse parents of *C. melo* L. varietal group viz., IC-0599709, Punjab Sunehri, Pusa Madhuras, Kashi Madhu (*C. melo* L.), AHK-119 (*C. melo* var. *callosus*), AHLM-2 (*C. melo* var. *utilissimus*), AHS-82 (*C. melo* var. *momordica*) and Arya-1 (*C. melo* var. *chate*) were undertaken. Among the dessertic F₁ hybrids, IC-0599709 × Punjab Sunehri resulted best with respect to first fruit harvest (73.33 days), fruit weight (938.00 g), fruit diameter (11.90 cm), flesh thickness (3.07 cm), total soluble solids (9.73%) and flesh colour (salmon orange). F₂ population of AHK-119 × Kashi Madhu produced maximum number of marketable fruits per plant (11.2) weighing 350.00 g in 86.1 days. It was also found to be tolerant to high temperature. The F₂ population of AHK-119 × Kashi Madhu were found to be tolerant to high temperature. The existing variability among the parents, intra-specific crosses and segregating generations for fruit (size, shape, colour), yield and quality parameters could be exploited to develop new segregants with desirable traits.

Introduction

Melon (*Cucumis melo* L.) is an economically important annual species cultivated all over the world. Among the genera of the Cucurbitaceae, the *Cucumis* contains two species of great economic importance. *Cucumis melo* L., the muskmelons (2n = 24), and *C. sativus* L., the cucumbers (2n = 14), are widely grown for their edible fruits or seeds in different parts of India. Nearly 40 species of the genus *Cucumis* have been documented (Whitaker and Davis 1962). *C. melo* is extremely variable and comprised of wild and cultivated varieties, the latter including sweet 'dessert' melons, as well as non-sweet forms that are consumed raw, pickled or cooked. The genus *Cucumis* is unique in India as all the species bear edible fruits esteemed for their taste and nutritive value. In India, the main states cultivating melons are Rajasthan, Uttar Pradesh, Bihar, Delhi, Haryana, Punjab and Kerala.

The species *C. melo* is a large polymorphic taxon, encompassing a large number of botanical and horticultural varieties or groups *agrestis*, *cantalupensis*, *inodorus*, *conomon*, *dudaim*, *flexuosus* and *momordica* (Munger and Robinson 1991). Intraspecific hybridization is used to improve crops by transferring desirable horticultural traits (Singh *et al.* 2013) and some specific traits such as pest and stress resistance from wild species to cultivated species (Whitaker and Davis 1962). Great morphological variation exists in fruit characteristics such as size, shape, colour, texture and composition, and *C. melo* is therefore, considered the most diverse species of the genus (Jaffery 1980, Stepansky *et al.* 1999). In India, wide genetic diversity in melons has been reported by Sheshadri and More (2002), Dhillon *et al.* (2007), Choudhary *et al.* (2012) and Malik *et al.* (2014). Melons may be andromonoecious, gynoeocious, gynomonoecious, hermaphrodite or monoecious. Muskmelon is predominantly andromonoecious in sex expression however, monoecious sex form is also found in natural populations (Choudhary *et al.* 2015) which

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could be utilized in hybrid seed production without emasculation. The extensive variation found in *C. melo* and their crossability to each other has led breeders to propose intraspecific hybridization. An exchange of genes between the cultivated sub-species of *C. melo* would open a vast potential resource of variability for commercial exploitation. This group of melons has not been exploited in crop improvement programme despite having several desirable traits (Pandey *et al.* 2010). The creation of variability is pre-requisite for any crop improvement programme. Keeping in view, the intraspecific crosses utilizing eight genetically diverse inbred lines of *C. melo* varietal group were hybridized and evaluated for different horticultural traits.

Therefore, the present study was designed involving commonly cultivated melons in India to determine the potential of F₁ hybrids and segregating generations derived through intraspecific hybridization of the genetically diverse melon groups and selection of high temperature tolerant segregants in subsequent generations.

Materials and Methods

The hybridization experiment comprised of eight diverse inbred lines comprising IC-0599709, Punjab Sunehri, Pusa Madhuras, Kashi Madhu of *C. melo* L., AHK-119 of *C. melo* var. *callosus*, AHLM-2 of *C. melo* var. *utilissimus*, AHS-82 of *C. melo* var. *momordica*, Arya-1 of *C. melo* var. *chate*. Hand pollination was carried out during summer season of 2014 at Research Farm of ICAR-Central Institute for Arid Horticulture, Bikaner, Rajasthan, India located at 28°N latitude, 73°18'E longitude at an altitude of 234.84 m above sea level. Fresh pollen was used for all the combinations and crossing was done during morning hours. The resultant hybrids and parents were evaluated during summer season of 2015 and 2016 in RBD with three replications. The hybrids were self pollinated to derive F₂ populations. The resultant F₂ families were evaluated during summer 2016 without randomization. One hundred plants of each F₂ population were raised and individual F₂ plants have been treated as an identical genotype (family). The soil of experimental field was loamy sand with a pH of 8.7, EC 0.20 dS/m and organic carbon 0.07%. The crop was raised on drip system maintaining row to row distance 2.5 m and plant to plant 0.60 m. Plants were fertilized and sprayed against pests and pathogens according to recommended agronomic practices.

The data were recorded on five randomly selected plants from each replication for days to produce 50% pistillate flowering, node at which first pistillate flower appeared, days to first fruit harvest, fruit weight (g), fruit length (cm), fruit diameter (cm), flesh thickness (cm), number of marketable fruits/ plant and TSS (%). Fruit traits *viz.*, weight, length, diameter and flesh thickness were recorded at marketable stage. Diameter of fruits was measured with the help of Digital Vernier Caliper (MITU-TOYO, 300 mm, 0.01 mm reading capacity). TSS was tested with the help of digital hand Refractometer (ATAGO-Japan) 0 - 53% readability at ripening stage. Sex expression was recorded at full flowering stage and flesh colour at ripening stage. Fruits were tested at tender stage and again at ripening stage for bitterness. The recorded data were statistically analysed using the INDOSTAT statistical package (Indostat Services, Hyderabad). The data of F₁ hybrids were recorded on five randomly selected plants from each replication. In F₂ families, data on each and every plant has been recorded.

Results and Discussion

The data presented on flowering, growth, yield and quality attributes of parents showed significant difference (Table 1). Among the parents, AHS-82 took minimum days to produce 50% pistillate flowering (41.00 days) followed by AHLM-2 (42.33 days) while Punjab Sunehri took maximum time (57.67 days). Node at which first pistillate flower appeared varied from 3.40 (IC-

0599709) to 6.27 (*Arya-1*). AHLM-2 was found to be earliest with respect to first harvesting which took 48.20 days whereas, Punjab Sunehri took maximum time (92.47 days). The maximum fruit weight was recorded in Kashi Madhu (842.47 g) followed by IC-0599709 (826.77 g) whereas, it was minimum in AHK-119 (72.20 g) followed by AHLM-2 (81.63 g). *Arya-1* resulted in maximum fruit length (29.70 cm) and it was minimum in AHK-119 (6.33 cm). Fruit diameter ranged from 2.10 - 11.27 cm being minimum in AHLM-2 and maximum in IC-0599709. The fruits of Pusa Madhuras had highest flesh thickness (2.60 cm) and AHK-119 had lowest (0.87 cm). AHK-119 produced maximum number of marketable fruits per plant (24.27) followed by AHLM-2 (20.33) whereas; it was minimum in Pusa Madhuras (2.47). The maximum TSS was recorded in IC-0599709 (11.30%) and minimum in AHK-119 (2.90%).

Significant difference was observed among the intraspecific F_1 hybrids of *Cucumis melo* group (Table 2). Among the crosses, AHLM-2 \times IC-0599709 took minimum days to produce 50% pistillate flowering (47.67 days) followed by AHLM-2 \times *Arya-1* (49.00 days). AHLM-2 \times *Arya-1* was found to be earliest in first fruit harvest (54.87 days) followed by AHLM-2 \times AHS-82 (55.07 days) and AHLM-2 \times IC-0599709 late in harvesting (84.00 days). The maximum fruit weight was recorded in AHLM-2 \times IC-0599709 (1142.00 g) followed by AHS-82 \times AHLM-2 (979.00 g) whereas, it was minimum in AHLM-2 \times AHS-82 (76.40 g) followed by AHLM-2 \times *Arya-1* (77.00 g). AHS-82 \times AHLM-2 resulted in maximum fruit length (53.80 cm) while it was minimum in IC-0599709 \times Pusa Madhuras (10.43 cm). The cross AHLM-2 \times IC-0599709 had maximum fruit diameter (12.03 cm) followed by IC-0599709 \times Punjab Sunehri (11.90 cm) and AHLM-2 \times AHS-82 had minimum (1.97 cm). Flesh thickness varied from 1.23 cm in AHS-82 \times AHLM-2 and IC-0599709 \times Punjab Sunehri (3.07 cm). The cross, AHK-119 \times Kashi Madhu produced maximum number of marketable fruits per plant (16.40) followed by AHLM-2 \times AHS-82 (10.00) whereas it was minimum in IC-0599709 \times Punjab Sunehri (4.00). The maximum TSS was observed in IC-0599709 \times Pusa Madhuras (11.27%) followed by IC-0599709 \times Punjab Sunehri (9.73%) and minimum in AHK-119 \times Kashi Madhu (6.10%). All evaluated intraspecific F_1 hybrids of *Cucumis* species showed monoecious sex expression. The morphology of the hybrids was generally intermediate between their parental varietal forms. Earlier several researchers observed great variability in melons and characterized the landraces of muskmelon (Sheshadri and More 2002, Choudhary *et al.* 2012), snapmelon (Dhillon *et al.* 2008) and melons (Sheshadri and More 2002, Malik *et al.* 2014).

The fruits of the F_1 hybrids of IC-0599709 \times Punjab Sunehri, IC-0599709 \times Pusa Madhuras, AHK-119 \times Kashi Madhu, AHLM-2 \times IC-0599709, AHS-82 \times AHLM-2 and AHS-82 \times AHK-119 were found bitter at immature stage and become edible at full ripening stage. Among the dessertic F_1 hybrids, IC-0599709 \times Punjab Sunehri resulted best with respect to earliness which took 73.33 days to first fruit harvest, fruit weight (938.00 g), fruit diameter (11.90 cm), flesh thickness (3.07 cm) and salmon orange coloured flesh. F_1 hybrid IC-0599709 \times Pusa Madhuras gave maximum TSS (11.27%) but it was found to be at par with IC-0599709 \times Punjab Sunehri (9.73%). Splitting of fruits at ripening stage was observed in AHLM-2 \times IC-0599709 and AHS-82 \times AHLM-2. AHLM-2 \times AHS-82 and AHLM-2 \times *Arya-1* produced fruits free from bitter principle at tender stage and can be used as salad purpose. The crosses made utilizing *C. melo* var. *utilissimus* \times *C. melo* var. *momordica* and *C. melo* var. *utilissimus* \times *C. melo* var. *chate* resulted in dessertic type fruits which were free from bitter principle at tender stage. The F_1 hybrids derived from *C. melo* var. *callosus* \times *C. melo*, *C. melo* var. *utilissimus* \times *C. melo*, *C. melo* var. *momordica* \times *C. melo* var. *utilissimus* and *C. melo* var. *momordica* \times *C. melo* var. *callosus* produced dessertic type of fruits which were bitter at tender stage and became edible at ripening stage. A very limited study has been made on intraspecific hybridization utilizing different varietal forms of *C. melo* L.

Table 1. Performance of parents used in intra specific hybridization.

Parents	Days to produce 50% pistillate flowering	Node at which first pistillate flower appeared	Days to first fruit harvest	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Flesh thickness (cm)	No. of marketable fruits/plant	TSS (%)	Sex expression
IC-0599709	48.00	3.40	76.07	826.77	10.43	11.27	3.43	3.60	11.30	Monoecious
Punjab Sunehri	57.67	4.47	92.47	646.40	9.23	9.77	2.47	4.00	10.53	Andromonoecious
Pusa Madhuras	50.33	3.87	85.87	692.20	10.84	10.33	2.60	2.47	10.10	"
Kashi Madhu	53.33	4.53	87.53	842.47	9.87	10.66	2.57	2.73	10.69	"
AHK-119	43.00	3.87	81.20	72.20	6.33	4.53	0.87	24.27	2.90	Monoecious
AHLM-2	42.33	7.60	48.20	81.63	27.40	2.10	1.13	20.33	3.60	"
AHS-82	41.00	5.47	76.27	808.67	22.03	7.90	2.07	6.67	4.70	"
<i>Arya-1</i>	45.00	6.27	51.00	109.70	29.70	2.43	1.47	22.67	3.07	"
S.Em±	1.29	0.31	1.87	31.38	1.17	0.29	0.17	1.45	0.25	
LSD (0.05)	3.92	0.93	5.67	95.18	3.56	0.89	0.50	4.39	0.76	
CV (%)	4.70	10.78	4.33	10.66	12.92	6.91	13.78	23.12	6.13	

Table 2. Performance of different intraspecific F₁ hybrids of *Cucumis* species.

Cross combination	Days to produce 50% pistillate flowering	Node at which first pistillate flower appeared	Days to first fruit harvest	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Flesh thickness (cm)	No. of marketable fruits/plant	TSS (%)	Sex expression and other characteristics
IC-0599709 × Punjab Sunehri	51.00	3.89	73.33	938.00	13.20	11.90	3.07	4.00	9.73	Monococious. Bitter at tender stage and edible at ripening stage. Flesh salmon orange.
IC-0599709 × Pusa Madhuras	53.00	3.67	76.27	812.00	10.43	11.43	2.80	3.80	11.27	Monococious. Bitter at tender stage and edible at ripening stage. Flesh salmon orange.
AHK-119 × Kashi Madhu	51.67	3.89	80.07	465.40	27.30	6.73	1.67	16.40	6.10	Monococious. Bitter at tender stage and edible at ripening stage.
AHLM-2 × IC-0599709	47.67	3.67	84.00	1142.00	11.60	12.03	2.00	8.40	7.40	Monococious. Bitter at tender stage and edible at ripening stage. Fruits split at ripening stage.
AHLM-2 × AHS-82	49.33	3.98	55.07	76.40	40.20	1.97	1.60	10.00	7.50	Monococious. Edible at tender stage and fruits split at ripening stage.
AHLM-2 × <i>Arya-1</i>	49.00	3.67	54.87	77.00	37.60	1.98	1.27	7.20	7.70	Monococious. Edible at tender stage.
AHS-82 × AHLM-2	50.33	4.00	74.13	979.00	53.80	7.37	1.23	5.20	6.50	Monococious. Bitter at tender stage and edible at ripening stage. Fruits split at ripening stage.
AHS-82 × AHK-119	42.00	3.67	71.47	321.80	11.50	6.07	1.33	8.00	8.60	Monococious. Bitter at tender stage and edible at ripening stage.
S.Em†	0.81	0.22	2.08	39.92	2.34	0.43	0.15	0.81	0.72	
LSD (0.05)	2.16	NS	6.31	121.08	7.10	1.29	0.46	2.47	2.18	
CV (%)	5.85	10.24	5.06	11.50	15.78	9.90	14.09	17.89	15.38	

Table 3. Variation among F₂ populations derived from different intraspecific hybrids of *Cucumis* species.

Segregating populations	Days to produce 50% pistillate flowering	Node at which pistillate flower appeared	Days to first fruit harvest	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Flesh thickness (cm)	No. of marketable fruits/plant	TSS (%)	Sex expression and other traits
IC-0599709 × Punjab Sunehari	Range	4-6	76-85	850-1380	13.5-17.4	11.6-13.8	1.4-1.7	2-4	11.9-12.8	Monoeocious. Fruits edible at ripening stage and flesh colour is salmon orange.
	Mean	5.0	80.2	1050.2	15.5	12.5	1.5	2.8	12.3	
IC-0599709 × Pusa Madhuras	Range	3-5	72-80	430-750	6.8-11.0	8.2-11.7	2.5-4.0	3-5	8.3-11.9	Andromonoecious. Fruits edible at ripening stage and flesh colour is salmon orange.
	Mean	4.6	76.0	689.8	8.2	9.5	3.4	3.8	10.3	
AHK-119 × Kashi Madhu	Range	3-6	76-90	210-850	7.1-9.4	3.9-8.4	1.5-2.3	7-15	7.8-12.1	Monoeocious. Flesh greenish white. Bitter at tender stage and edible at ripening stage. Late in harvesting. Tolerant to high temperature and drought hardy.
	Mean	4.6	86.1	350.0	8.4	5.4	1.5-2.3	11.2	10.8	
AHLM-2 × IC-0599709	Range	4-6	72-78	500-900	15.2-22	11.3-15.1	2.2-2.5	3-6	8.7-12.2	Monoeocious. Fruits bitter at tender stage and edible at ripening stage.
	Mean	4.3	75.3	726.0	18.2	10.7	3.2	4.0	10.0	
AHLM-2 × AHS-82	Range	3-5	70-81	710-1000	12.6-20.4	7.3-10.7	1.7-2.4	7-11	10-11.9	Monoeocious/ andromonoecious. Fruits bitter at tender stage and edible at ripening stage.
	Mean	4.5	74.0	795.4	16.0	8.6	2.9	10.2	11.2	
AHLM-2 × Arya-1	Range	4-7	68-77	400-890	15.3-22.6	5.9-11.6	1.2-2.3	5-9	9.9-12	Monoeocious. Fruits edible at tender stage.
	Mean	4.3	72.2	656.6	18.6	8.9	3.4	8.6	10.7	
AHS-82 × AHK-119	Range	3-5	72-76	600-910	4.3-8.5	5.2-12.3	1.4-4.2	3-7	8.7-12.6	Monoeocious. Fruits bitter at tender stage and edible at ripening stage.
	Mean	4.5	67.0	804.0	6.5	10.1	3.2	4.8	10.4	

Nath and Dutta (1971) attempted intraspecific crosses among muskmelon, snapmelon and longmelon. Singh *et al.* (2013) reported Vellari (*C. melo* var. *acidulous*) × Tibish melon (*C. melo* var. *tibish*) as the best cross for nutritional quality and maximum consumer preference. Pandey *et al.* (2010) hybridized different varietal form of *C. melo* L. and observed significant heterosis for the number of marketable fruits per plant, and ascorbic acid and carotenoid content in marketable fruits in the hybrid derived from longmelon (*C. melo* var. *utilissimus*) × tibish (*C. melo* var. *tibish*) and longmelon (*C. melo* var. *utilissimus*) × Punjab Wanga (unknown botanical variety).

Considering the existing great variation among the intraspecific crosses of *Cucumis melo* group in fruit (size, shape, colour), yield and quality parameters segregating populations were developed to explore the possibilities of new desirable segregants. Evaluated seven segregating populations of F₂ generations of *Cucumis* species for different horticultural traits and observed wide variability. The mean data and range of flowering, fruit, yield, quality and sex expression have been presented in Table 3. Among the evaluated F₂ populations, AHK-119 × Kashi Madhu produced maximum number of marketable fruits per plant (11.2) weighing 350.00 g however it was late in harvesting (86.1 days). It was also found to be tolerant to high temperature.

The selected generations were advanced through inbreeding to develop inbred lines having desirable traits. Pandey *et al.* (2011) studied the 599 F₂ population derived from an intraspecific cross between Kashi Madhu (*C. melo* L.) and B-159 (*C. melo* var. *momordica*) to establish inter-trait relationship among the traits and developed recombinant inbred lined for QTL mapping for horticultural traits and total soluble solids. The results obtained will further be useful in classification studies of *Cucumis* species.

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