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Research Note

Assessment of genetic variability for intraspecific hybrid derived from muskmelon and Mangalore melon (Arka Siri × SS-17)

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Abstract

Muskmelon (*Cucumis melo* L.) is a globally valued crop, particularly under hot and dry weather. Its nutritional richness and culinary versatility make it a significant horticultural commodity. However, challenges in shelf life motivate genetic enhancements, including cross-breeding with Mangalore melon (culinary melons) known for their extended shelf life. Understanding genetic variability, heritability, and gene action is pivotal for targeted breeding. The F_3 generation of the intraspecific cross Arka Siri x SS-17 was studied for quantitative traits like vine length, fruit attributes, yield parameters, and shelf life. The significant variation observed in fruit yield, average fruit weight, and shelf life within the F_3 families provides a diverse genetic pool from which superior lines can be selected and bred for improved Muskmelon varieties. Traits like vine length, fruit length, and average fruit weight showed strong genetic basis with high heritability and genetic advance and hence could be improved by direct selection. Fruit width and flesh thickness were observed to have a positive correlation with yield. Average fruit weight emerged as a key trait directly impacting yield, guiding breeding strategies. Although shelf life showed negative correlations with some traits, its indirect effect on yield through average fruit weight suggests opportunities for improvement while maintaining or enhancing yield. The study highlights significant genetic variability in the hybrid population, particularly in traits influencing yield and shelf life. This information guides targeted breeding efforts to develop improved muskmelon varieties meeting market demands effectively.

Keywords: Muskmelon, *GCV*, *PCV*, correlation

Muskmelon, scientifically known as *Cucumis melo* L., is a prized horticultural crop cultivated globally. Belonging to the *Cucurbitaceae* family, this eudicot diploid has a chromosome count of 2n = 2X = 24, with a compact genome spanning 375 Mb. Its cultivation spans tropical, subtropical, and temperate zones of the world, thriving in hot, dry climates typical of Indian sub-tropical regions and adaptable to diverse soil types. India stands prominently in muskmelon production, ranking fifth globally with a yield of 1346 million tons and cultivated across 0.69 mha. Uttar Pradesh leads the national production, contributing over 56% of the total output. Musk melon's versatility extends beyond its consumption as a dessert or in blended juices; its immature green fruits find use in culinary dishes, while its juice serves medicinal purposes, aiding skin ailments, freckles, and digestive issues.

Nutritionally rich, muskmelons are packed with vitamins, minerals, and dietary fiber, offering a low-calorie yet highly nutritious choice for health-conscious individuals (Akashi *et al.,* 2002). Notably, the yellow and orange-fleshed varieties are rich in β-carotene and vitamin C, enhancing their appeal as nutritional powerhouses (Chakrabarti, 2001; Pandidurai and Vennila, 2018). Despite its virtues, muskmelon faces challenges in shelf life, typically lasting around 15 days under ambient conditions. This limitation calls for genetic enhancements to prolong shelf life to meet market demands effectively. While the available gene pool offers limited improvements, cross-breeding with Mangalore melon presents a promising avenue due to their genetic compatibility.

Mangalore melon, also known as culinary melons, has an impressive average shelf life of 150 days. Despite being non-dessert types with lower sweetness, their extended shelf life and culinary versatility make them highly valued. The genetic similarity between muskmelon and mangalore melon opens doors for hybridization, aiming to enhance muskmelon's shelf life and overall quality. To achieve these goals, understanding genetic variability, heritability, and gene action is crucial. Estimating phenotypic and genotypic variations, along with conducting path analysis, guides breeders in selecting traits for targeted improvement. The present study was undertaken with a muskmelon x manglorore melon interspecific derivative to gain insights about genetics interaction among different traits, specifically focusing on yield and shelf life.

The research was carried out during the late *Kharif* 2020 at the Department of Biotechnology and Crop Improvement, College of Horticulture, Sirsi, Karnataka, India. This study utilized the F_3 generation of the intraspecific cross Arka Siri x SS-17, derived from muskmelon and Mangalore melon. Seventy families, along with their respective parents, were evaluated in a randomized complete block design (RCBD) with two replications. Plants were grown with a spacing of 60 cm between vines and 2 m between rows. All the suggested agronomic measures were adhered to for producing a healthy crop. Observations on quantitative traits, namely, vine length (cm), days to first harvest, fruit length (cm), fruit width (cm), fruit shape index, average fruit weight (g), number of fruits per vine, hundred seed weight (g), number of seeds per fruit, peduncle length (cm), flesh thickness (cm), TSS (^{0}brix), seed cavity length (cm), seed cavity width (cm), shelf life (days), and fruit yield per vine (g) were recorded on individual vines within the F_3 families, along with their parents. Genetic parameters, including genotypic and phenotypic coefficients of variation (GCV and PCV), heritability, and genetic advance as a percentage of mean, were estimated using formulas proposed by Burton (1952) in Microsoft Excel sodtware. Skewness and kurtosis were determined using STATISTICA software.

The mean of each trait was subjected to analysis of variance as per Panse and Sukhatme (1954). Phenotypic correlation coefficients were estimated according to Singh and Choudhary (2004). Direct and indirect effect of different traits in yield was assessed as per the procedure outlined by Wright (1921); Dewey and Lu (1959)

Analysis of variance for F_3 families of Arka Siri x SS-17 : Assessment of nature and the extent of variation among the lines used for hybridisation is one of the basic approaches for planning effective breeding programmes. The analysis of variance indicated significant variation among the F_3 families for most of the characters studied except for growth parameter *viz.,* nodes at first female flower, days to first male flower, nodes at first male flower and days to first female flower found non-significant variation among the F_3 families (**Table 1**). These results are in accordance with Gichimu *et al.* (2008), Ohashi *et al.* (2009), Babu (2013), Kamagoud *et al.* (2018), Shah *et al.* (2018), Singh and Kandaswamy (2020), Indraja *et al.* (2021), Kalgudi *et al*. (2021) Kumbar *et al.* (2021) and Hiremata *et al.* (2022a).

The F_3 population exhibited significant phenotypic variability across important growth and yield traits, as evidenced by the range and mean values for TSS, Shelf life, average fruit weight, and fruit yield per vine. This variability suggests substantial genetic segregation for these traits, providing a foundation for targeted selection in subsequent generations (Venkatesan *et al.,* 2016).

The PCV values were slightly higher than their corresponding GCV values, which indicates the influence of environment in the expression of trait. High PCV and GCV values were observed for fruit yield per vine (26.69% & 21.18%) and average fruit weight (27.52% & 24.74%) (**Table 2**). Similar observations were reported by Ramana (2000) and Rakhi and Rajamony (2005) in culinary melon and Hiremata *et al.* (2022a) in intraspecific hybrids of muskmelon and mangalore melon for fruit yield, the number of fruits per vine and shelf-life.

Consistent with findings in muskmelon (Singh and Lal, 2005) and cucumber (Reddy and Shanthi, 2013; Choudhary *et al.,* 2011; Hossain *et al.,* 2010; Gaikwad *et al.,* 2011), this study revealed moderate phenotypic and genotypic coefficients of variation (PCV and GCV) for several key traits. Specifically, moderate PCV and GCV values were observed for fruit shape index (15.65% and 12.56%), fruit length (16.74% and 13.94%), seed cavity length (14.87% and 11.00%), hundred seed weight (14.92% and 11.52%), and vine length (19.34% and 18.22%). These observations are also supported by reports in melon for number of branches and node at first female flower appearance (Ramana, 2000), as well as in muskmelon (Singh and Lal, 2005) and cucumber (Kumar *et al.,* 2011).

Traits such as days to the first female flower, days to the first male flower, sex ratio, number of fruits per vine, fruit width, days to harvest, and flesh thickness exhibited lower genotypic and phenotypic coefficients of variation (GCV and PCV). These findings align with results reported in cucumber by Kumar *et al.* (2011) and in pointed gourd by Khan *et al.* (2009). The lower GCV and PCV values suggest limited genetic variability for these traits, which may necessitate the use of indirect selection strategies for their improvement.

Table 1. Analysis of mean sum of square values for F3 population of Arka Siri × SS-17 cross.

S. No	Sources of variation	Replication	Families	Error	CD @ 5%	CD @ 1%
	Degrees of freedom	**1**	**64**	0	0	0
1	Days to first male flower	0.34	0.54	0.49	1.40	1.86
2	Days to first female flower	1.71	0.62	0.48	1.38	1.83
3	Node at first male flowers	0.06	0.05	0.10	0.62	0.83
4	Node at first female flowers	0.20	0.05	0.08	0.57	0.75
5	Sex ratio (%)	0.46	0.90*	0.58	1.53	2.03
6	Vine length (cm)	1110.77	2534.38*	151.13	24.56	32.64
7	Number of branches	0.19	0.38*	0.08	0.55	0.73
8	Days to harvest	19.15*	6.41*	2.09	2.89	3.84
9	Fruit length (cm)	0.17	5.77*	1.05	2.04	2.72
10	Fruit width (cm)	0.01	1.24*	0.35	1.18	1.56
11	Fruit shape Index	0.01	0.06*	0.01	0.22	0.30
12	Average fruit weight (g)	12288.02	46742.94*	4995.33	141.19	187.64
13	Number of fruits per vine	0.44*	0.08*	0.04	0.42	0.56
14	Hundred seed weight (g)	0.20	0.19*	0.05	0.43	0.58
15	Number of seeds per fruit	3105.64	6318.73*	2401.15	97.89	130.09
16	Peduncle length (cm)	0.01	0.16*	0.07	0.52	0.69
17	Flesh thickness (cm)	0.00	0.1*	0.03	0.34	0.45
18	TSS (obrix)	0.69	0.98*	0.26	1.01	1.35
19	Seed cavity length (cm)	3.33*	1.80*	0.49	1.40	1.87
20	Seed cavity width (cm)	0.05	0.50*	0.16	0.80	1.07
21	Shelf life (days)	254.52	123.92*	64.55	16.05	21.33
22	Fruit yield per vine (g)	136851.39	454788.38*	103295.51	642.06	853.26

Table 2. Estimates of genetic parameters for growth and yield traits in F3 generation of Arka Siri × SS-17

S. No	Character	Mean ± S.Em	Range		PCV (%)	GCV (%)	h^2 (%)	GAM (%)
			Min	Max				
1	Days to first male flower	28.01±0.50	26.70	29.00	2.57	0.57	4.85	0.26
2	Days to first female flower	32.50±0.49	31.00	33.90	2.28	0.83	13.13	0.62
3	Node at first male flowers	1.54±0.22	1.00	1.95	7.77	4.28	28.66	10.49
4	Node at first female flowers	3.55±0.20	3.00	3.90	7.16	4.15	24.22	3.57
5	Sex ratio (%)	9.61±0.54	4.75	10.79	8.96	4.15	21.42	3.96
6	Vine length (cm)	189.45±8.69	106.20	315.20	19.34	18.22	88.74	35.36
7	Number of branches	3.94±0.19	3.10	5.30	12.18	9.98	67.23	16.86
8	Days to first harvest	76.04±1.02	71.20	81.50	2.71	1.93	50.77	2.84
9	Fruit length(cm)	11.03±0.72	6.56	16.12	16.74	13.94	69.29	23.97
10	Fruit width(cm)	9.25±0.42	7.32	10.91	9.62	7.20	56.13	11.12
11	Fruit shape Index	1.19±0.08	0.64	1.60	15.65	12.56	64.40	20.76
12	Average fruit weight (g)	583.93±49.98	305.40	1011.30	27.54	24.74	80.69	45.78
13	Number of fruits per vine	3.73±0.15	3.00	4.10	6.70	3.59	28.81	3.97
14	Hundred seed weight (g)	2.29±0.15	1.27	2.78	14.92	11.52	59.66	18.34
15	Number of seeds per fruit	323.78±34.65	200.80	454.20	20.39	13.67	44.93	18.87
16	Peduncle length (cm)	2.50±0.18	2.04	3.16	13.51	8.69	41.34	11.51
17	Flesh thickness (cm)	2.73±0.12	2.11	3.26	9.49	7.14	56.65	11.08
18	TSS (obrix)	6.07±0.36	4.47	8.15	11.93	9.87	58.21	15.51
19	Seed cavity length (cm)	7.34±0.50	4.04	9.42	14.59	11.00	56.91	17.10
20	Seed cavity width (cm)	4.98±0.28	4.07	6.47	11.58	8.30	51.35	12.25
21	Shelf life (days)	31.78±5.68	12.30	49.90	30.55	17.14	31.50	19.82
22	Fruit yield per vine (g)	1979.55±227.26	1202.90	3054.30	26.69	21.18	62.98	34.62

In general, the study of GCV and PCV reveals the extent of variation present for various characters prevailing in the hybrids and it does not give any idea about how much of the existing variation is heritable to the next generation. To avail the knowledge regarding the heritable portion of the variation, it is essential to know the heritability estimates of different attributes. Among the characters under study, vine length (88.74%), fruit shape index (64.40%), fruit length (69.29%), number of primary branches (67.23%), fruit yield per vine (62.98%), and average fruit weight (80.69%) had higher estimates of heritability accompanied by high genetic advance (**Table 2**). This may be attributed to the additive gene action. The F_2 population of Arka Siri x SS-17 cross also found the same pattern of heritability and genetic advance for the above traits (Hiremata *et al.,* 2022). It indicates that direct selection may be possible considering these traits for yield improvement. These results validate previous findings by Kalloo and Dixit (1983) in melon accessions for fruit length and width, Vijay (1987) for number of fruits per vine, Rakhi and Rajamony (2005) in culinary melon for fruit length and average fruit weight, and Tomar *et al.* (2008) for fruit weight. Moderate heritability with moderate genetic advance was observed for fruit width (56.13%), hundred seed weight (59.66%), number of seeds per fruit (44.93%), peduncle length (41.34%), days to first harvest (50.77%), flesh thickness (56.65%), TSS (58.21%), seed cavity length (56.91%), seed cavity width (51.35%) and shelf-life (31.50%). Lower heritability and genetic advance were observed in days to first male flower (4.85%), days to first female flower (13.13%), sex ratio (21.42%), node at first female flowers appears (24.22%), node at first male flowers appears (28.66%) and number of fruits per vine (28.81%) this may be due to higher environmental influence. It indicates less scope for improvement of melon through selection of these characters. These results are in confirmation with the findings of Reddy and Shanthi, (2013) and Mehta *et al*. (2009) in muskmelon, Hiremata *et al.* (2022a) in intraspecific hybrids of muskmelon and mangalore melon.

Correlation coefficient studies : The magnitude as well the direction of the association among the various traits provides important information in bringing a desired improvement in the fruit yield of the crop. Consistent with observations in the F_2 generation by Hiremata *et al.* (2022b), the F_3 population in the present study exhibited highly positive and significant associations with fruit yield per vine. Specifically, significant positive correlations were observed for average fruit weight (0.947), fruit width (0.724), fruit length (0.669), flesh thickness (0.591), seed cavity width (0.517), seed cavity length (0.435), days to first harvest (0.363), TSS (0.266), fruit shape index (0.216), shelf-life (0.171), and hundred seed weight (0.156). Conversely, a significant negative association was found between vine length and fruit yield per vine (-0.146). (**Table 3**). The observed improvements in key traits across generations suggest promising potential for selection in future breeding efforts. In the F_3 generation, fruit yield demonstrated significant associations with most

Table 3. Phenotypic correlation coefficients among fruit yield & its components in F3 generation of cross Arka Siri × SS-17 (N= 62 families)

Traits	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	X1
X1	-0.058	0.011	0.031	-0.038	0.057	-0.033	0.052	**0.166***	-0.018	0.101	0.075	0.017	0.109	-0.105	0.037
X2	1.000	-0.029	-0.109	**-0.159***	0.007	-0.111	-0.020	0.050	0.042	0.114	0.104	0.061	-0.026	-0.007	**-0.146***
X3		1.000	0.205	0.065	**0.206****	**0.274****	0.115	**0.195****	0.003	**0.294****	**0.394****	-0.038	**0.172***	0.027	**0.363***
X4			1.000	**0.589****	**0.720****	**0.697****	**-0.139***	0.020	0.054	**0.582****	0.111	**0.681****	**0.524****	0.084	**0.669****
X5				1.000	-0.131	**0.795****	-0.109	0.034	0.048	**0.478****	0.113	**0.392****	**0.407****	0.130	**0.724****
X6					1.000	**0.188****	-0.086	-0.010	0.026	**0.305****	0.245**	**0.504****	**0.307****	0.002	**0.216****
X7						1.000	-0.049	0.125	0.033	**0.598****	**0.221****	**0.499****	**0.534****	0.207	**0.947****
X8							1.000	0.015	0.022	0.035	**0.263****	-0.068	-0.052	-0.099	0.008
X9								1.000	-0.112	**0.173***	**0.142***	0.030	**0.165***	0.034	**0.156**
X10									1.000	-0.033	0.047	**0.194****	**0.153***	0.008	-0.020
X11										1.000	0.107	**0.421****	**0.319****	0.039	**0.591****
X12											1.000	**-0.248****	-0.055	-0.087	**0.266****
X13												1.000	**0.657****	0.129	**0.435****
X14													1.000	0.151	**0.517****
X15														1.000	**0.171**

*** Significant at P=0.05 and P=0.01 respectively

X1 -Sex ratio (%), X2- Vine Length (cm), X3- Days to first harvest, X4- Fruit length (cm), X5- fruit width (cm), X6- Fruit shape index, X7- Average Fruit weight (g), X8- Number of fruits /vine, X9- 100 seed weight(g), X10- Number of seeds/fruit, X11- Flesh thickness (cm), X12- TSS (oBrix), X13- Seed cavity length (cm), X14- Seed cavity width (cm), X15 – Shelf life (days) , X16 -Fruit yield per vine (g).

Table 4. Genotypic direct (diagonal) and indirect effects of different quantitative traits in F3 generation of cross Arka Siri × SS-17.

Traits	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13	X14	X15	„r" with yield
X1	**0.057**	0.002	0.001	-0.016	-0.014	0.026	-0.030	0.002	0.002	0.001	0.001	0.001	-0.001	0.003	0.001	0.037
X2	-0.003	**-0.035**	-0.002	0.055	-0.057	0.003	-0.100	-0.001	0.001	-0.002	0.001	-0.002	-0.003	-0.001	0.000	**-0.146***
X3	0.001	0.001	**0.076**	-0.103	0.023	0.094	0.248	0.005	0.002	0.000	0.004	0.006	0.002	0.005	0.000	**0.363***
X4	0.002	0.004	0.016	**-0.501**	0.212	0.329	0.632	-0.006	0.000	-0.002	0.007	-0.002	-0.035	0.015	-0.001	**0.669****
X5	-0.002	0.006	0.005	-0.296	**0.360**	-0.060	0.720	-0.005	0.000	-0.002	0.006	0.002	-0.020	0.011	-0.001	**0.724****
X6	0.003	0.000	0.016	-0.361	-0.047	**0.457**	0.171	-0.004	0.000	-0.001	0.004	-0.004	-0.026	0.009	0.000	**0.216****
X7	-0.002	0.004	0.021	-0.349	0.286	0.086	**0.906**	-0.002	0.001	-0.001	0.007	0.003	-0.025	0.015	-0.002	**0.947****
X8	0.003	0.001	0.009	0.070	-0.039	-0.039	-0.044	**0.042**	0.000	-0.001	0.000	0.004	0.003	-0.001	0.001	0.008
X9	0.009	-0.002	0.015	-0.010	0.012	-0.005	0.113	0.001	**0.011**	0.005	0.002	0.002	-0.002	0.005	0.000	**0.156**
X10	-0.001	-0.001	0.000	-0.027	0.017	0.012	0.030	0.001	-0.001	**-0.042**	0.000	-0.001	-0.010	0.004	0.000	-0.020
X11	0.006	-0.004	0.022	-0.292	0.172	0.140	0.542	0.001	0.002	0.001	**0.012**	0.002	-0.021	0.009	0.000	**0.591****
X12	0.004	0.004	0.030	0.056	0.041	-0.112	0.201	0.011	0.002	0.002	0.001	**0.015**	0.013	-0.002	0.001	**0.266****
X13	0.001	-0.002	-0.003	-0.342	0.141	0.231	0.452	-0.003	0.000	-0.008	0.005	-0.004	**-0.051**	0.018	-0.001	**0.435****
X14	0.006	0.001	0.013	-0.263	0.147	0.140	0.484	-0.002	0.002	-0.006	0.004	-0.001	-0.033	**0.028**	-0.002	**0.517****
X15	-0.006	0.000	0.002	-0.042	0.047	0.001	0.188	-0.004	0.000	0.000	0.000	-0.001	-0.007	0.004	**-0.012**	**0.171**

Residual effect 0.07896

X1 -Sex ratio (%), X2- Vine Length (cm), X3- Days to first harvest, X4- Fruit length (cm), X5- fruit width (cm), X6- Fruit shape index, X7- Average Fruit weight (g), X8- Number of fruits/vine, X9- 100 seed weight(g), X10- Number of seeds/fruit, X11- Flesh thickness (cm), X12- TSS (oBrix), X13- Seed cavity length (cm), X14- Seed cavity width (cm), X15 – Shelf life (days), X16 -Fruit yield per vine (g).

measured traits, with the notable exceptions of number of fruits per vine (0.008), sex ratio (0.037), and number of seeds per fruit (-0.020). These non-significant associations may be attributed to environmental interactions during the cropping season, a phenomenon supported by comparable results in oriental pickled melon, muskmelon, and cucumber reported by Ramana (2000), Singh and Lal (2005), Rukam *et al.* (2008), Hanchinamani and Patil (2009), Choudhary *et al.* (2011), Reddy and Shanthi, (2013), Vijay (1987), and Reddy *et al.* (2017).

Furthermore, the consistent improvement in shelf life across generations is a positive indicator for developing muskmelon lines with enhanced post-harvest longevity. The fruit shape index also emerges as a crucial trait, exhibiting highly significant associations with average fruit weight (0.188), flesh thickness (0.305), seed cavity length (0.504), and seed cavity width (0.307). Notably, it also showed a positive association with shelf life (0.002), suggesting that the fruit shape index can be a valuable selection criterion for developing muskmelon lines with improved shelf life (Shet *et al.,* 2022; Hiremata *et al.,* 2022b).

Path Analysis: Fruit shape index (0.457), fruit width (0.360), sex ratio (0.057), number of fruits per vine (0.042), seed cavity width (0.028), TSS (0.015), flesh thickness (0.012), and hundred seed weight (0.011) were the next highest positive direct effects on fruit yield per vine (0.906). Negative direct effects included fruit length (-0.501), days to first harvest (-0.076), length of seed cavity (-0.051), quantity of seeds per fruit (-0.042), vine length (-0.035), and shelf-life (-0.012) (**Table 4**). Results from Choudhary *et al.* (2019), Singh and Lal (2005), and Rukam *et al.* (2008) in musk melon also showed similar outcomes. Low direct effect and negative shelf-life were observed (-0.12). Average fruit weight (0.193) exerted a moderate indirect effect, contributing to its strong positive correlation with yield (0.171). This suggests that selecting fruit production with shelf life provides a minimal advantage over generations. These findings are consistent with previous research on muskmelon, including studies by Reddy *et al.* (2017) for flesh thickness, Karadi *et al.* (2016b) for cavity width, and Priyanka and Moond (2020) for seed cavity width and TSS. The residual effect in the F_3 generation of Arka Siri × SS-17 was low (0.079), indicating that 92% of the variation in yield was explained by the studied yield-associated components in this investigation.

Thus the study indicated that significant variation existed among the F_3 families, especially for fruit yield, average fruit weight, and shelf life, offering breeding potential. Traits like vine length, fruit length, and average fruit weight displayed strong genetic bases for direct selection, aiding yield improvement. Positive correlations with yield were found for traits like fruit width and flesh thickness. Average fruit weight was observed to significantly influence yield directly, guiding breeding strategies. Despite some negative correlation, shelf life indirectly impacted yield through average fruit weight, suggesting opportunities for enhancing both traits.

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