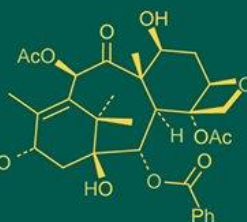
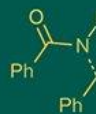
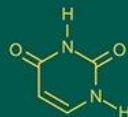
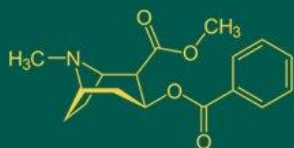


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(7): 723-727
www.biochemjournal.com
Received: 11-05-2026
Accepted: 15-06-2026

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Assessment of genetic variability for yield and fruit quality traits in F₅ melon lines derived from intraspecific hybridization

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i7Si.9089>

Abstract

The present investigation was conducted during Rabi 2025 at the College of Horticulture, Bagalkot, Karnataka, to assess genetic variability, heritability and genetic advance among 26 F₅ melon (*Cucumis melo* L.) lines derived from hybridization between *C. melo* ssp. *agrestis* and *C. melo* ssp. *melo*, along with their parents and F₁ hybrid. The experiment was laid out in a Randomized Complete Block Design with two replications. Analysis of variance revealed significant differences among genotypes for all traits except number of primary branches, indicating substantial genetic variability. Wide variation was observed for shelf life, individual fruit weight, fruit length, beta-carotene content and fruit yield per plant. High PCV and GCV were recorded for shelf life, individual fruit weight, fruit length, pulp thickness, total soluble solids and beta-carotene content. High heritability coupled with high genetic advance was observed for fruit length, fruit diameter, pulp thickness, seed cavity diameter, individual fruit weight, shelf life, total soluble solids, beta-carotene content and ascorbic acid content, indicating the predominance of additive gene action. The results suggest that these traits can be effectively improved through phenotypic selection. The superior recombinants identified in the present study may serve as valuable genetic resources for developing high-yielding melon cultivars with improved fruit quality and extended shelf life.

Keywords: *Cucumis melo*, genetic variability, heritability, genetic advance, F₅ lines, shelf life, fruit quality

1. Introduction

Cucurbits belonging to the family Cucurbitaceae and the genus *Cucumis* represent one of the largest groups of vegetable crops exhibiting wide diversity in fruit morphology and quality traits. Although East Africa was initially considered the primary centre of origin for melons (Pitrat *et al.*, 2000) [1], subsequent diversity studies suggested Asia as the probable centre of origin (Sebastian *et al.*, 2010) [2]. *Cucumis melo* L. (2n = 24) exhibits remarkable genetic diversity and polymorphism compared to other species of the genus (Pitrat *et al.*, 2000). [1] The species displays extensive variability in fruit size, shape, colour, texture, taste and biochemical composition (Bates, 1995) [5]. Cultivated forms include sweet dessert melons and non-sweet types consumed fresh or cooked. *Cucumis melo* can be divided into two major subspecies, *melo* and *agrestis* (Jeffrey, 1980) [4], based on the pubescence of the female hypanthium. In subspecies *melo*, ovaries are pilose or lanate with long spreading trichomes, whereas in subspecies *agrestis*, ovaries are sericeous with appressed short trichomes (Kirkbride, 1993) [3].

In India, melons are cultivated over an area of about 54,100 ha with a production of 12.3 MT and productivity of 22.74 t/ha (Anon., 2021) [6]. Despite their economic importance, muskmelon cultivation faces several production constraints including susceptibility to pests and diseases, poor shelf life and rapid post-harvest deterioration. Most commercial cultivars are climacteric in nature and possess limited keeping quality, resulting in reduced marketability.

Exploitation of genetic variability is fundamental for crop improvement programmes. Hybridization between diverse melon groups offers an excellent opportunity for combining desirable traits such as yield, shelf life and fruit quality. Estimation of variability parameters including genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (H^2_{bs}) and genetic advance as per cent mean (GAM) helps breeders understand the inheritance pattern of economically important traits and aids in effective selection (Burton, 1952) ^[21]. Therefore, the present study was undertaken to estimate the extent of variability, heritability and genetic advance as per cent mean among advanced F_5 melon lines derived from inter-specific hybridization.

2. Materials and Methods

2.1 Experimental Site and Plant Material

The experiment was conducted during Rabi 2025 at the College of Horticulture, Bagalkot, Karnataka. The experimental material consisted of 26 F_5 breeding lines developed from inter-specific hybridization between *Cucumis melo* ssp. *agrestis* and *Cucumis melo* ssp. *melo*, along with the parental lines and F_1 hybrid. The female parent, *Cucumis melo* ssp. *agrestis*, is a locally cultivated type widely grown in Karnataka and commonly used as salad and vegetable. It is characterized by low beta-carotene content and poor shelf life. The male parent, *Cucumis melo* ssp. *melo*, possesses oval to ellipsoid fruits with smooth rind and dark green stripes. Hybridization was carried out between the two subspecies to combine superior quality and yield traits. The F_1 plants were selfed and advanced through continuous selfing and selection up to the F_5 generation to stabilize desirable recombinants. The experiment was laid out in Randomized Complete Block Design (RCBD) with two replications following recommended agronomic practices.

2.2 Observations Recorded

Observations were recorded for vine length at 45 days (m), vine length at harvest (m), days to first male flower, days to first female flower, node at first female flower appearance, number of male flowers, number of female flowers, sex ratio, days to first fruit harvest, number of fruits per plant, fruit length (cm), fruit diameter (cm), pulp thickness (cm), seed cavity diameter (cm), individual fruit weight (kg), shelf life (days), moisture content (%), total soluble solids ($^{\circ}$ brix), beta carotene (mg/100 g), ascorbic acid (mg/100 g) and fruit yield per plant (kg).

2.3 Statistical Analysis

Analysis of variance (ANOVA) was performed to test the significance of differences among genotypes. Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were estimated according to Burton and Devane (1953) ^[21]. Broad-sense heritability (H^2_{bs}) and genetic advance as per cent mean (GAM) were calculated following the methods suggested by Allard (1960) ^[20].

3. Results and Discussion

3.1 Genetic variability among advanced F_5 melon lines

Analysis of variance revealed significant differences among the genotypes for all the characters studied except for number of primary branches, indicating the presence of considerable genetic variation in the experimental material

(Table 1). The mean performance, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (H^2_{bs}) and genetic advance as per cent of mean (GAM) are presented in Table 2. The observed variability provides ample scope for effective selection and the identification of superior advanced lines for yield and quality improvement. Traits exhibiting a wider range of variation may be given greater emphasis during selection, as they offer better opportunities for genetic enhancement.

Vine length at 45 days ranged from 1.02 to 1.75 m with a mean value of 1.43 m, whereas vine length at harvest varied from 1.99 to 2.84 m with a mean of 2.44 m. Internodal length exhibited considerable variation ranging from 4.30 to 12.90 cm with an average of 9.07 cm. The number of primary branches ranged from 1.80 to 3.55 with a mean value of 2.44. Earliness-related traits also exhibited appreciable variation. Days to first male flower ranged from 33.02 to 46.30 days with a mean of 41.19 days, while days to first female flower varied from 41.70 to 56.10 days with a mean of 49.56 days. The node at first female flower appearance ranged from 5.00 to 8.00 with an average value of 6.57, indicating the existence of variability for flowering behaviour among the advanced lines. The number of male flowers per vine ranged from 62.75 to 98.70 with a mean value of 83.42, whereas the number of female flowers varied from 4.81 to 15.51 with an average of 9.75. Sex ratio exhibited a wide range from 4.42 to 16.50 with a mean value of 8.94, indicating substantial diversity for reproductive traits. Days to first fruit harvest ranged from 81.40 to 89.20 days with a mean value of 85.27 days. The number of fruits per vine varied from 3 to 8 with an average of 4.91 fruits per vine, suggesting considerable variation for yield components among the genotypes. Fruit length exhibited a broad range from 5.55 to 31.10 cm with a mean of 18.43 cm, while fruit diameter ranged from 5.17 to 11.24 cm with an average value of 8.21 cm. Pulp thickness varied between 1.15 and 3.95 cm with a mean of 2.28 cm, whereas seed cavity diameter ranged from 1.72 to 5.41 cm with a mean value of 3.71 cm. Individual fruit weight ranged from 0.11 to 1.31 kg with an average of 0.60 kg. Shelf life exhibited substantial variation ranging from 15 to 95 days with a mean value of 49.66 days, indicating the successful generation of variability for post-harvest keeping quality through inter-specific hybridization (Table 2).

Quality traits also showed considerable variation. Moisture content ranged from 85.10 to 92.90 per cent with a mean of 88.95 per cent, while total soluble solids varied from 2.00 to 5.80 $^{\circ}$ Brix with an average value of 3.81 $^{\circ}$ Brix. Beta-carotene content ranged from 0.03 to 0.34 mg/100g with a mean of 0.15 mg/100g, whereas ascorbic acid content varied from 3.75 to 8.95 mg/100g with an average of 6.15 mg/100g (Table 2).

The wide range observed for shelf life (15-95 days), individual fruit weight (0.11-1.31 kg), fruit length (5.55-31.10 cm), beta-carotene content (0.03-0.34 mg/100g), sex ratio (4.42-16.50) and number of female flowers (4.81-15.51) indicates the presence of substantial variability among the advanced melon lines. Such variability provides considerable scope for the selection of superior recombinants possessing desirable combinations of yield, quality and shelf-life traits for future melon breeding programmes. Similar variability among advanced breeding lines has been reported in melon and other vegetable crops

by Sahana *et al.* (2020), Pathak *et al.* (2024), Tabassum *et al.* (2024), Liu *et al.* (2025), and Prapthi *et al.* (2025)^[7, 8, 11, 10, 9].

3.2 Phenotypic and Genotypic Coefficients of Variation

To determine the relative contribution of genetic and environmental factors to trait expression, the observed phenotypic variability was partitioned into its heritable and environmental components. The estimates of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) are presented in Table 2. The PCV values were higher than the corresponding GCV values for all the characters studied. However, the differences between PCV and GCV were generally narrow, indicating a relatively low environmental influence on the expression of these traits and suggesting that the observed variability was predominantly under genetic control.

The phenotypic coefficient of variation ranged from 1.98% for moisture content to 50.13% for shelf life. High PCV values were recorded for shelf life (50.13%), individual fruit weight (45.87%), fruit length (28.67%), pulp thickness (26.03%), total soluble solids (24.89%), sex ratio (24.58%), beta-carotene content (24.55%), seed cavity diameter (23.28%), ascorbic acid content (22.37%) and number of female flowers (20.47%). Moderate PCV values were observed for internodal length (19.81%), number of fruits per vine (17.74%), number of primary branches (17.26%), fruit diameter (17.14%), node at first female flower appearance (13.28%), vine length at 45 days (10.74%) and number of male flowers (10.98%). Relatively lower PCV values were recorded for days to first male flower (8.04%), days to first female flower (7.65%), vine length at harvest (7.21%), days to first fruit harvest (2.29%) and moisture content (1.98%).

Similarly, the genotypic coefficient of variation ranged from 1.36% for moisture content to 49.75% for shelf life. High GCV values were observed for shelf life (49.75%), individual fruit weight (45.50%), fruit length (28.45%), pulp thickness (25.96%), total soluble solids (24.72%), beta-carotene content (24.20%), seed cavity diameter (23.24%), ascorbic acid content (22.08%) and sex ratio (21.46%). Moderate GCV values were recorded for number of female flowers (17.65%), internodal length (17.35%), fruit diameter (17.12%), number of primary branches (14.25%), number of male flowers (10.82%) and number of fruits per vine (10.02%). Lower GCV values were observed for vine length at 45 days (9.88%), node at first female flower appearance (9.84%), days to first male flower (7.61%), days to first female flower (7.36%), vine length at harvest (6.15%), days to first fruit harvest (1.86%) and moisture content (1.36%).

The highest phenotypic and genotypic coefficients of variation were observed for shelf life (50.13% and 49.75%, respectively), followed by individual fruit weight (45.87% and 45.50%), indicating substantial variability for these economically important characters. The lowest PCV and GCV values were recorded for moisture content (1.98% and 1.36%, respectively), followed by days to first fruit harvest (2.29% and 1.86%), suggesting limited variability for these traits. Comparatively wider differences between PCV and GCV estimates were observed for number of fruits per vine, node at first female flower appearance and number of primary branches, indicating greater environmental influence on their expression, whereas the narrow differences observed for most other characters suggested

predominance of genetic control and effectiveness of selection for their improvement. Similar findings of high PCV and GCV for yield and quality-related traits and comparatively narrow differences between PCV and GCV estimates for most characters were reported by Gaikwad *et al.* (2021)^[12] and Pramitha *et al.* (2024)^[13] in muskmelon and by Rai *et al.* (2025)^[14] and Srinivasulu *et al.* (2025)^[15] in other cucurbit crops. The predominance of genetic variation over environmental influence for several economically important traits suggests good scope for effective selection and genetic improvement.

3.3 Heritability and genetic advance as percent mean

An estimate of heritability provides a measure of the effectiveness of selection for a particular character. As evident from Table 2, heritability estimates ranged from 31.93% for number of fruits per vine to 99.86% for fruit diameter, indicating moderate to high heritability for all the traits studied. High heritability estimates were observed for vine length at 45 days (84.68%), vine length at harvest (72.78%), internodal length (76.65%), number of primary branches (68.16%), days to first male flower (89.45%), days to first female flower (92.62%), number of male flowers (97.03%), number of female flowers (74.36%), sex ratio (76.24%), days to first fruit harvest (65.71%), fruit length (98.48%), fruit diameter (99.86%), pulp thickness (99.43%), seed cavity diameter (99.67%), individual fruit weight (98.37%), shelf life (98.46%), total soluble solids (98.60%), beta-carotene content (98.37%) and ascorbic acid content (97.35%), while moderate heritability estimates were recorded for node at first female flower appearance (54.89%), moisture content (47.13%) and number of fruits per vine (31.93%). The predominance of high heritability values for most traits indicates that genetic factors played a major role in the expression of these characters and that selection based on phenotypic performance would be effective.

The heritable component of variation can be assessed more accurately when heritability is considered together with genetic advance. Johnson *et al.* (1955)^[19] suggested that heritability coupled with genetic advance is more useful than heritability alone in predicting the effectiveness of selection. In the present investigation, the highest genetic advance as per cent of mean was observed for shelf life (101.69%), followed by individual fruit weight (92.96%), beta-carotene content (86.23%), fruit length (58.16%), pulp thickness (53.32%), total soluble solids (50.56%), seed cavity diameter (47.80%), ascorbic acid content (44.87%), sex ratio (38.60%), fruit diameter (35.25%), number of female flowers (31.36%), internodal length (31.29%), number of primary branches (24.23%) and number of male flowers (21.96%), whereas the lowest genetic advance was recorded for moisture content (1.92%) followed by days to first fruit harvest (3.10%).

It is evident from the present study that internodal length, number of primary branches, number of male flowers, number of female flowers, sex ratio, fruit length, fruit diameter, pulp thickness, seed cavity diameter, individual fruit weight, shelf life, total soluble solids, beta-carotene content and ascorbic acid content exhibited high heritability coupled with high genetic advance. Such a combination indicates the predominance of additive gene action and suggests that these traits can be effectively improved through simple phenotypic selection. Similar findings of

high heritability coupled with high genetic advance for fruit weight, fruit length, fruit diameter, total soluble solids and other yield and quality traits have been reported in muskmelon and related cucurbit crops by Pramitha *et al.* (2024)^[13], Pooja *et al.* (2024)^[18], Hiremata *et al.* (2025)^[17], Rai *et al.* (2025)^[14], Srinivasulu *et al.* (2025)^[15] and Tinkie *et al.* (2025)^[16].

Vine length at 45 days, vine length at harvest, days to first male flower and days to first female flower exhibited high heritability coupled with moderate genetic advance, indicating the involvement of both additive and non-additive gene effects in the inheritance of these traits. Node at first female flower appearance exhibited moderate heritability coupled with moderate genetic advance, suggesting the operation of both additive and non-additive gene action.

Days to first fruit harvest showed high heritability coupled with low genetic advance, indicating the predominance of non-additive gene effects. Similarly, moisture content

exhibited moderate heritability coupled with low genetic advance, suggesting greater environmental influence and non-additive gene action in the expression of this trait. Number of fruits per vine recorded moderate heritability and moderate genetic advance, indicating that improvement through selection is possible, although the expected response may be comparatively lower than that of traits exhibiting high heritability coupled with high genetic advance.

The present findings indicate that traits such as shelf life, individual fruit weight, beta-carotene content, fruit length, pulp thickness, seed cavity diameter, fruit diameter, total soluble solids and ascorbic acid content possess substantial scope for genetic improvement owing to their high heritability and genetic advance. These traits may therefore be considered as important selection criteria in melon breeding programmes aimed at improving fruit yield, quality and shelf-life attributes.

Table 1: Analysis of variance for growth, yield and quality traits in the F₅ lines, parents and F₁ hybrid

Sl. No.	Traits	MSS (Replication)	MSS (Treatment)	Error	S.Em	SE.d
1	Vine length at 45 days (m)	0.014	0.044**	0.004	0.043	0.060
2	Vine length at harvest (m)	0.016	0.054**	0.008	0.065	0.092
3	Internodal length (cm)	4.751	5.704**	0.754	0.614	0.868
4	Number of primary branches	0.028	0.299 NS	0.057	0.168	0.238
5	Days to first male flower	4.142	20.793**	1.159	0.761	1.076
6	Days to first female flower	8.345	27.691**	1.062	0.729	1.030
7	Node at first female flower appears	0.319	1.178**	0.343	0.414	0.586
8	Number of male flowers	12.906	165.409**	2.490	1.116	1.578
9	Number of female flowers	0.155	6.951**	1.022	0.715	1.011
10	Sex ratio	0.944	8.502**	1.146	0.757	1.071
11	Days to first fruit harvest (days)	3.321	6.338**	1.311	0.810	1.145
12	Number of fruits per vine	0.017	1.003*	0.517	0.509	0.719
13	Fruit length (cm)	0.006	55.419**	0.424	0.460	0.651
14	Fruit diameter (cm)	0.011	3.957**	0.003	0.037	0.052
15	Pulp thickness (cm)	0.083	0.704**	0.002	0.032	0.045
16	Seed cavity (cm)	0.202	1.488**	0.003	0.035	0.050
17	Individual fruit weight (kg)	0.008	0.149**	0.001	0.025	0.035
18	Shelf life (days)	8.345	1229.861**	9.523	2.182	3.086
19	Moisture content (%)	0.011	4.542**	1.632	0.903	1.278
20	Total soluble solids (°B)	0.062	1.785**	0.013	0.079	0.112
21	Beta carotene (mg/100g)	0.001	0.008**	0.000	0.006	0.008
22	Ascorbic acid (mg/100g)	0.262	3.731**	0.050	0.158	0.224
23	Fruit yield per plant (kg)	0.008	2.839**	0.165	0.287	0.406

* and ** indicates significance of values at P=0.05 and P=0.01, respectively

Table 2: Estimation of genetic variability parameters in the F₅ lines, parents and F₁ hybrid

Sl. No.	Traits	Mean	Range		PCV%	GCV%	H ² _{bs} %	GAM%
			Min	Max				
1	Vine length at 45 days (m)	1.43	1.02	1.75	10.74	9.88	84.68	18.73
2	Vine length at harvest (m)	2.44	1.99	2.84	7.21	6.15	72.78	10.81
3	Internodal length (cm)	9.07	4.30	12.90	19.81	17.35	76.65	31.29
4	Number of primary branches	2.44	1.80	3.55	17.26	14.25	68.16	24.23
5	Days to first male flower	41.19	33.02	46.30	8.04	7.61	89.45	14.82
6	Days to first female flower	49.56	41.70	56.10	7.65	7.36	92.62	14.60
7	Node at first female flower appears	6.57	5.00	8.00	13.28	9.84	54.89	15.01
8	Number of male flowers	83.42	62.75	98.70	10.98	10.82	97.03	21.96
9	Number of female flowers	9.75	4.81	15.51	20.47	17.65	74.36	31.36
10	Sex ratio	8.94	4.42	16.50	24.58	21.46	76.24	38.60
11	Days to first fruit harvest (days)	85.27	81.40	89.20	2.29	1.86	65.71	3.10
12	Number of fruits per vine	4.91	3.00	8.00	17.74	10.02	31.93	11.67
13	Fruit length (cm)	18.43	5.55	31.10	28.67	28.45	98.48	58.16
14	Fruit diameter (cm)	8.21	5.17	11.24	17.14	17.12	99.86	35.25
15	Pulp thickness (cm)	2.28	1.15	3.95	26.03	25.96	99.43	53.32
16	Seed cavity (cm)	3.71	1.72	5.41	23.28	23.24	99.67	47.80
17	Individual fruit weight (kg)	0.60	0.11	1.31	45.87	45.50	98.37	92.96

18	Shelf life (days)	49.66	15.00	95.00	50.13	49.75	98.46	101.69
19	Moisture content (%)	88.95	85.10	92.90	1.98	1.36	47.13	1.92
20	Total soluble solids (°B)	3.81	2.00	5.80	24.89	24.72	98.60	50.56
21	Beta carotene (mg/100g)	0.15	0.03	0.34	42.55	42.20	98.37	86.23
22	Ascorbic acid (mg/100g)	6.15	3.75	8.95	22.37	22.08	97.35	44.87
23	Fruit yield per plant (kg)	2.88	0.80	5.79	42.55	40.15	89.05	78.05

Conclusion

The present study revealed substantial genetic variability among *F_s* melon lines derived from inter-specific hybridization. High estimates of PCV and GCV for traits such as shelf life, individual fruit weight, fruit length, total soluble solids and beta-carotene content reflected considerable genetic variation. High heritability coupled with high genetic advance for traits such as fruit length, fruit diameter, pulp thickness, individual fruit weight, shelf life, total soluble solids, beta-carotene and ascorbic acid content indicated the predominance of additive gene action and the effectiveness of phenotypic selection. The wide variability observed for shelf life and fruit quality traits highlights the success of inter-specific hybridization in generating useful recombinants. Therefore, these traits can serve as reliable selection criteria for developing high-yielding melon cultivars with improved fruit quality and extended shelf life.

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