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Genetic analysis in muskmelon (*Cucumis melo* L.)

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ABTRACT

Fifty genotypes of muskmelon (*Cucumis melo* L.) were evaluated for variability, correlation, path analysis and divergence for yield and its contributing characters. Analysis of variance showed significant variation for all the characters, indicating presence of sufficient variability in the material studied. Genotypic correlations were higher than those of their respective phenotypic correlation coefficients in majority of the cases suggesting, that, genotypic correlations were stronger, reliable and free from environmental influences. Path analysis based on genotypic association revealed that number of fruits per plant and moisture percentage was the main yield-attributing characters in fruit yield of muskmelon. Total soluble solids exhibited positive direct effect on fruit yield per plant. Thus, number of fruits per plant, moisture percentage and total soluble solids may be given more weightage for an effective selection to improve fruit yield in muskmelon. On the basis of relative magnitude of D^2 values, all the genotypes were grouped in seven clusters. Maximum genetic distance was observed between clusters II and V, while clusters III and VII displayed the lowest degree of divergence. Total soluble sugars followed by total soluble solids and fruit yield per plant contributed the most towards divergence.

Key words: Muskmelon, variability, correlation, path analysis, genetic divergence

INTRODUCTION

In India, vegetables are grown in an area of 5.8 million hectares with production of 87.5 million tonnes, of which, melons are grown on an area of 1,66,000 ha (More, 2001). The main areas under muskmelon cultivation are riverbeds of Jamuna, Ganges, Narmada rivers in the north and Pennar, Kaveri, Krishna and Godavari rivers in the south (Singh, 1998). Muskmelon (*Cucumis melo* L., 2n = 24) is the most common dessert vegetable crop grown all over the world. It is highly relished because of its flavour, sweet taste and refreshing effect. It is a good source of dietary fiber, vitamins and minerals. However, very little work has been carried out on improvement of the muskmelon crop. For any crop improvement programme aimed at achieving maximum productivity, a detailed knowledge of genetic variability and diversity of various quantitative characters, and their contribution to yield, is essential. Correlation studies help to find the degree of inter-relationship among various characters and to evolve selection criteria for improvement. Path coefficient analysis provides better index for selection than mere correlation coefficient by separating correlation coefficients of yield and its component into direct and indirect effects. Therefore, the present study was carried out to find out all possible component characters for improvement of this crop through character association, path-coefficient analysis and genetic diversity.

MATERIAL AND METHODS

The experiment was carried out at the Main Vegetable Research Station, Anand Agricultural University, Anand, during 2004-05. The experimental material comprised of 50 genotypes of muskmelon from different sources in India (Table 1). The experimental site is situated at an altitude of 45.1 m above mean sea level, lying between latitude 22°-35' North and longitude 77°-55' East. The genotypes were grown in randomized block design with three replications at a spacing of 150 x 90 cm in a plot size of 6 x 4.5 m. Observations were taken on 10 randomly selected plants from each plot. Observations were recorded on the number of the node on which first female flower appeared, days to first picking, fruit weight (kg), fruit length (cm), fruit girth (cm), flesh thickness (cm), number of fruits per plant, fruit yield per plant (kg), moisture content (%),

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total soluble solids (TSS in %), total soluble sugars (mg g^{-1}) and acidity (%). Moisture content of fruit was determined as per standard procedures given by Official Methods of Analysis, Association of Analytical Chemists (Anonymous, 1980), while total soluble solids were determined by Zeiss Hand Refractometer. Total soluble sugars and acidity percentage were determined by methods given by Dubios *et al* (1956) and Ranganna (1976), respectively. Analysis of variance proposed by Panse and Sukhatme (1978) was followed to test the significance of difference between genotypes for all the characters studied, while, correlation coefficient and path coefficient analysis was carried out using methods given by Singh and Choudhary (1977) and Wright (1921), respectively. Genetic divergence was estimated by calculating Mahalanobis D^2 statistics (Mahalanobis, 1936) between different pairs of genotypes. Different clusters were then generated through Tocher's method as given by Rao (1952).

RESULTS AND DISCUSSION

The analysis of variance showed significant variation for all the characters indicating presence of sufficient variability in the material studied. Genotypic variance contributed a major proportion of total variance in characters like fruit yield per plant, number of the node on which first flower appeared, days to first picking, fruit girth, flesh thickness, number of fruits per plant, total soluble solids, total soluble sugars and acidity percentage suggesting, that, these characters were under the control of the genetic system, whereas, characters like fruit weight, fruit length and moisture percentage showed differences between genotypic and phenotypic variance, indicating that environment played an important role in expression of these traits.

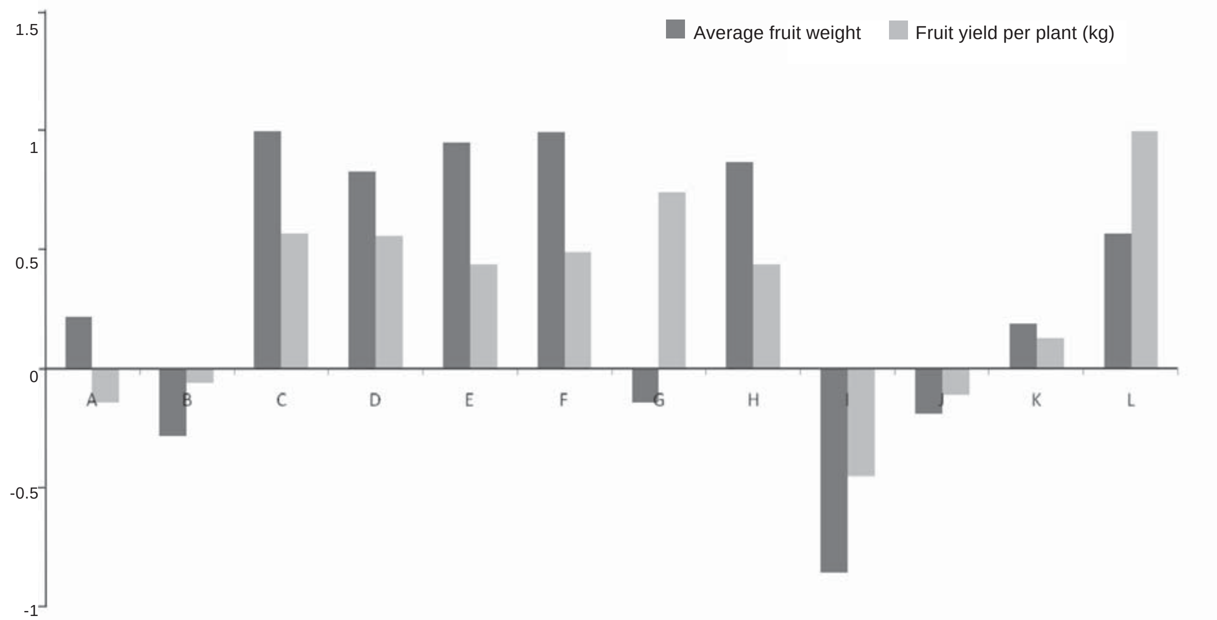
Moderately high genotypic and phenotypic coefficient of variation was observed for fruit yield per plant, followed by acidity percentage, number of fruits per plant and total soluble sugars. Moderate estimates of GCV and PCV were obtained for the number of the node at which first female flower appeared and fruit weight. Moderately low estimates were also observed for total soluble solids, flesh thickness and fruit girth, whereas, fruit length recorded low estimates and days to first picking and moisture percentage exhibited very low GCV and PCV in comparison to other traits (Table 1).

Very high heritability estimates were obtained for total soluble sugars, total soluble solids and fruit yield per plant and high heritability estimates were observed for acidity percentage. Number of days to first picking, moisture percentage, node at which the first female flower appeared, number of fruits per plant, fruit girth, flesh thickness and fruit weight exhibited moderately high estimates of heritability. Fruit length recorded moderately low heritability, characters like moisture percentage and days to first picking showed moderately high estimates of heritability, but, genetic advance as per cent of mean was low because of lower values of GCV and PCV indicating presence of a lower amount of variability for these traits in the population studied. However, traits like fruit yield per plant, acidity percentage, total soluble sugars, number of fruits per plant, number of the node at which first female flower appeared and fruit weight (having very high to moderately high heritability) coupled with high to moderately high genetic advance (as per cent mean) suggested that these characters can be improved by effective selection of genotypes.

Table 1. Source of genotype

Sr. No.	Source	Genotype
1	Anand Agricultural University, Anand, Gujarat	AMM-99-199, MM-68, MMM-45, AMM-15, GMM-2, AMM-31, AMM-49, AMM-35-2, AMM-99-135, AMM-02-25, AMM-99-125, MMM-77, MMM-66, AMM-02-27, AMM-16-1, AMM-26, MMM-61, MMM-75, AMM-00-25, GMM-1, AMM-02-26, AMM-21, AMM-01-18, AMM-10, AMM-43, AMM-27, AMM-99-112, AMM-02-22, AMM-01-19, AMM-02-20, AMM-99-122, AMM-01-24, AMM-8, AMM-99-113, AMM-19, AMM-00-7, AMM-00-11, AMM-7, AMM-00-6, MMM-67
2	IARI, New Delhi	Pusa Madhuras, DM 1
3	GBPUAT, Pantnagar, Uttarakhand	PMM 96-20, PMM 97-10
4	Punjab Agricultural University, Ludhiana, Punjab	Punjab Sunhari, Hara Madu, MM -28
5	NDUAT, Faizabad, Uttar Pradesh	NDM 15, NDM 21
6	RAU, Durgapura, Rajasthan	RM 50

For a majority of the characters, genotypic correlation coefficient was higher than that of their respective phenotypic correlation coefficient indicating, that, genotypic correlations were stronger, reliable and free from environmental influences. Fruit weight showed positive and significant genotypic and phenotypic



A= Number of the node at which the first female flower appeared; B=Days to first picking; C= Fruit weight (kg); D=Fruit length (cm); E= Fruit girth (cm); G=Flesh thickness; H=Number of fruits per plant; I= Moisture (%); J= Total Soluble Solids; K= Total soluble sugars; L=Fruit Acidity (%)

Fig 1. Correlation of average fruit weight and fruit yield per plant with other characters in Muskmelon (*Cucumis melo* L.)

association with fruit yield per plant, fruit length, fruit girth, flesh thickness and moisture percentage, while negative and significant correlation was seen with total soluble solids (Fig 1). These results are in accordance with those of Kalyanasundaram (1976), Singh and Nandpuri (1978), Chonkar *et al* (1979), Parthasarathy and Kalyanasundaram (1979), Kalloo *et al* (1983), Swamy *et al* (1985), Lal and Singh (1997) and Yadav and Ram (2002). Similarly, fruit yield was positively correlated with fruit weight, fruit girth, flesh girth, flesh thickness, number of fruits per plant and moisture percentage at both the genotypic and phenotypic level, while, it had significant and positive correlation with fruit length at the genotypic level only. On the other hand, it showed significant and negative correlation with total soluble solids at both the phenotypic and genotypic level. The results are akin to those reported by Singh and Nandpuri (1978), Chonkar *et al* (1979), Kalloo *et al* (1983), Swamy *et al* (1985), Dhaliwal *et al* (1996), Lal and Singh (1997) and Somkuwar *et al* (1997). Therefore, fruit yield may be improved by selecting genotypes with higher fruit weight, fruit length, and fruit girth, number of fruits per plant, flesh thickness and moisture percentage, with less total soluble solids.

Path coefficient analysis revealed that fruit weight had a positive direct effect on fruit yield. It showed negative indirect effect through total soluble solids and acidity percentage and positive indirect effects through moisture percentage, fruit girth, total soluble sugars and flesh thickness. Though fruit length had a positive correlation with yield, it showed negative direct effect and had maximum positive indirect effect through fruit weight. It had negative indirect effect through total soluble solids, acidity percentage and number of fruits per plant. Fruit girth had a positive direct effect on fruit yield and positive indirect effect through moisture percentage and total soluble sugars, while, it had a negative indirect effect through total soluble solids and acidity percentage. Flesh thickness had a positive direct effect on yield and positive indirect effect through moisture percentage, total soluble sugars and fruit girth and had a negative indirect effect through total soluble solids and acidity percentage. Number of fruits per plant had the maximum positive direct effect on fruit yield and negative indirect effect through moisture percentage and total soluble sugars. Moisture percentage had higher positive direct effect on yield. It had a positive indirect effect through total soluble sugars and fruit girth and a negative indirect effect through total soluble solids and acidity percentage (Table 2). Kalloo *et al* (1982b), Vijay (1987) and Somkuwar *et al* (1997) reported that the number of fruits per plant and fruit weight had a positive direct effect on fruit yield per plant. However,

Table 2. Estimates of genotypic and phenotypic variance and other genetic parameters for fruit yield and yield-attributing characters in *Cucumis melo* L.

	Number of the node at which the first female flower appeared	Days to first picking	Fruit weight (kg)	Fruit length (cm)	Fruit girth (cm)	Flesh thickness (cm)	Number of fruits per plant	Fruit yield per plant (kg)	Moisture content (%)	Total soluble solids (TSS in %)	Total soluble sugars (mg g^{-1})	Acidity (%)
Genotypic variance	0.85	2.96	0.016	0.43	16.63	0.053	1.08	0.55	1.88	1.91	5.64	0.002
Phenotypic variance	1.06	3.37	0.021	1.68	21.43	0.071	1.37	0.58	2.23	1.92	5.65	0.002
GCV (%)	21.46	2.24	20.66	3.80	11.09	11.20	27.61	32.66	1.54	12.67	26.99	30.77
PCV (%)	24	2.39	24.04	7.53	12.59	12.91	31.07	33.31	1.68	12.78	27	31.70
Broad Sense Heritablility(%)	80	87.81	73.82	25.46	77.63	75.29	79.07	96.12	84.59	99.66	99.94	94.19
GA (as per cent mean)	39.53	4.32	36.56	3.93	20.18	20.02	50.54	65.93	2.92	26.04	55.58	61.52

Table 3. Path coefficient analysis showing direct and indirect effect of morphological characters on fruit yield in muskmelon

Sl. no	Character	No of node at which female flower appears	Days to first picking	Fruit weight (kg)	Fruit length (cm)	Fruit girth (cm)	Pulp thick-ness (cm)	No. of fruits per plant	Moisture) (%	Total soluble solids (%)	Total soluble sugars (mg g^{-1})	Acidity (%)	Genotypic correlation with fruit yield per plant	
1	No. of the node at which the first female flower appeared	-0.06	0.02	0.03	-0.03	0.07	0.05	-0.28	0.22	-0.17	0.00	0.02	-0.14	
2	Days to first picking	0.02	-0.05	-0.04	0.02	-0.07	-0.03	0.12	-0.16	0.10	0.06	-0.03	-0.06	
3	Fruit weight (kg)	-0.02	0.01	0.15	-0.09	0.27	0.18	-0.07	0.79	-0.66	0.26	-0.26	0.57	**
4	Fruit length (cm)	-0.03	0.01	0.18	-0.07	0.33	0.22	-0.23	1.05	-0.87	0.24	-0.27	0.56	**
5	Fruit girth (cm)	-0.02	0.01	0.14	-0.09	0.29	0.17	-0.17	0.76	-0.61	0.28	-0.33	0.44	**
6	Flesh thickness	-0.02	0.01	0.15	-0.09	0.27	0.18	-0.14	0.80	-0.64	0.27	-0.30	0.49	**
7	Number of fruits per plant	0.02	-0.01	-0.01	0.02	-0.06	-0.03	0.90	-0.11	0.10	-0.09	0.01	0.74	**
8	Moisture (%)	-0.02	0.01	0.13	-0.09	0.24	0.16	-0.11	0.90	0.75	0.25	-0.28	0.44	**
9	Total soluble solids (%)	0.01	-0.01	-0.13	0.08	-0.23	-0.15	0.11	-0.90	0.76	-0.30	0.30	-0.45	**
10	Total soluble sugars (mg g^{-1})	0.00	0.00	-0.03	0.01	-0.06	-0.04	0.06	-0.16	0.16	-1.39	1.34	-0.11	
11	Acidity (%)	0.00	0.00	0.03	-0.02	0.07	0.04	-0.01	0.18	-0.17	1.37	-1.36	0.13	

Residual effect -0.0291

** Significant at level

Pandita *et al* (1997) observed that the number of fruits and early picking of fruits per plant had the highest positive direct effect on yield per plant. Total soluble solids had significant and negative correlation with fruit yield though this showed a high, positive direct effect on fruit yield. It had a positive indirect effect through acidity percentage and negative indirect effect through moisture percentage, total soluble sugars and fruit girth. Total soluble sugars and acidity percentage had non-significant association with fruit yield. However, both these traits exhibited very high, negative direct effect on fruit yield. Total soluble sugars had high a positive indirect effect on fruit yield through acidity percentage, while, acidity percentage had a high, positive indirect effect through total soluble sugars.

Therefore, based on path analysis, it can be said that number of fruits per plant and moisture percentage were the main yield-attributing characters in fruit yield of muskmelon because of its high, positive direct effect and positive correlation with fruit yield per plant. In addition to moisture percentage and number of fruits per plant, total soluble solids also exhibited a positive direct effect on fruit yield per plant. Thus, it can be advocated that number of fruits per plant, moisture percentage and total soluble solids deserve more weightage for effective selection of genotypes to improve fruit yield in muskmelon.

Table 4. Cluster groups of 50 genotypes formed on the basis of D^2 statistics in muskmelon

Cluster	Number of genotypes	Genotype
I	24	AMM-99-199, MM-68, MMM-45, AMM-15, MM-28, GMM-2, AMM-31, AMM-49, AMM-35-2, AMM-99-135, NDM-21, AMM-02-25, NDM -15, AMM-99-125, PMM-97-10, MMM-77, MMM-66, AMM-02-27, AMM-16-1, AMM-26, MMM-61, MMM-75, AMM-00-25, GMM-1
II	12	AMM-02-26, RM-50, AMM-21, Punjab Sunehri, AMM-01-18, AMM-10, AMM-43, AMM-27, AMM-99-112, AMM-02-22, PMM-96-20, Hara Madhu
III	2	AMM-01-19, AMM-02-20
IV	2	AMM-99-122, AMM-01-24
V	8	AMM-8, AMM-99-113, AMM-19, Pusa madhuras, AMM-00-7, AMM-00-11, DM-1, AMM-7
VI	1	AMM-00-6
VII	1	MMM-67

Table 5. Intra-and inter-cluster distance between genotypes of muskmelon

Cluster	I	II	III	IV	V	VI	VII
I	35.45	83.55	40.9	69.70	70	50.56	41.45
II		40.00	91.00	49.43	138.78	54.87	78.24
III			22.12	60.12	68.54	45.49	21.35
IV				18.23	124.24	21.46	44.22
V					41.24	104.56	81.54
VI						0.00	30.54
VII							0.00

On the basis of Mahalanobis's D^2 values, seven clusters were formed from fifty accessions from different geographical areas. These seven clusters formed from 50 genotypes could be grouped depending upon the genetic constitution of the strains (Table 4). Genetic diversity observed among the genotypes may be due to factors like history of selection, heterogeneity, selection under diverse environments and genetic drift. Results further indicated that the maximum number of similar genotypes (24) appeared in cluster I. Clusters II and V were composed of 12 and 8 genotypes, respectively, whereas, clusters III, IV and VI, VII were composed of two genotypes and a single genotype, respectively. Kalloo *et al* (1982a) and Singh and Lal (2000) studied 45 and 51 diverse genotypes of muskmelon, respectively, for yield and yield-related traits and grouped them into 14 and 13 clusters, respectively. More and Seshadri (2002) evaluated 98 geographically diverse muskmelon genotypes obtained from 10 countries. Based on statistical significance, these 98 genotypes were classified into 12 clusters.

Intra-and inter-cluster average values ranged from 0.00 to 41.24 (Table 5). Since clusters VI and VII consisted of a single genotype, the intra-cluster distance was zero (0). The maximum intra-cluster distance was observed for

Table 6. Cluster mean and contribution of various characters in muskmelon

Sl. No	Character	Number of clusters							Contribution (%) towards divergence
		I	II	III	IV	V	VI	VII	
1	No of node at which female flower appear	4.50	4.40	6.70	4.00	4.33	3.67	2.33	0.00(0)
2	Days to first picking	77.01	76.80	75.68	76.33	76.81	75.67	81.67	0.53(14)
3	Fruit weight (kg)	0.60	0.60	0.91	0.85	0.66	0.62	0.81	0.11(11)
4	Fruit length (cm)	17.50	17.15	18.85	18.57	17.18	17.41	17.94	0.00(0)
5	Fruit girth (cm)	36.03	36.36	40.75	43.4	38.35	36.52	40.81	0.00(12)
6	Flesh thickness (cm)	2.01	2.02	2.50	2.40	2.15	2.06	2.31	0.00(0)
7	Fruits per plant	40.20	3.81	2.51	2.64	3.32	5.41	3.91	0.41(12)
8	Fruit yield per plant (kg)	2.55	2.21	2.10	2.15	2.03	3.28	3.14	2.11(49)
9	Moisture (%)	89.00	88.74	91.90	91.11	89.30	90.26	90.90	0.00(0)
10	Total soluble solids (%)	11.23	11.50	8.61	8.63	10.74	9.15	8.81	22.25(201)
11	Total soluble sugars (%)	4.75	6.77	4.85	6.54	3.01	6.25	5.25	74.45(926)
12	Acidity (%)	0.16	0.01	0.15	0.01	0.21	0.11	0.13	0.00(0)

● Data in parentheses indicate number of times the character appeared first in ranking towards contribution to total divergence in yield cluster V (41.24). The inter-cluster distance was maximum between clusters II and V (138.78), followed by clusters IV and V (124.24), clusters V and VI (104.56) and clusters I and II (83.55). The minimum inter-cluster distance was observed between clusters III and VII (21.35), followed by clusters IV and VI (21.46). Data further reveals that there was good scope for selection within a cluster as indicated by the high magnitude of intra-cluster distance among clusters. Cluster VI and VII, with single genotype, indicated an independent identity and importance, due to various unique characters possessed by the genotypes.

Mean values of clusters for various characters are presented in Table 6. Almost all the clusters were highly distinct from each other in all the characters studied. Cluster III exhibited the highest mean value for the number of the node at which the first female flower appeared (6.7), fruit weight (0.91), fruit length (18.85), flesh thickness (2.50) and moisture content (91.90). Cluster II exhibited highest values for total soluble solids (11.50) and total soluble sugars (6.77), and cluster VI for number of fruits per plant (5.41) and fruit yield per plant (3.28). Clusters IV, V and VII exhibited highest value for fruit girth (43.4), acidity percentage (0.21) and days to first picking (81.67), respectively.

Cluster II showed the lowest mean values for fruit weight (0.60), fruit length (17.15), flesh thickness (2.02) and moisture percentage (88.74); cluster I exhibited the lowest mean value for fruit weight (0.60) and fruit girth (36.03); cluster V had the lowest mean values for fruit yield per plant (2.03) and total soluble sugars (3.01), and, cluster III for number of fruits per plant (2.51) and total soluble solids (8.61). Clusters IV, VI and VII showed the lowest mean values for acidity percentage (0.01), days to first picking (75.67) and the number of the node at which the first female flower appeared (2.33), respectively.

Contribution of different traits to diversity indicates that total soluble sugars (74.45) provide the highest contribution to diversity, followed by total soluble solids (22.25) and fruit yield per plant (2.11). Thus, these three characters need more attention for improvement of muskmelon.

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