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Correlation and Path Coefficient Analysis of Yield and Yield Components of Muskmelon (*Cucumis melo* L.) Genotypes at Varanasi, Eastern Uttar Pradesh

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A B S T R A C T

The knowledge of the direction and magnitude of correlation is used to know the improvement in a character that causes simultaneous changes in other characters. Further correlation studies alone can't point out inter-relationships between heritable characteristics, so path analysis in combination with correlation is shouted which splits the estimated correlation into direct and indirect effect and specifies the causes and determines their relative effects. Therefore, it would provide a better index for selection rather than the correlation alone. Hence, the genotypic and phenotypic correlation coefficients along with the path coefficients were worked out and studied for thirty-six characters in twenty-six muskmelon (*Cucumis melo* L.) genotypes. The result revealed that, in general genotypic correlation coefficients were higher than that of the phenotypic correlation coefficients which may be due to the modified effect of the environment on the composition of characters at the phenotypic level or due to strong genotypic association between traits. The path analysis based on genotypic associations revealed that fruit yield plant per plant was the main yield attributing characters in yield of muskmelon for determining the true form of character association. Total female flowers, total leaves, pulp weight, and leaf area etc. exhibited positive direct effect on fruit yield per plant thus, a significant improvement in fruit yield can be expected through selection by giving them more weightage.

Key words: Attributing characters, Correlation, Genotypic association, Path analysis

Muskmelon (*Cucumis melo* L.) is an annual that climbs, creeps, or trails. The vines may grow up to 3.0 m in length, with deep or shallow lobed leaves, solitary blooms that range in colour from yellow to deep orange, and fruits are called pepo. Pollination is typically aided by honey bees, as it is a highly cross-pollinated crop. It is produced as a Zaid crop in the summer. Bachang, Chira, Chiral, Kalinga, Kharbooj, Kharbuja, Khurmuj, Kasturi tarabuja, Melonegurke, Sweet melon,Velapalam, and Velapandu are some of the vernacular names used throughout India. China, Iran, Spain, and the United States are the world's top muskmelon producers. It is widely grown in India's hot and arid regions, including Bihar, Madhya Pradesh, Karnataka, Punjab, Rajasthan, and Uttar Pradesh, with a total area of 54.10 thousand hectares and a yield of 1230.66 thousand tonnes [1]. Muskmelon has a high amount of dietary fibre, vitamins, and minerals, making both ripe and immature fruits effective in treating human ailments such as renal disease, eczema, tan freckles, and dyspepsia. Hence, it is turning to be a healthy fruit, but its production is low in spite of having a theoretical yield of 60 t/ha in India, however actual yields vary between 12.5-20.0 t/ha depending on management techniques, when compared to other vegetable fruit crops. This could be due to production constraints and the existing open-pollinated cultivars' low producing potential and poor fruit quality. In spite of all, it is booming because to its medium duration, higher market price and great production potential, along with its excellent nutritional, therapeutic, and industrial value.

The creation of high producing cultivars with good fruit quality is a significant focus in muskmelon breeding. Fruit yield is a complicated quantitative feature in muskmelon since it is polygenic and is heavily influenced by the environment. As a result, selecting lines only on the basis of yield is ineffective. The component method to breeding can be used to improve complicated characteristics like as yield. Hence, correlation has been extensively used in breeding to determine the nature of yield contributing relationships. As a result, knowing the genetic mechanisms of development, earliness, and other yield-related

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characteristics is critical for yield enhancement. The selection for high yielding cultivars and genotypes are based on significant relationships existing between growth, earliness and yield related attributes [2]. The effectiveness of a breeding programme with suitable selection criteria will be improved by investigating the interrelationships between yield and its components. Also, correlation studies alone can't point out inter-relationships between heritable characteristics and can, therefore, leads to the negative results [3]. The correlation analysis doesn't show the direct or indirect effects of different yield aspects on yield *per se*, path analysis which splits the estimated correlation into direct and indirect effect is used for that. In plant breeding, correlation and path coefficient studies are commonly employed to investigate the nature of connections between yield and its contributing components. Since, both might reveal the impact of each character on yield. Most crop improvement programmes rely heavily on a knowledge of the link between characteristics, and the size of that relationship aids breeders in determining breeding selection criteria. Therefore, the present study was formulated and conducted to find out the association among different agro-morphological and biochemical traits and identify the characters having direct and indirect effect on fruit yield per plant with the help of path analysis.

MATERIALS AND METHODS

During the summer season (Zaid season) of 2019, the investigation was conducted at the Vegetables Research Farm of the Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi. The farm is located in the north Gangetic plains, on the left bank of the Ganga, approximately 10 kilometres from Varanasi railway station in the city's south-eastern corner, at 25°15" North latitude and 83°03" East longitude, with an elevation of 129.23 metres above mean sea level. The experimental materials used consisted of 26 genotypes of muskmelon (*Cucumis melo* L.) collected from different organizations. The list of genotypes used in the study and their source of collection is given in (Table 1). The experiment was performed in a randomized block design which are replicated thrice, because in RBD we have all choice to use the three principles of experimental design i.e., replication, randomization and local control at once which results in easy handling of any number of treatments and replications, easy and simple statistical analysis, and error isolation. Seeds were directly shown in the basins, made on the paired row system of layout with a row to row spacing of 1.5 m and plant to plant spacing of 0.5 m, having a channel width of 0.3 m between adjacent rows. The sowing was done on 25th of February, 2019. In each replication, every germplasm was grown on 4 consecutive basins having at least ten plants in total. Standard package of practices were followed to raise healthy and disease-pest free plant population. The observations on various characters were recorded on five randomly selected plants in each treatment/genotype of replication and average was taken for the final value for length of cotyledon (mm), width of cotyledon (mm), days to first male flower, days to first female flower, node to first male flower, node to first female flower, petiole length (cm), leaf blade length (cm), leaf blade width (cm), leaf area (cm^2), chlorophyll content (spad value), total number of male flowers, total number of female flowers, sex ratio (m/f), total no. of leaves, total number of 1° branches, total no. of nodes, total number of fruits, vine length (m), days to first fruit harvest, fruit weight (g), yield of fruit/plant (g), thickness of flesh (cm), cavity width (cm), cavity length (cm), fruit length (cm), fruit diameter (cm), pulp weight (g), seeds/fruit, seed weight (g), index seed weight (g), pulp to seed ratio , TSS (°B), ascorbic acid (mg/100 g), titratable acidity (%), and phenol content (mg/g). TSS was measured by Abbe's Hand Refractometer (0-32%), titratable acidity and ascorbic acid were determined by visual titration method given by [4]. The phenotypic and genotypic correlation coefficients were computed from the phenotypic and genotypic variance and co-variances [5] and the direct and indirect effects were estimated through path coefficient analysis as suggested by Wright [6] and elaborated by Dewey and Lu [7].

Table 1 List of source of muskmelon genotypes

Source	Genotypes
RARI, Durgapura	GP-73, GP-150, RM-102, RM-43, Kazri, RM-101, GP-128(+), GP-105, Durgapur Kranti, M +HY-3, MHY-5(+), GP-20, Pusa Madhuras, GP-176, Durgapur Madhu, GP-168, Golden Yellow, Durgapur Selection, RM- 49, RM-50
IIVR, Varanasi	VRMM-46, MMIIHR-653, Punjab Sunehri, MM-1, Kashi Madhu, VRM-4

RESULTS AND DISCUSSION

Knowledge of the direction and magnitude of correlation is used to know the improvement in a character that causes simultaneous changes in other characters. The present study revealed in general, genetic correlation coefficient was higher than the corresponding phenotypic correlation coefficient, which may be due to the modified effect of the environment on the composition of characters at the phenotypic level or due to strong genotypic association between these traits. Therefore, for a rational approach to improve fruit yield and fruit quality, it may be useful to collect information on character association [8-9]. The high magnitude of the positive correlation coefficient at the genetic level between component characters and fruit yield is important for indirect selection for fruit yield plant^{-1} and fruit quality criteria. The characters namely; days to first female flower (0.243, 0.269), node to 1st male flower (0.228, 0.278), total number of male (0.470, 0.489), and female (0.696, 0.718) flowers, total number of fruits per plant (0.677, 0.671), fruit weight (0.750, 0.767), cavity width (0.363, 0.378), cavity length (0.264, 0.289), fruit length (0.310, 0.331), pulp weight (0.718, 0.745), seed weight (0.367, 0.372), index seed weight (0.292, 0.332), pulp to seed ratio (0.297, 0.422), and titratable acidity (0.234, 0.236) are found significantly and positively associated with fruit yield per plant both at phenotypic and genotypic levels. This suggests that the selection for these traits will contribute to the fruit yield per plant. However, leaf blade width (-0.230, -0.271), sex ratio (-0.494, -0.539), and days to first fruit harvest (-0.378, -0.389) showed negative and significant correlation [10-13]. Similarly, fruit weight at phenotypic and genotypic levels respectively, showed significantly positive correlation with flesh thickness (0.505, 0.522), cavity width (0.521, 0.535), cavity length (0.292, 0.309), fruit length (0.364, 0.363), fruit diameter (0.282, 0.298), pulp weight (0.939, 0.955), seeds per fruit (0.437, 0.423), seed weight (0.533, 0.530), index seed weight (0.236, 0.254), pulp to seed ratio (0.375, 0.488) and TSS (0.323, 0.344) while, it had non-significantly negative correlation with phenol content (-0.018, -0.021). These results are presented in (Fig 1) are akin to those reported by [14-15].

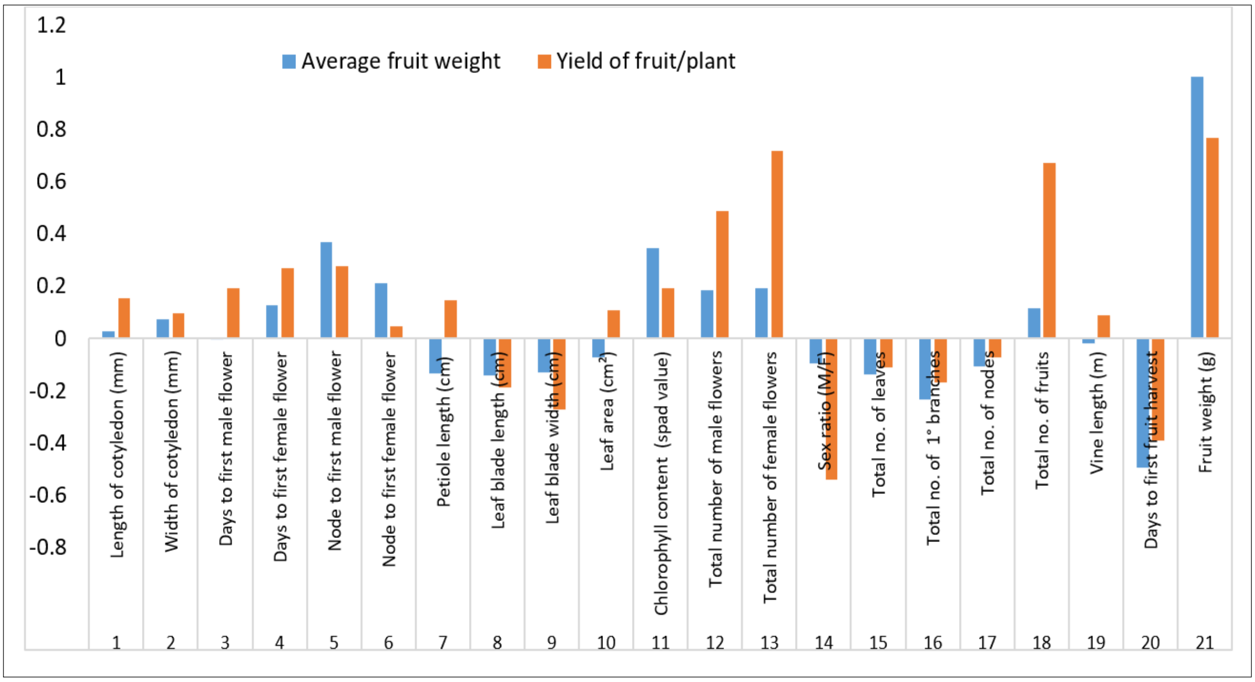

Fig 1 Correlation of fruit weight and yield of fruit per plant with other characters in muskmelon (*Cucumis melo* L.)

Table 2 Path coefficient analysis showing direct and indirect effects of characters on fruit yield in muskmelon

Characters	Days to first female flower	Leaf area (cm²)	Total no. of female flower	Total no. of branches	Total no. of fruits	Fruit weight (gm)	Thickness of flesh (cm)	Fruit length (cm)	Pulp weight (gm)	TSS (°B)	Ascorbic acid content (mg/100gm)	Titratable acidity (%)	Phenol content (mg/gm)	Genotypic correlation with fruit yield per plant
Days to first female flower	-0.25	-0.08	-0.05	-0.04	-0.06	-0.03	0.07	0.03	0.005	0.01	-0.02	-0.07	-0.01	0.27
Leaf area (cm²)	0.32	0.93	0.23	-0.39	0.26	-0.07	-0.14	-0.04	-0.02	-0.52	-0.1	0.05	-0.08	0.11
Total no. of female flowers	0.78	0.89	3.68	0.03	3.67	0.71	-0.44	0.12	0.89	0.17	0.05	0.34	-0.35	0.72
Total no. of primary branches	0.12	-0.29	0.006	0.7	-0.01	-0.16	-0.29	-0.2	-0.16	0.25	-0.18	0.09	-0.08	-0.17
Total no. of fruits	-0.54	-0.62	-2.17	0.05	-2.18	-0.25	0.47	-0.07	-0.3	-0.07	-0.17	-0.26	0.17	0.67
Fruit weight (gm)	0.17	-0.09	0.26	-0.32	0.16	1.36	0.71	0.5	1.3	0.47	0.17	0.2	-0.02	0.77
Thickness of flesh (cm)	0.55	0.29	0.23	0.79	0.42	-1	-1.92	-0.9	-1	-0.27	-0.28	0.16	-0.43	0.22
Fruit length (cm)	-0.17	-0.06	0.03	-0.32	0.04	0.42	0.53	1.14	0.36	0.39	0.12	0.18	0.21	0.33
Pulp weight (gm)	-0.02	-0.03	0.27	-0.25	0.16	1.06	0.58	0.35	1.11	0.3	0.02	0.06	0.01	0.75
TSS (°B)	0.008	0.08	-0.006	-0.05	-0.005	-0.05	-0.02	-0.05	-0.04	-0.14	-0.03	-0.02	-0.04	0.21
Ascorbic acid content (mg/100 gm)	0.043	-0.06	0.006	-0.14	0.04	0.06	0.08	0.05	0.01	0.12	0.54	-0.1	0.18	0.15
Titratable acidity (%)	-0.073	-0.01	-0.02	-0.03	-0.03	-0.03	0.01	-0.03	-0.01	-0.03	0.04	-0.23	-0.01	0.24
Phenol content (mg/gm)	0.03	-0.04	-0.04	-0.05	-0.03	-0.01	0.11	0.09	0.008	0.14	0.16	0.03	0.47	-0.05

Residual effect -0.0551

Path coefficient analysis was carried out taking the fruit yield plant^{-1} as the dependent variable to divide the correlation coefficients into direct and indirect effects to determine the contribution of different characters to fruit yields and represented in (Table 2). The direct and indirect effects of different traits on the fruit yield indicated that there is a compromise between the direction and magnitude of the direct effects of different characters and the correlation with fruit yield plant^{-1}. Thus, a significant improvement in fruit yield can be expected through selection in component characters with high positive direct effects at genotypic and phenotypic levels on fruit yield plant^{-1}. Traits viz.; fruit weight (1.360, 0.636), total number of female flowers (3.680, 0.362), total number of 1° branches per plant (0.708, 0.087), pulp weight (1.113, 0.153), fruit length (1.142, 0.114), ascorbic acid content (0.537, 0.050), leaf area (0.934, 0.047) and phenol content (0.474, 0.040) etc. had positive direct effects on yield of fruit plant^{-1}, both at genotypic and phenotypic levels, respectively. This indicates a true relationship between these traits with the yield of fruit plant^{-1} and direct selection for these traits helps to improve fruit yield per plant of muskmelon. The above outcomes have consent of the findings of [16] for cavity width in muskmelon and [17-19] in muskmelon for total number of fruits plant^{-1}.

Indirect effects at genotypic levels on fruit yield plant^{-1} are shown by traits viz. days to first female flower, leaf area, total number of female flowers, total number of 1° branches per plant, total number of fruits, pulp weight, total soluble solids and ascorbic acid. Days to first female flower had an indirect positive effect on fruit yield per plant through pulp weight, and TSS while, negative indirect effect on fruit yield per plant via, leaf area, total number of female flowers, total number of 1° branches, total number of fruits per plant, ascorbic acid content and titratable acidity. Leaf area had an indirect positive effect on fruit yield per plant through days to 1st female flower, total number of female flowers and total number of fruits per plant while, negative indirect effect on total number of 1° branches per plant, pulp weight, TSS, and ascorbic acid content. Total number of female flowers showed positive indirect effect on the fruit yield per plant through days to 1st female flower, leaf area, total number of 1° branches per plant, total number of fruits per plant, pulp weight, TSS, and ascorbic acid content in contrast, negative indirect effect via thickness of flesh and phenol content. Total number of branches had shown positive indirect effect on fruit yield/plant through days to 1st female flower and TSS while, negative indirect effect via, leaf area, total number of fruits per plant pulp weight, and ascorbic acid content. Total number of fruits showed a positive indirect effect on fruit yield per plant through total number of primary branches per plant whereas, negative indirect effect via, days to first female flower, leaf area, total number of female flowers, pulp weight, TSS and ascorbic acid content. Pulp weight showed positive indirect effect on fruit yield per plant through total number of female flowers, total number of fruits per plant, TSS, and ascorbic acid content, in contrast negative indirect effect via, leaf area, total number of 1° branches per plant and days to first female flower. Total soluble solids showed a positive indirect effect on fruit yield per plant through the days to first female flower and leaf area. In contrast, negative indirect effect via, total number of female flowers, total number of 1° branches per plant, total number of fruits per plant, pulp weight and ascorbic acid content. Ascorbic acid content possessed positive indirect effect on the fruit yield/plant through days to 1st female flower, total number of female flowers, total number of fruits per plant, fruit weight, pulp weight, flesh thickness, fruit length, phenol content and TSS whereas, negative indirect effect via, leaf area and total number of 1° branches per plant and titratable acidity (Table 2). Though total number of fruits, flesh thickness, and total soluble solids had a positive correlation with fruit yield per plant, it showed negative direct effect and had maximum positive indirect effect through flesh thickness, total number of 1° branches and leaf area, respectively. Also, they had negative indirect effect through total number of female flowers, titratable acidity and fruit weight, pulp weight, fruit length and fruit weight, and total number of branches, fruit weight and flesh thickness, respectively.

CONCLUSION

Considering correlations, the fruit yield per plant may be improved by selecting genotypes with higher, flesh thickness, total number of fruits per plant, cavity width, cavity length, fruit length, fruit diameter, pulp weight, seeds per fruit, seed weight, index seed weight, pulp to seed ratio and TSS with less phenol content. And, on the basis of path analysis, it can be concluded that the total number of female flowers, fruit weight, fruit length, pulp weight and leaf area were the main yield-attributing characters in fruit yield per plant of muskmelon because of its high and positive direct effect along with positive correlation with fruit yield per plant. In addition to the above total number of 1° branches per plant and ascorbic acid content also exhibited a direct positive effect on fruit yield per plant. Thus, the above can be advocated or deserves more weightage for effective selection of genotypes to improve fruit yield in muskmelon.

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