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Correlation and Path Analysis Studies on Yield and Yield Components in Musk Melon (*Cucumis melo* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Problem: The correlation co-efficient indicates the nature of association among the different traits, path analysis splits the correlation co-efficient into measure of direct and indirect effects thus providing understanding of the direct and indirect association of each character towards yield.
Methods: An experiment on correlation and path analysis involving thirty F_1 and six parents in muskmelon (*Cucumis melo* L.) was carried out at Department of Horticulture, Adhiparasakthi Agricultural College, Kalavai, Vellore district, Tamil Nadu India.
Results: The fruit yield per plant had exhibited highly significant and positive correlation with individual fruit weight (0.845), fruit diameter (0.656), fruit length (0.536) and flesh thickness (0.503). Path coefficient analysis revealed that the characters *viz.,* fruit weight exerted the highest positive direct effect (1.034) on fruit yield per vine followed by number of fruits per vine (0.497), days to first female flower anthesis (0.088), vine length (0.072) and fruit length (0.070).
Conclusion: The fruit yield per plant can be improved by making selection of these traits in yield improvement programme.

Keywords: Correlation; genotype; path analysis; muskmelon; growth parameters; yield.

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1. INTRODUCTION

Muskmelon (*Cucumis melo* L.) is one of the important cucurbitaceous crops having a chromosome number (2n = 24). *Cucumis* spp. consists of 118 genera and 825 species including considerable economic important vegetables such as cucumber (*C. sativus*), muskmelon and West Indian gherkin (*C. anguria* L.). All species are indigenous to Africa, which were apparently introduced to the West Indies from Africa and *C. sativus* and *C. hardwickii* are native to Asia. The secondary centres of diversity for muskmelon are India, Persia, China and Southern Russia [1]. Among the cucurbits, muskmelon is one of the most economically important crops, cultivated in many tropical, subtropical and temperate regions around the world. Fruits are very good source of dietary fiber, vitamins and minerals. The edible portion of melon contains water (90 per cent) and carbohydrates (10 per cent). The high amount of beta carotene (2020 µg 100 g^{-1}) content was found in yellow and orange fleshed melons. Immature muskmelons may be used as salads, cooked or pickled. Local market preferences in muskmelon made several land races/local cultivars to be established themselves in different geographical pockets of India. These cultivars, which exhibit enormous variability with respect to fruit traits but are basically poor yielders, as they are traditionally being grown and selected under low input agricultural systems by traditional growers, who have developed their own skill and management practices to raise this crop. It is therefore considered worthwhile to collect diversified genotypes from various places and local markets for breeding towards an effective improvement in fruit traits and yield of muskmelon.

Correlation and path co-efficient analysis are the important factors to determine the association between the yield and yield components. The characters that are positively correlated with yield are of considerable importance to plant breeder for selection purpose. The interrelationships between yield and components will improve the efficiency of a breeding programme with suitable selection basis as per Feyzian et al. [2]. All the changes in the components need not, however be expressed by changes in the yield. A study of association of these characters helps in selection of genotypes and also suggests the advantage of a selection scheme for more than one character at a time, which could be explained that improvement of one trait results in improvement of all positively related characters. In the present study, the simple correlation coefficients between yield and its components and their inter correlations among the components were estimated. Although the correlation co-efficient indicates the nature of association among the different traits, path analysis splits the correlation co-efficient into measure of direct and indirect effects thus providing understanding of the direct and indirect association of each character towards yield. Hence, the present investigation was planned to unravel the correlation and path co-efficient of yield and yield attributing traits in muskmelon.

2. MATERIALS AND METHODS

The experiment was carried out during Rabi, 2015 at Department of Horticulture, Adhiparasakthi Agricultural College, Kalavai, Vellore district, Tamil Nadu, India. The experimental materials for the present study consisted of six parents namely IC524113, IC524128, IC524135, Arka Jeet, Dharwad local and Thirur local and thirty hybrids were produced through full diallel mating design. The experiment was laid out in a Randomized Block Design. Each plot consisted of ten plants in a row at of 2.5 m x 1 m inter and intra row spacing. Five randomly selected plants, excluding the border ones, from each plot of all the three replications were tagged and used for recording the observations and average values were computed. Analysis of covariance for all combinations were done and used for estimation of correlations. Phenotypic and genotypic correlations were worked out by the formulae recommended Al-Jibouri et al. [3]. Path analysis was done as per the procedure outlined Wright [4] and Dewey [5].

3. RESULTS AND DISCUSSION

3.1 Association Analysis

The genotypic correlation coefficients between yield and its components and inter correlations among different yield attributes were estimated and presented in Table 1.

3.1.1 Correlation between fruit yield per vine and other traits

Individual fruit weight (0.845) [6], fruit diameter (0.656) [7], fruit length (0.536) [8], flesh thickness (0.503) [9], number of seeds per fruit (0.308) and vine length (0.290) showed significant positive association with fruit yield per vine, while number

of primary branches (0.226), number of fruits per vine (0.164), total soluble solids (0.117), fruit-cavity ratio (0.074), ascorbic acid (0.063) and total sugars (0.046) showed positive non-significant correlation with fruit yield per vine. On the contrary the traits *viz*., days to first male flower anthesis (-0.569) [10], days to first harvest (-0.500), node at which first male flower appeared (-0.499), days to first female flower anthesis (-0.404) and sex ratio (-0.277). Tamilselvi et al. [11] showed negative and significant association with fruit yield per vine. Whereas, node at which first female flower appeared (-0.203) showed negative and non-significant relationship with fruit yield per vine (Table 1).

3.1.2 Inter correlation among different traits

Vine length showed significant positive correlation with number of fruits per vine (0.535), total soluble solids (0.499) and number of primary branches (0.352) and it had non-significant positive correlation with node at which first female flower appeared (0.168), total sugars (0.151), flesh thickness (0.075) and fruit weight (0.004). The trait, node at which first male flower appeared exhibited positive and significant correlation with node at which first female flower appeared (0.450), days to first male flower anthesis (0.412) and days to first female flower anthesis (0.366). While, it showed non-significant positive correlation with sex ratio (0.221), days to first harvest (0.162) and fruit-cavity ratio (0.080). Node at which first female flower appeared had significant and positive correlation with days to first harvest (0.290) whereas, it was significant but negatively associated with fruit diameter (-0.333) and fruit length (-0.255). It had positive and non-significant correlation with sex ratio (0.238) and number of primary branches (0.205). While, it was negative and non-significantly correlated with number of seeds per fruit (-0.430), fruit weight (-0.248), flesh thickness (-0.240) and ascorbic acid (-0.117).

The days to first male flower anthesis was significant and negatively correlated with fruit weight (-0.523), flesh thickness (-0.398), fruit diameter (-0.327), total sugars (-0.298) and fruit length (-0.297). It had non-significant and positively correlated with fruit-cavity ratio (0.227), days to first harvest (0.054) and ascorbic acid content (0.042). While, it had non-significant and negative relationship with number of primary branches (-0.218), number of fruits per vine (-0.108) and number of seeds per fruit (-0.019). Days to first female flower anthesis recorded negative and significant association with fruit weight (-0.555), flesh thickness (-0.533), fruit length (-0.448) and fruit diameter (-0.379). It had positive and non-significantly correlated with fruit-cavity ratio (0.258) and ascorbic acid (0.249). It also exhibited positive and non-significant correlation with number of fruits per vine (0.201), sex ratio (0.141) and days to first harvest (0.139) while it was negative and non-significantly correlated with number of primary branches (-0.171) and total soluble solids (-0.002). The trait number of primary branches registered significant and positive correlation with total soluble solids (0.526) and number of fruits per vine (0.343). While, it had significant and negatively correlated with sex ratio (-0.446), number of seeds per fruit (-0.307) and ascorbic acid (-0.289).

The trait sex ratio (M/F) was significant and negatively associated with number of fruits per vine (-0.496) and total soluble solids (-0.446). This trait exhibited positive and non-significant relationship with fruit-cavity ratio (0.190), fruit length (0.109), flesh thickness (0.108) and fruit diameter (0.078). It had negative and non-significant correlation with total sugars (-0.149), fruit weight (-0.050) and ascorbic acid (-0.039). The character days to first harvest exhibited highly significant negative association with fruit weight (-0.560), fruit diameter (-0.526), fruit length (-0.445), flesh thickness (-0.352), number of seeds per fruit (-0.333) and fruit-cavity ratio (-0.278). It had exhibited positive and non-significant association with number of fruits per vine (0.198), total soluble solids (0.191), total sugars (0.170) and ascorbic acid (0.058).

Fruit length had positive and significant association with the traits *viz*., fruit weight (0.728), fruit diameter (0.719), flesh thickness (0.580) and number of seeds per fruit (0.533), while it was positively and non-significantly correlated with fruit-cavity ratio (0.192) and total sugars (0.106). The trait fruit diameter exhibited positively significant correlation with fruit weight (0.746), flesh thickness (0.661), number of seeds per fruit (0.512) and fruit-cavity ratio (0.378) whereas, it was positively and non-significantly associated with total sugars (0.003).

The traits ascorbic acid (-0.188), fruit-cavity ratio (-0.182) and total soluble solids (-0.148) registered negative and non-significant correlations with flesh thickness while the trait had positively significant association with fruit

Table 1. Genotypic correlation coefficient between fruit yield and its component characters in muskmelon

Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	**1.000**	-0.096	0.168	-0.449**	-0.228	0.352**	-0.419**	-0.041	-0.184	-0.001	0.075	0.004	-0.318*	-0.306*	0.535**	0.499**	0.151	-0.229*	0.290*
2		**1.000**	0.450**	0.412**	0.366**	-0.102	0.221	0.162	-0.339*	-0.407**	-0.403**	-0.485**	0.080	-0.283*	-0.047	-0.212*	-0.122	-0.059	-0.499**
3			**1.000**	0.031	0.167	0.205	0.238	0.290*	-0.255*	-0.333*	-0.240	-0.248	-0.063	-0.430	0.076	0.112	-0.030	-0.117	-0.203
4				**1.000**	0.694**	-0.218	0.259*	0.054	-0.297*	-0.327*	-0.398**	-0.523**	0.227	-0.019	-0.108	-0.262*	-0.298*	0.042	-0.569**
5					**1.000**	-0.171	0.141	0.139	-0.448**	-0.379*	-0.533**	-0.555**	0.258*	-0.288*	0.201	-0.002	-0.288*	0.249*	-0.404**
6						**1.000**	-0.446**	0.086	-0.058	0.029	0.018	0.097	-0.017	-0.307*	0.343**	0.526**	0.110	-0.289*	0.226
7							**1.000**	0.034	0.109	0.078	0.108	-0.050	0.190	0.044	-0.496**	-0.446**	-0.149	-0.039	-0.277*
8								**1.000**	-0.445**	-0.526**	-0.352*	-0.560**	-0.278*	-0.333*	0.198	0.191	0.170	0.058	-0.500**
9									**1.000**	0.719**	0.580**	0.728**	0.192	0.533**	-0.434**	-0.241*	0.106	-0.203	0.536**
10										**1.000**	0.661**	0.746**	0.378*	0.512**	-0.237	-0.021	0.003	-0.137	0.656**
11											**1.000**	0.636**	-0.182	0.328*	-0.255*	-0.148	0.102	-0.188	0.503**
12												**1.000**	0.173	0.490**	-0.347*	-0.156	-0.055	-0.038	0.845**
13													**1.000**	0.174	-0.243*	-0.015	-0.236	0.152	0.074
14														**1.000**	-0.357*	-0.409**	-0.110	-0.097	0.308*
15															**1.000**	0.562**	0.215	0.103	0.164
16																**1.000**	0.297*	-0.116	0.117
17																	**1.000**	0.071	0.046
18																		**1.000**	0.063

**, **- Significant at 5 % and 1 % probability level, respectively*

1. Vine length (m)
2. Node at which first male flower appeared
3. Node at which first female flower appeared
4. Days to first male flower anthesis
5. Days to first female flower anthesis
6. Number of primary branches (Nos.)
7. Sex ratio (M/F)
8. Days to first harvest
9. Fruit length (cm)
10. Fruit diameter (cm)
11. Flesh thickness (cm)
12. Fruit weight (kg)
13. Fruit-Cavity ratio
14. Number of seeds per fruit (Nos.)
15. Number of fruits per vine (Nos.)
16.Total soluble solids (^{0}brix)
17. Total sugars (%)
18. Ascorbic acid (mg/100g)
19. Fruit yield per vine (kg)

Table 2. Direct and indirect effects of various yield attributes on fruit yield in brinjal

Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	**0.0724**	-0.0069	0.0122	-0.0325	-0.0165	0.0255	-0.0303	-0.0030	-0.0133	-0.0001	0.0054	0.0003	-0.0230	-0.0222	0.0388	0.0361	0.0109	-0.0166	0.2895*****
2	-0.0022	**0.0227**	0.0102	0.0094	0.0083	-0.0023	0.0050	0.0037	-0.0077	-0.0093	-0.0092	-0.0110	0.0018	-0.0064	-0.0011	-0.0048	-0.0028	-0.0013	-0.4991******
3	0.0005	0.0015	**0.0032**	0.0001	0.0005	0.0007	0.0008	0.0009	-0.0008	-0.0011	-0.0008	-0.0008	-0.0002	-0.0014	0.0002	0.0004	-0.0001	-0.0004	-0.2026
4	-0.0006	0.0005	0.0002	**0.0012**	0.0009	-0.0003	0.0003	0.0001	-0.0004	-0.0004	-0.0005	-0.0006	0.0003	0.0005	-0.0001	-0.0003	-0.0004	0.0001	-0.5693**
5	-0.0203	0.0324	0.0148	0.0616	**0.0888**	-0.0152	0.0125	0.0123	-0.0398	-0.0336	-0.0473	-0.0493	0.0229	-0.0255	0.0178	-0.0001	-0.0256	0.0221	-0.4041**
6	-0.0087	0.0025	-0.0051	0.0054	0.0042	**-0.0248**	0.0110	-0.0021	0.0014	-0.0007	-0.0004	-0.0024	0.0004	0.0076	-0.0085	-0.0130	-0.0027	0.0072	0.2260
7	-0.0142	0.0075	0.0081	0.0088	0.0048	-0.0151	**0.0338**	0.0012	0.0037	0.0026	0.0037	-0.0017	0.0064	0.0015	-0.0168	-0.0151	-0.0050	-0.0013	-0.2769*
8	0.0006	-0.0023	-0.0042	-0.0008	-0.0020	-0.0012	-0.0005	**-0.0144**	0.0064	0.0076	0.0051	0.0081	0.0040	0.0048	-0.0029	-0.0027	-0.0024	-0.0008	-0.5002**
9	-0.0130	-0.0239	-0.0179	-0.0210	-0.0316	-0.0041	0.0077	-0.0313	**0.0705**	0.0506	0.0409	0.0513	0.0135	0.0376	-0.0306	-0.0170	0.0075	-0.0143	0.5356**
10	0.0002	-0.0190	-0.0155	-0.0152	-0.0176	0.0013	0.0036	-0.0245	0.0335	**0.0466**	0.0308	0.0347	0.0176	0.0239	-0.0110	-0.0010	0.0001	-0.0064	0.6555**
11	-0.0037	0.0197	0.0117	0.0194	0.0260	-0.0009	-0.0053	0.0172	-0.0283	-0.0322	**-0.0488**	-0.0310	0.0089	-0.0160	0.0125	0.0072	-0.0050	0.0092	0.5032**
12	0.0039	-0.5015	-0.2568	-0.5404	-0.5741	0.1003	-0.0517	-0.5793	0.7525	0.7711	0.6579	**1.0344**	0.1789	0.5063	-0.3585	-0.1618	-0.0570	-0.0395	0.8450**
13	0.0142	-0.0036	0.0028	-0.0102	-0.0115	0.0007	-0.0085	0.0124	-0.0086	-0.0169	0.0081	-0.0077	**-0.0447**	-0.0078	0.0109	0.0007	0.0106	-0.0068	0.0735
14	0.0014	0.0013	0.0020	0.0001	0.0013	0.0014	-0.0002	0.0015	-0.0025	-0.0024	-0.0015	-0.0023	-0.0008	**-0.0046**	0.0016	0.0019	0.0005	0.0004	0.3084*
15	0.2660	-0.0231	0.0377	-0.0535	0.0999	0.1704	-0.2465	0.0986	-0.2155	-0.1177	-0.1269	-0.1723	-0.1210	-0.1776	**0.4971**	0.2793	0.1069	0.0512	0.1639
16	0.0066	-0.0028	0.0015	-0.0035	0.0000	0.0070	-0.0059	0.0025	-0.0032	-0.0003	-0.0020	-0.0021	-0.0002	-0.0054	0.0075	**0.0133**	0.0040	-0.0015	0.1165
17	0.0004	-0.0003	-0.0001	-0.0008	-0.0008	0.0003	-0.0004	0.0004	0.0003	0.0006	0.0003	-0.0001	-0.0006	-0.0003	0.0006	0.0008	**0.0026**	0.0002	0.0464
18	-0.0141	-0.0037	-0.0072	0.0026	0.0154	-0.0178	-0.0024	0.0036	-0.0125	-0.0084	-0.0116	-0.0024	0.0094	-0.0060	0.0064	-0.0071	0.0044	**0.0617**	0.0630

Residual effect: 0.1878

**, **- Significant at 5 % and 1 % probability level, respectively*

1. Vine length (m)
2. Node at which first male flower appeared
3. Node at which first female flower appeared
4. Days to first male flower anthesis
5. Days to first female flower anthesis
6. Number of primary branches (Nos.)
7. Sex ratio (M/F)
8. Days to first harvest
9. Fruit length (cm)
10. Fruit diameter (cm)
11. Flesh thickness (cm)
12. Fruit weight (kg)
13. Fruit-Cavity ratio
14. Number of seeds per fruit (Nos.)
15. Number of fruits per vine (Nos.)
16.Total soluble solids (^{0}brix)
17. Total sugars (%)
18. Ascorbic acid (mg/100g)
19. Fruit yield per vine (kg)

weight (0.636) and number of seeds per fruit (0.328). This trait exhibited positive and non-significant relationship with total sugars (0.102). Fruit weight was significant and positively correlated with number of seeds per fruit (0.490). It had negatively non-significant correlations with number of fruits per vine (-0.347). Fruit-cavity ratio was significantly and negatively correlated with number of fruits per vine (-0.243) while, it had negative and non-significant association with total sugars (-0.236) and total soluble solids (-0.015). This trait exhibited positive and non-significant relationships with number of seeds per fruit (0.174) and ascorbic acid (0.152).

The trait number of seeds per fruit was registered total soluble solids (-0.409) and number of fruits per vine (-0.357) were correlated negatively and significantly with number of seeds per fruit. It was non-significant and negative correlations with total sugars (-0.110) and ascorbic acid (-0.097). The trait number of fruits per vine exhibited positive and significant relationship with total soluble solids (0.562). Whereas, it was positively and non-significantly correlated with the traits *viz*., total sugars (0.215) and ascorbic acid content (0.103). Total soluble solids had significant and positive association with total sugars (0.297). Whereas, it showed negative and non-significant association with ascorbic acid content (-0.116). The trait total sugars exhibited positive and non-significant correlation with ascorbic acid content (0.071) (Table 1).

3.2 Path Analysis

The direct and indirect effects of eighteen important yield contributing characters on fruit yield per vine was statistically analyzed using path analysis. The residual effect (0.1878) indicated that most of the characters contributing towards the yield were included in the study (Table 2).

3.2.1 Direct effects

Fruit weight exerted the highest positive direct effect (1.0344) on fruit yield per vine followed by number of fruits per vine (0.4971), days to first female flower anthesis (0.0888), vine length (0.0724) and fruit length (0.0705). The results obtained were in agreement with the previous reports [8,10,12,13,14]. The negative direct effect on yield was contributed by the characters *viz.,* flesh thickness (-0.0488) followed by fruit-cavity ratio (-0.0447), number of primary branches (-0.0248) and days to first harvest (-0.0144). Other characters had negligible direct or indirect influence on yield per vine. This observation was in agreement with the results [8,13,15] (Table 2).

3.2.2 Indirect effects

Vine length exerted the highest positive indirect effect on fruit yield per vine through number of fruits per plant (0.0388) followed by total soluble solids (0.0361) and number of primary branches (0.0255). While, days to first male flower anthesis (-0.0325), sex ratio (-0.0303), fruit-cavity ratio (-0.0230), number of seeds per fruit (-0.0222) showed negative indirect effects on yield.

Node at which first male flower appeared showed highest positive indirect effect towards fruit yield per vine through node at which first female flower appeared (0.0102), days to first male flower anthesis (0.0094) and days to first female flower anthesis (0.0083). Whereas, negative indirect effect on fruit yield per vine *via* fruit weight (-0.0110), fruit diameter (-0.0093) and flesh thickness (-0.0092) were exhibited.

The indirect effects of fruit length were highest and positive on fruit yield per vine through fruit weight (0.0513) followed by fruit diameter (0.0506) and flesh thickness (0.0409). It exerted negligible indirect effects through rest of the characters. On the other hand, days to first female flower anthesis (-0.0316) exerted the highest and negative indirect effect on yield followed by days to first harvest (-0.0313) and number of fruits per vine (-0.0306).

Fruit weight showed maximum positive indirect effect on fruit yield per vine through fruit diameter (0.7711), fruit length (0.7525) and flesh thickness (0.6579), while days to first harvest (-0.5793), days to first female flower anthesis (-0.5741), days to first male flower anthesis (-0.5404) and node at which first male flower appeared (0.5015) exhibited negative indirect effect towards yield.

The highest negative indirect effect of number of fruits per vine on fruit yield per vine was observed through sex ratio (-0.2465) and fruit length (-0.2155). Whereas, the maximum indirect effect on yield was recorded through total soluble solids (0.2793) and vine length (0.2660) (Table 2).

The days to first male flower anthesis, flesh thickness, fruit diameter, sex ratio and fruit-cavity ratio showed negligible indirect effects on fruit

yield per vine through other characters both in positive and negative direction.

4. CONCLUSION

Yield is dependent on various characters which are mutually related. These will in turn impair the true association existing among the components and fruit yield. A change in any one factor is likely to disturb the whole network of cause and effect. Individual fruit weight showed high positive direct effect at both levels on fruit yield per plant. This trait showed positive significant correlation and had high positive direct effect on yield per plant and hence direct selection through this character would be effective.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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