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Correlation and Path Coefficient Analysis Studies on Yield and Yield Related Traits in Bitter Gourd (*Momordica charantia* L.) under Garhwal Himalaya

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Abstract—*Correlation studies with twenty genotypes in bitter gourd revealed that yield per vine had the significant positive association at genotypic level for vine length (cm), number of primary branches per vine, number of fruits per vine, fruit length (cm) and fruit weight (g), while negative association at genotypic level were also reported for the fruit diameter (cm) and least negative correlation were recorded for the days to opening of first male flower, days to opening of first female flower and percent of fruit setting. The path analysis study revealed that the fruit weight is the most important yield determinant, because of its high direct effect and indirectly influence the yield through vine length, number of primary branches per vine, number of fruits per vine, fruit length (cm) and number of seeds per fruit. Moderate effects exerted by number of seeds per fruit, fruit diameter and percent of fruit setting were also influences the yield via many yield improving traits. Emphasis must be given the traits having high degree of direct effect like, fruit weight, fruit diameter and percent of fruit setting, while exercising selection to improve the yield.*

Key words: *Bitter gourd, genotype, correlation and path analysis*

Introduction

Bitter gourd (*Momordica charantia* L.) one of the most important and popular cucurbitaceous crop grown in all parts of India for various purposes. It is highly rich in nutrients, medical properties and adoptable in various agro climatic conditions. Bitter gourd is use in different way like, boiled, curried, stuffed or sliced and also pickled. The fruit acts as an anthelmintic, stomachic, purgative, antibilious, carminative, anti-diabetic and laxative. A decoction of the root extract is helpful in abortion, hemorrhoids and also in biliaesness (**Khulakpam *et al.*, 2015**). India is a place of vast genetic variability of bitter gourd; mostly it is showed their variability in the morphological and also their fruit traits. Basically, the selection of parental strains in bitter gourd breeding programs has been cleared on the basis of horticultural traits (**Singh *et al.*, 2014)**. Yield being a multifarious trait, it is dependent upon several attributes. Before starting an effective selection programme, it is very compulsory to know the significance and association of various characters with yield and among each other. Studies on this aspect were made earlier by several research workers. A simple measure of correlation of characters does not quantify the relative contribution of causal factors to the ultimate yield (**Dewey and Lu, 1959**). Since the component traits themselves are inter-dependant, they often affect their direct relationship with yield and consequently restrict the reliability of selection indices based upon correlation coefficients (**Dewey and Lu, 1959**). The path coefficient analysis permits the separation of direct effects from indirect effects through other related characters by partitioning the genotypic correlation coefficients. Hence, the present study was undertaken to estimate the genotypic correlations and direct and to determine the indirect effects of component characters on yield in bitter gourd.

Materials and Methods

The field experiment was conducted with 20 lines were laid out in randomized block design (RBD) which was replicated thrice with twelve plants in each treatments during March 2014 at Horticultural Research Centre, Chauras Campus, Department of Horticulture, H.N.B. Garhwal University, Srinagar, Garhwal, Uttarakhand (India). These lines were collected from various sources like, IIVR and other places. Thirty days old seedlings were transplanted in the spacing of 1.50 × 0.50 m. The standard horticultural practices and plant protection measures recommended for bitter gourd were adopted uniformly for good yield. The observation were recorded for length of vine (cm), number of primary branches per vine, days to opening of first male and female flower, number of nodes bearing first male and female flower, percent of fruit setting, number of fruit per vine, fruit length (cm), fruit diameter (cm), fruit weight (g), fruit yield per vine (kg), ascorbic acid (mg/100g) and number of seeds per fruit. Genotypic correlation coefficient was estimated according to the formulae given by **Johnson *et al.* (1955)**. The significance of the genotypic correlation coefficients was tested as given by **Snedecor and Cochran (1967)**. Path coefficient analysis as

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applied by **Dewey and Lu (1959)** was used to partition the genotypic correlation into components of direct and indirect effects.

Result and Discussion

The results in the present experiment, revealed that yield per vine had significant positive association at genotypic level for vine length, number of primary branches per vine, number of fruit per vine, fruit length and fruit weight. Similar results were also observed by **Miah *et. al.* (2000)**, **Dey *et. al.* (2005)** & **Singh *et. al.* (2014)** in bitter gourd and **Fayeun *et. al.* (2012)** in fluted pumpkin also reported that fruit yield positively correlated with number of number of fruit per plant, fruit length and fruit weight in bitter gourd. Ascorbic acid showed negative association at genotypic level in some traits *viz.*, fruit diameter, while the least negative correlation was reported at genotypic level in the traits like, days taken to opening of first male and female flower, percent of fruit setting and total soluble solid. Similar observations were also reported by **Rao *et. al.* (2002)** in ridge gourd; **Sanwal *et. al.* (2007)** in sweet gourd and **Selvi *et. al.* (2012)** in pumpkin. It is suggested that vigorous plant with profuse growth, high number of primary branches per vine produce high yield per vine. A very strong positive and significant correlation was observed between yield and average weight of fruit, whereas the number of fruit per vine and fruit length also reported the good association with yield. **Bhave *et. al*. (2003)**, **Dey *et. al*. (2005)**, **Ram *et. al.* (2006)** and **Islam *et. al*. (2009)** in bitter gourd also reported similar association of fruit yield with number of fruits per vine. **Bhave *et. al*. (2003)** and **Sundaram (2010)** in bitter gourd reported similar association of fruits per vine with vine length.

Vine length showed significant positive association with number of nodes bearing first male and female flower, fruit length, fruit weight and number of seeds per fruit at genotypic level. Similar results were also reported by **Fayeun *et. al.* (2012)** in fluted pumpkin and **Selvi *et. al.* (2012)** in pumpkin. The number of primary branches per vine exhibited significant positive correlations with percent of fruit setting, number of fruits per vine, fruit length and fruit diameter at genotypic level, while number of nodes bearing first male flower at genotypic level. The days taken to opening of first male flower showed positive significant association at genotypic level with the traits like, days taken to opening of first female flower, vitamin C and number of seeds per fruit. Similar finding were also confirmed by **Arunkumar *et. al.* (2011)** & **Hossain *et. al.* (2010)** in cucumber and **Rao *et. al.* (2002)** in ridge gourd. The number of nodes bearing first male flower reported the significant positive correlation with number of nodes bearing first female flower, percent of fruit setting and fruit length at genotypic level. The similar results had also been reported earlier by **Singh *et. al.* (2014)** in bitter gourd. Days taken to opening of first female flower showed positive association at genotypic level with number of seeds per fruit. The results of present studies are in line with **Selvi *et. al.* (2012)** in pumpkin. The number of nodes bearing first female flower showed significant positive association at genotypic level with fruit weight. These finding are in harmony with **Selvi *et. al.* (2012)** in pumpkin and **Mandal *et. al.* (2015)** in bottle gourd. Percent of fruit setting exhibited significant positive correlations with number of fruit per vine, fruit length, ascorbic acid and number of seeds per fruit at genotypic level. The number of fruits per vine had significant positive correlations with fruit length, fruit weight and number of seeds per fruit both at genotypic level. These results are also confirmed by **Hossain *et. al.* (2010)** in cucumber; **Selvi *et. al.* (2012)** in pumpkin and **Mandal *et. al.* (2015)** bottle gourd. Fruit length associated positively and significantly with fruit weight and fruit diameter at genotypic level. Similar results had also been reported earlier by **Afangideh & Uyoh (2007)**, **Hossain *et. al.* (2010)** & **Arunkumar *et. al.* (2011)** in cucumber and **Khan *et. al.* (2016)** in snake gourd. The fruit weight exhibited significant positive correlations with number of seeds per fruit at genotypic level. Similar results were also reported by **Hossain *et. al.* (2010)** & **Mandal *et. al.* (2015)** in cucumber and **Singh *et. al.* (2014)** in bitter gourd. The significant positive correlation was recorded with number of seeds per fruit at genotypic level. The significant positive correlation was recorded with days taken to opening of first male flower, percent of fruit setting and fruit length genotypic level. These finding are in harmony with those of **Selvi *et. al.* (2012)** in pumpkin and **Singh *et. al.* (2014)** in bitter gourd.

Among all the traits studied, fruit weight had high positive direct effect on fruit yield per vine, whereas number of seeds per fruit, fruit diameter, days to opening of first male flower and percent of fruit setting showed moderate positive direct effect on fruit yield per vine at genotypic level. The number of primary branch per vine showed positive and direct effect on fruit yield per vine at genotypic level, but in very low frequency. Some other traits like, vine length, number of nodes bearing first male and female flower, days taken to opening of first female flower, fruit length, number of fruit per vine and ascorbic acid exhibited moderate to negligible negative direct effects on genotypic level on fruit yield per vine. **Srivastava & Srivastava (1976)**, **Miah *et. al.* (2000)** & **Bhave *et. al.* (2003)** in bitter gourd and **Bharathi *et. al.* (2005)** in spine gourd reported negative low direct effects of days to first pistillate flower appearance on fruit yield. Based on the traits, which had positive and negative direct effects on fruit yield could be exploited for selection to improve bitter gourd as they are directly responding for selection. The indirect effect for almost all the traits on fruit yield per vine was positive *viz.*, vine length, number of primary branches per vine, number of nodes bearing first male and female flower, number of fruit per vine, fruit length, fruit weight and number of seeds per fruit at genotypic level. The remaining traits showed negative indirect effect on fruit yield per vine. Similar results were also obtained by **Latif *et. al.* (2008)** in ash gourd;

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Singh *et. al.* (2012) in bottle gourd. Vine length reported positive indirect effect on fruit yield per vine through percent of fruit setting and ascorbic acid, while number of primary branches per vine, days taken to opening of first male and female flower, number of nodes bearing first male and female flower, number of fruit per vine, fruit length and fruit weight had negative indirect effect on fruit yield per vine. These findings are also harmony with **Arunkumar *et. al.* (2011)** in cucumber; **Kumar *et. al.* (2013)** in sponge gourd. Number of primary branches per vine had moderate positive indirect effect via vine length, days taken to opening of first male and female flower, number of nodes bearing first male and female flower, percent of fruit setting, number of fruit per vine, fruit length, fruit weight, fruit diameter, vitamin C and number of seeds per fruit. The results are in similar with **Arunkumar *et. al.* (2011)** in cucumber; **Kumar *et. al.* (2013)** in sponge gourd.

Number of fruit per vine had positive and moderate indirect effect via number of nodes bearing first male and female flower and days taken to opening of first female flower on fruit yield per vine. On the other hand, fruit length had positive and moderate indirect effect via negative effect through vine length, number of primary branches per vine, number of nodes bearing first male flower, percent of fruit setting, number of fruit per vine, fruit weight, fruit diameter and number of seeds per fruit, while positive effect through days taken to opening of first male and female flower, number of nodes bearing first female flower and vitamin C on fruit yield per vine. These findings are also harmony with **Latif *et. al.* (2008)** in ash gourd; **Hossain *et. al.* (2010)** & **Arunkumar *et. al.* (2011)** in cucumber. Fruit weight had maximum positive indirect effect via vine length, number of primary branches per vine, number of nodes bearing first male and female flower, number of fruit per vine, fruit length and number of seeds per fruit, while fruit weight showed negative effect through days taken to opening of first male and female flower, percent of fruit setting, fruit diameter and vitamin C on fruit yield per vine. The results were in conformity with the finding of **Latif *et. al.* (2008)** in ash gourd; **Hossain *et. al.* (2010)** & **Arunkumar *et. al.* (2011)** in cucumber. Fruit diameter had negative and low indirect effect via positive effect through vine length, number of primary branches per vine, days taken to opening of first male and female flower, number of fruit per vine, fruit length and ascorbic acid, while negative effect through number of nodes bearing male and female flower, percent of fruit setting, fruit weight and number of seeds per fruit on fruit yield per vine. Ascorbic acid had negative and moderate indirect effect via number of primary branches per vine, days taken to opening of first male and female flower, number of nodes bearing first male and female flower, percent of fruit setting, number of fruits per vine, fruit diameter and number of seeds per fruit, while positive effect through vine length, fruit length and fruit weight on fruit yield per vine.

Conclusion

The results of correlation studies suggest that fruit yield per plant can be improved by selecting strains for vine length, number of primary branches per vine, number of fruit per vine, fruit length and fruit weight. Importance must be given for the traits having direct effects like, fruit weight, number of seeds per fruit, fruit diameter and percent of fruit setting while exercising selection to improve the yield. The indirect effect also showed that most of the traits influenced the yield through vine length, number of primary branches per vine, number of fruit per vine, fruit length, fruit weight and number of seeds per fruit.

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Table 1. Genotypic correlation coefficients in bitter gourd (*Momordica charantia* L.)

Characters	No. of primary branch / vine	Days to opening of first male flower	No. of nodes bearing first male flower	Days to opening of first female flower	No. of nodes bearing first female flower	percent of fruit setting	No. of fruit per vine	Length of fruit (cm)	Weight of fruit (g)	Diameter of fruit (cm)	Vit. C (mg/100 g)	Number of seeds/ fruit	Fruit yield/ vine (kg)
Length of vine (cm)	0.047	0.020	0.425**	0.020	0.685**	-0.018	0.009	0.320*	0.599**	0.075	-0.017	0.262*	0.254*
No. of primary branch/ vine	X	0.189	0.264*	0.093	0.079	0.573**	0.760**	0.678**	0.186	0.414**	0.308*	0.175	0.269*
Days to opening of first male flower		X	-0.097	0.984**	-0.073	0.089	0.014	-0.012	-0.012	0.119	0.262*	0.478**	-0.042
No. of nodes bearing first male flower			X	-0.128	0.576**	0.540**	-0.049	0.393**	0.251	-0.154	0.112	0.163	0.068
Days to opening of first female flower				X	-0.074	0.057	-0.068	-0.061	-0.019	0.047	0.232	0.446**	-0.091

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No. of nodes bearing first female flower					X	-0.038	-0.053	-0.024	0.293*	-0.052	0.221	0.196	0.068
percent of fruit setting						X	0.255*	0.621**	-0.063	-0.006	0.335*	0.195	-0.002
No. of fruit per vine							X	0.429**	0.256*	0.166	0.143	0.311*	0.355**
Length of fruit (cm)								X	0.374**	0.462**	-0.018	0.213	0.328*
Weight of fruit (g)									X	-0.187	-0.219	0.288*	0.776**
Diameter of fruit (cm)										X	0.171	-0.116	-0.155
Vit. C (mg/100 g)											X	0.094	-0.408**
Number of seeds/ fruit												X	0.209
Fruit yield/ vine (kg)													X

*** - Significant at 5.0% level** ****- Significant at 1.0% level**

Table 2. Direct and indirect effect of yield components on fruit yield in bitter gourd (*Momordica charantia* L.)

Characters	Length of vine (cm)	No. of primary branch	Days to opening of first male flower	No. of nodes bearing first male flower	Days to opening of first female flower	No. of nodes bearing first female flower	Percent of fruit setting	No. of fruits per vine	Length of fruit (cm)	Weight of fruit (g)	Diameter of fruit (cm)	Vit. C (mg/100g)	No. of seeds per fruit	Fruit yield/ vine (kg)
Length of vine (cm)	-0.354	-0.016	-0.007	-0.137	-0.007	-0.233	0.006	-0.003	-0.113	-0.212	-0.026	0.006	-0.091	0.254
No. of primary branch	0.004	0.087	0.016	0.021	0.008	0.006	0.048	0.065	0.058	0.016	0.035	0.026	0.015	0.263
Days to opening of first male flower	0.004	0.039	0.216	-0.018	0.211	-0.016	0.019	0.003	-0.002	-0.003	0.026	0.056	0.101	-0.042
No.of nodes bearing first male flower	-0.049	-0.030	0.011	-0.127	0.013	-0.065	-0.062	0.006	-0.045	-0.029	0.017	-0.013	-0.020	0.061

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Days to opening of first female flower	-0.009	-0.039	-0.418	0.042	-0.428	0.029	-0.024	0.029	0.026	0.008	-0.021	-0.098	-0.188	-0.091
No. of node bearing first female flower	-0.043	-0.004	0.005	-0.034	0.004	-0.066	0.003	0.003	0.002	-0.019	0.003	-0.013	-0.013	0.064
Percent of fruit setting	-0.004	0.115	0.018	0.102	0.012	-0.009	0.208	0.053	0.128	-0.013	-0.002	0.069	0.038	-0.002
No. of fruits per vine	0.000	-0.039	-0.001	0.002	0.004	0.003	-0.013	-0.053	-0.023	-0.014	-0.009	-0.008	-0.016	0.355
Length of fruit (cm)	-0.294	-0.608	0.011	-0.323	0.057	0.022	-0.565	-0.395	-0.921	-0.344	-0.423	0.017	-0.194	0.328
Weight of fruit (g)	0.839	0.254	-0.017	0.319	-0.026	0.395	-0.088	0.359	0.523	1.401	-0.261	-0.302	0.397	0.776
Diameter of fruit (cm)	0.019	0.105	0.031	-0.035	0.013	-0.011	-0.002	0.043	0.119	-0.048	0.258	0.043	-0.030	-0.155
Vit. C (mg/100g)	0.003	-0.049	-0.042	-0.016	-0.037	-0.034	-0.054	-0.023	0.003	0.035	-0.028	-0.164	-0.015	-0.404
No. of seeds per fruit	0.072	0.049	0.130	0.044	0.122	0.055	0.051	0.086	0.059	0.079	-0.032	0.025	0.279	0.206

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