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CORRELATION AND PATH ANALYSIS OF YIELD AND YIELD COMPONENTS IN SOME GENETIC STOCKS OF BITTER GOURD (*Momordica charantia* L.)

N. GUPTA[1], M.L. BHARDWAJ[2], S.P. SINGH[3] and S. SOOD[4*]

[1, 2, 3]Department of Vegetable Science, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni Solan, 173 230
[4]Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Agricultural University, Palampur176 062, Himachal Pradesh, India
[*]Corresponding author's email: soniasood2005@rediffmail.com
Co-authors' email addresses: guptanavi38@gmail.com

SUMMARY

Bittergourd (*Momordica charantia* L.) is an important cucurbitaceous crop due to its potential to return profit, nutritional value, and production potential. The experiment was carried out with 26 genotypes including check (Solan Hara) in randomized complete block design with 3 replications to study the association among yield and yield components, their direct and indirect influence on total marketable fruit yield. Correlation of various characters with yield is useful and provides criteria for direct selection of component characters. While selection for yield, improvement of yield contributing characters, which can be better ascertained if the nature and kind of association of such traits with yield is available, must be considered. The characters average fruit weight (0.726), marketable fruits per vine (0.547) and seeds per fruit (0.377) exhibited positive phenotypic association while marketable fruits per vine (0.684), seeds per fruit (0.625), average fruit weight (0.591) and node at which first female flower appears (0.338) showed genotypically positive association with total marketable fruit yield per hectare. Marketable fruits per vine (0.560) had maximum positive direct effect on total marketable fruit yield per hectare followed by average fruit weight (0.528), seeds per fruit (0.299), number of days to first female flower appearance (0.282), branches per plant (0.117) and node at which first female flower appears (0.107).

Key words: Bitter gourd (*Momordica charantia* L.), phenotypic correlation, genotypic correlation, horticultural traits, path analysis

Key findings: Improvement in any crop depends upon magnitude of genetic variability and extent to which desired characters are heritable. Although, the correlation coefficient indicates the nature of association among traits, path analysis splits the correlation coefficient into measures of direct and indirect effects. This study was therefore taken out to evaluate the performance and association of different bitter gourd genotypes with regard to yield and its contributing traits.

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INTRODUCTION

Bitter gourd (*Momordica charantia* L.) also called bitter melon, is a tropical and subtropical crop belonging to the family Cucurbitaceae which has 90 genera and 750 species. It is grown up to an elevation of 1600-1700 m above mean sea level. The center of origin of this crop is India, with a secondary center of diversity in China and South East Asia (Gruthew, 1977). It is a common cucurbit of wild flora of tropical Africa which offers great resources for breeding of cultivated bitter gourd for desirable qualitative traits, tolerance to biotic and abiotic factors etc. Bitter gourd is a valuable vegetable owing to its high nutritive and medicinal properties. The plants contain several biologically active compounds chiefly momordicin and cucurbitacin. Thus, bitter gourd being an important vegetable crop requires a systematic breeding program for enhancement in its yield potential and other horticultural traits. The wild species offer great resource for breeding of cultivated bitter gourd varieties with desirable qualitative traits and tolerance to various biotic and abiotic stresses.

Yield is a complex character which is highly influenced by environment, hence selection based on yield alone may limit the improvement, whereas yield component characters are less complex in inheritance and influenced by the environment to a lesser extent. Thus, effective improvement in yield may be brought about through selection of various yield component characters, which show association among themselves and also with yield. Plant breeder has to find simple correlation and the extent of direct and indirect effects of attributes with seed yield that could be useful to predict superior cross combinations and to identify traits for ideal plant type and aid in indirect selection. In the present study phenotypic and genotypic correlations were employed to determine direct and indirect effects of yield and yield contributing characters in selection of superior cross combinations in bitter gourd genotypes.

MATERIALS AND METHODS

Twenty six genotypes including check were planted in randomized complete block design (RCBD) at experimental farm of Department of Vegetable Science, Dr. Y.S. Parmar University of Horticulture and Forestry at Nauni, Solan, Himachal Pradesh, located at 1,270 m above mean sea level during *kharif* season of 2012. The field is located at 30°51'N latitude, 70°11'E longitude. The location is characterized by sub-tropical climate representing mid-hills of Himachal Pradesh.

Planting material

The material used for the present studies comprised of 26 genotypes of bitter gourd including check (Solan Hara), grown in a RCBD with 3 replications at the Experimental Farm of Department of Vegetable Science, Solan, Himachal Pradesh. Observations were recorded on 10 randomly selected plants in each variety /replication for yield and its contributing traits. The phenotypic and genotypic coefficient of variation was carried out as suggested by Panse and Sukhatme (1967). Path analysis was carried out as per the method suggested by Dewey and Lu (1959).

Field activities and data collection

The soil of experiment was clay loam and acidic (pH = 5.7). The field was ploughed and leveled properly. Raised beds were formed to facilitate drainage during the rainy season. Each entry/progeny was accommodated in 3 rows spaced 2.0 m apart with intra-row spacing of 1.0 m. About 10 Mt ha^{-1} of Farm Yard Manure and chemical fertilizers @ 100kg N, 55 kg P_2O_5 and 45 kg K_2O ha^{-1} were applied. Half dose of N and full doses of P_2O_5 and K_2O were applied at the time of field preparation and the remaining half dose of N was top dressed in 2 equal amounts, first at earthing up one month after planting and second after one month of first earthing up. All the recommended cultural and management practices were followed to raise a good crop.

Observations were recorded on vine length (m), branches per plant, days to first female flower appearance, node at which first female flower appeared, days to first harvest, fruit size (cm^2), ridges per fruit, marketable fruit per vine, average fruit weight (g), fruit yield per plant, seeds per fruit and total marketable fruit yield·ha^{-1}.

Statistical analysis

SPAR-I (developed by the Indian Agricultural Statistic Research Institute, New Delhi, India) software was used for statistical analysis. The genotypic and phenotypic correlation coefficients were calculated as per Al-Jibouri, *et al*. (1958) by using ANOVA-covariance matrix in which total variability has been split into replications, genotypes and errors.

Coefficients of correlation

Phenotypic coefficient of correlation

r_p	=	$Vpxy / \sqrt{Vpx \cdot Vpy}$
Vpxy	=	Phenotypic covariance between X and Y
Vpx	=	Phenotypic variance of X
Vpy	=	Phenotypic variance of Y

Genotypic coefficient of correlation

$$r_g = Vgxy / \sqrt{Vgx.Vgy}$$

Path coefficient analysis

The path coefficient analysis of those characters which had shown significant correlations with yield was done by the method given by Dewey and Lu (1959). The path coefficients were obtained by simultaneous selection of following equations, which expresses the basic relationship between genotypic correlation (r) and path coefficient (P).

$$r_{14}: P_{14} + P_{24}r_{12} + P_{34}r_{13}$$
$$r_{24}: P_{14}r_{21} + P_{24} + P_{34}r_{23}$$
$$r_{34}: P_{14}r_{31} + P_{24}r_{32} + P_{34}$$

where, r_{14}, r_{24} and r_{34} are genotypic correlations of component characters with yield (dependent variable) and r_{12}, r_{13} and r_{23} are the genotypic correlations among component characters (independent variables). The direct effects were calculated by the following set of equations:

$$P_{14} = C_{11}r_{14} + C_{12}r_{24} + C_{13}r_{34}$$
$$P_{24} = C_{21}r_{14} + C_{22}r_{24} + C_{23}r_{34}$$
$$P_{34} = C_{31}r_{14} + C_{32}r_{24} + C_{33}r_{34}$$

where, $C_{11,}$ $C_{22,}$ C_{23} and C_{33} are constants derived by using abbreviated Doulittle's technique as explained by Goulden (1959).

$r_{12}P_{24}$, $r_{13}P_{34}$, $r_{21}P_{14}$, $r_{23}P_{34}$, $r_{31}P_{14}$, $r_{32}P_{24}$ are indirect effects.

RESULTS AND DISCUSSIONN

The estimation of genotypic coefficient of variation measures the extent of genetic variation among the genotypes within the particular character**s**. Correlation coefficient among characters was worked out at phenotypic and genotypic levels (Table 1). In general, genotypic correlation coefficients were high**er** in magnitude than phenotypic correlation coefficients. Phenotypic correlation coefficient among different characters showed that total marketable fruit yield per hectare had positive and significant association with average fruit weight (0.726) followed by marketable fruits per vine (0.547), seeds per fruit (0.377) at 1% level of significance. Average fruit weight had positive significant correlation with seeds per fruit (0.227). Marketable fruits per vine were positively correlated with seeds per fruit (0.315). Genotypic correlation coefficient among different characters revealed that total marketable fruit yield per hectare had significant positive association with marketable fruits per vine (0.684), seeds per fruit (0.625), average fruit weight (0.591) and node at which first female flower appears (0.338) at 1% level of significance while negative association with vine length (-0.390). Marketable fruits per vine were significantly correlated with number of seeds per fruit (0.404). Branches per plant had positive and significant genotypic correlation with average fruit weight (0.241), ridges per fruit (0.297), days to first picking (0.311), days to first female flower appearance (0.350) and vine length (0.501) at 1% level of significance. Similarly, node at which first female flower appears had positive correlation with average fruit weight (0.226) and days to first picking (0.419).

Table 1. Estimates of correlation coefficients at phenotypic (P) and genotypic (G) levels in various genotypes of bitter gourd (*M. charantia* L.)

Traits		VN	BP	DFFA	NFFA	FP	FS	RPF	MFV	AFW	FYPP	SPF	TMFYPH
VN	P	1.000	0.359**	0.216	0.126	0.075	0.326**	0.073	-0.280*	-0.048	-0.190	-0.844	-0.190
	G	1.000	0.501**	0.581**	0.331**	0.249*	0.417**	0.169	-0.516**	-0.010	-0.390**	-0.111	-0.390**
BP	P		1.000	0.145	0.083	0.114	0.044	0.276*	-0.156	0.134	0.016	-0.056	0.016
	G		1.000	0.350**	0.167	0.311**	0.042	0.297**	-0.187	0.241*	0.030	-0.056	0.030
DFFA	P			1.000	0.303**	0.711**	0.046	-0.058	0.090	-0.238*	-0.095	-0.209	-0.095
	G			1.000	0.561**	0.628**	0.097	0.118	0.214	-0.470**	-0.141	-0.428**	-0.141
NFFA	P				1.000	0.193	0.116	-0.018	0.018	0.131	0.141	0.088	0.141
	G				1.000	0.419**	0.211	0.001	0.149	0.226*	0.338**	0.074	0.338**
FP	P					1.000	-0.067	0.060	0.089	-0.114	-0.018	-0.081	-0.018
	G					1.000	-0.155	0.092	0.360**	0.550**	-0.110	-0.124	-0.110
FS	P						1.000	-0.059	-0.134	0.020	-0.085	0.155	-0.085
	G						1.000	-0.084	-0.163	0.039	-0.116	0.175	-0.116
RPF	P							1.000	0.001	-0.041	-0.070	0.137	-0.070
	G							1.000	0.062	-0.079	-0.064	0.205	-0.064
MFV	P								1.000	-0.144	0.547**	0.315**	0.547**
	G								1.000	-0.176	0.684**	0.404**	0.684**
AFW	P									1.000	0.726**	0.227*	0.726**
	G									1.000	0.591**	0.418**	0.591**
FYPP	P										1.000	0.377**	1.000**
	G										1.000	0.625**	1.000**
SPF	P											1.000	0.377**
	G											1.000	0.625**
TMFYPH	P												1.000
	G												1.000

VN = Vine length, BPP = Branches per plant, DFFA = Days to first female flower appearance, NFFFA = Node at which first female flower appears, DFP = Days to first picking, FS = Fruit size, RPF = Ridges per fruit, HD = Harvest duration, MFV = Marketable fruits per vine, AFW = Average fruit weight, FYPP = Fruit yield per plant, SPF = Seeds per fruit, TMFYPH = Total marketable fruit yield per hectare

** Significant at 1% level of significance * Significant at 5% level of significance

Table 2. Estimates of direct and indirect effects of different characters on total marketable fruit yield per hectare at genotypic level in bitter gourd (*M. charantia* L.)

Character	Vine length (m)	Branches per plant	Days to first female flower appearance	Node at which first female flower appears	Days to first picking	Fruit size (cm^2)	Ridges per fruit	Marketable fruits per vine	Average fruit weight (g)	Seeds per fruit	Coefficient of correlation with total marketable fruit yield per ha (q)
Vine length (m)	-0.202	0.059	0.164	0.035	-0.049	-0.046	-0.024	-0.289	-0.005	-0.033	-0.390**
Branches per plant	-0.101	0.117	0.098	0.018	-0.061	-0.005	-0.042	-0.105	0.127	-0.017	0.030
Days to first female flower appearance	-0.117	0.041	0.282	0.060	-0.123	-0.011	-0.017	0.119	-0.248	-0.128	-0.141
Node at which first female flower appears	-0.066	0.019	0.158	0.107	-0.082	-0.023	-0.00007	0.083	0.119	0.022	0.338**
Days to first picking	-0.050	0.036	0.177	0.044	-0.195	0.017	-0.013	0.201	-0.290	-0.037	-0.110
Fruit size (cm^2)	-0.084	0.005	0.027	0.023	0.030	-0.110	0.012	-0.091	0.020	0.052	-0.116
Ridges per fruit	-0.034	0.035	0.033	0.00005	-0.018	0.009	-0.143	0.034	-0.042	0.061	-0.064
Marketable fruits per vine	0.104	-0.022	0.060	0.016	-0.070	0.018	-0.008	0.560	-0.093	0.121	0.684**
Average fruit weight (g)	0.002	0.028	-0.132	0.024	0.107	-0.004	0.011	-0.098	0.528	0.125	0.591**
Seeds per fruit	0.022	-0.006	-0.120	0.007	0.024	-0.019	-0.029	0.226	0.221	0.299	0.625**

Diagonal elements are direct effects
Residual effect = 0.003

The results are in line with the findings of Srivastava and Srivastava (1976), Lawande and Patil (1989), Bhave *et al*. (2003), Raja *et al.* (2007) and Kumar *et al.* (2008).), Mangal *et al.* (1983), Ranpise *et al.* (1992), Paranjape and Rajput, (1995), Dey *et al.* (2005), Hanchinamani and Patil (2009), Kumar *et al.* (2011) and Veena *et al.*(2013) and Pathak *et al*. (2014).

Path coefficient analysis depicts the effect**s** of different independent characters individually and in combination with other character on fruit yield. The data on path coefficient analysis at genotypic level showing direct and indirect effects of significant characters over total marketable fruit yield per hectare is tabulated in Table 2.

The perusal of data revealed that marketable fruits per vine (0.560) had maximum positive direct effect on total marketable fruit yield per hectare followed by average fruit weight (0.528), seeds per fruit (0.299), days to first female flower appearance (0.282), branches per plant (0.117) and node at which first female flower appears (0.107). The negative direct effect on total marketable fruit yield per hectare was shown by characters vine length (- 0.202), days to first picking (-0.195), number of ridges (-0.143) and fruit size (-0.110).

Maximum positive indirect effect**s** on total marketable fruit yield per hectare was exhibited by seeds per fruit (0.226) via marketable fruits per vine followed by seeds per fruit (0.221) through average fruit weight, days to first picking (0.201) via marketable fruits per vine, days to first picking (0.177) via days to first female flower appearance, vine length (0.164) through days to first female flower appearance, node at which first female flower appears (0.158) via days to first female flower appearance, number of branches (0.127) via average fruit weight, average fruit weight (0.125) through seeds per fruit, marketable fruits per vine (0.121) via seeds per fruit, node at which first female flower appears (0.119) via average fruit weight and days to first female flower appearance (0.119) through marketable fruits per vine, respectively.

Maximum negative indirect effects on total marketable fruit yield per hectare was shown by days to first picking (-0.290) via average fruit weight followed by vine length (-0.289) via marketable fruits per vine, days to first female flower appearance (-0.248) through average fruit weight, average fruit weight (-0.132) via days to first female flower appearance, days to first female flower appearance (-0.128) via number of seeds and same character (-0.117) via vine length. Similar findings were also reported by Hanchinamani and Patil (2009), Kumar *et al.* (2008), Kumar *et al.* (2011), Kutty and Dharmatti (2005), Lawande and Patil (1989), Ying *et al.* (2004), Dey *et al.* (2005), Ranpise *et al.* (1992), Paranjape and Rajput (1995), Bhave *et al.* (2003), Ying *et al.* (2004) and Veena *et al.* (2013) and Pathak *et al*. (2014). The residual value (0.003) indicated that the effect of the remaining characters other than those studied had negligible effects.

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