Correlation and Path coefficient analysis in Bitter gourd (*Momordica charantia* L.) genotypes

Abstract

The present investigation wasundertakenattheExperimentalfield of Urban Technological Park Habbak, Srinagar, Jammu and Kashmirduring *kharif*-2022. The experiment was laid outin Randomized Block Designwith three replications and plant spacing of 2×1 m for thirty genotypes in order 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. Observations were recorded on variousgrowth and yield traits, seed traits and quality parameters. Positive and significant correlation was noted for fruit yield ha^{-1} with number of male flowers plant^{-1}, number of female flowers plant^{-1}, vine length (m), number of fruits, average fruit weight (g), leaf area (cm^2), number of seeds fruit^{-1}, seed weight fruit^{-1} and fruit yield plant^{-1} both at genotypic and phenotypic levels.Path coefficient analysis disclosed that traits such as number of fruits per plant, vine length (m), number of female flowers, average fruit weight(g) and number of seeds per fruit should be given due importance by selection for breeding of new cultivars as they exhibited the highest directeffects on the fruit yield ha^{-1}.

Key words: Bitter gourd, correlation, path analysis

Introduction

Bitter gourd (*Momordica charantia* L.) also known as bitter melon, is a tropical and subtropical crop belonging to the family Cucurbitaceae which includes 90 genera and 750 species. The primary centre of origin of this crop is India, with a secondary centre of diversity in China and South East Asia (Gruthew, 1977). Bitter gourd is a valuable vegetable owing to its high nutritive and medicinal properties. The plants contain several biologically active compounds chiefly momordicine and cucurbitacin. Considerable variation in different nutrients, including carbohydrates, ascorbic acid, zinc, iron, calcium, magnesium, phosphorus and protein content has been observed in bitter gourd (Kale *et al.*, 1991). Thus, bitter gourd being an important vegetable crop requires a systematic breeding program for enhancement in its yield potential and other horticultural traits. Yield is a highly 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 needs to obtain the simple correlations as well as the extent of direct and indirect effects of attributes on 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. Path coefficient provides a better index for selection than mere correlation coefficient by partitioning the correlation coefficients between yield and its components into direct and indirect effects. The information on such aspects can be of great help in formulating an appropriate breeding strategy for genetic upgradation of this crop.

Materials and methods

The present research study was carried out at the experimental field of Urban Technological Park, Habbak, Srinagar, Jammu and Kashmir during *kharif*-2022. It is situated at an altitude of 1608 meters above mean sea level lying between 34.16^0 North latitude and 74.83^0 East longitude.The climate is temperate characterized by mild summers. The mean minimum and maximum temperatures are 2.42 ºC and 30ºC recorded in the months of October and August-September (respectively). The maximum rain fall is received during June. The experimental material consisted of thirty genotypes of bitter gourd which were obtained from various sources. The field experiment was laid out using Randomized Block Design comprising of thirty treatments and three replications. Recommended agronomic practices were followed to raise a good crop. Observations were recorded on 24 quantitative and quality traits viz. days to appearance of 1st male flower, days to appearance of 1st female flower, number of male flowers plant^{-1}, node at which 1st female flower appears, number of female flowers plant^{-1}, vine length (m), fruit length (cm), fruit diameter (cm), number of fruits plant^{-1}, average fruit weight (g), leaf area (cm^2), 100 seed weight (g), number of seeds fruit^{-1}, seed weight fruit^{-1}(g), days to 1st fruit harvest, fruit yield plant^{-1} (kg), fruit yield hectare^{-1} (q), TSS (°Brix), crude protein (%), vitamin C content (mg/100g), iron content (mg/100g), total chlorophyll content (mg/100g), dry matter content (%) and total phenols (mg/100g).The observations on different parameters were taken from three randomly selected plants from each line of all replications.

Estimates of genotypic and phenotypic variances and covariances were substituted in the formula suggested by Panse and Sukatme (1985) so as to calculate the correlation coefficients between all possible pairs of characters. The methodology suggested by Wright (1921) and Li (1956) was adopted while using the formula given by Dewey and Lu (1959) to carry out path coefficient analysis. All the above computations were carried out using the R software at the Division of Agricultural statistics, SKUAST-Kashmir, Shalimar.

Results and discussions

In the present study, the correlation coefficients were computed and path analysis carried out among thirty different genotypes of bitter gourd. In order to make indirect selection for the enhancement of economic traits, knowledge of the associationbetween various attributes and economic traits is required. Studies of correlation help us in understanding the relationships that exist between highly heritable traits and the economic traits and how each trait contributes to the genetic make-up of a crop. Genotypic correlations provide an estimate of inherent association between genes controlling any two characters. Hence, it is of greater significance and could be effectively utilized in formulating an effective selection scheme. Perusal (Table-1) indicated that in the present investigation, the magnitude of the genotypic correlation coefficients was higher than the phenotypic coefficients, establishingthe predominance of heritable components and demonstrating the additive nature of gene action for these traits.

Correlation coefficients disclosed that the economically important trait, i.e. fruit yield hectare^{-1} was found to have a positive and significant correlation with the traits; number of male flowers plant^{-1} (r_g = 0.391, r_p = 0.392), number of female flowers plant^{-1} (r_g = 0.883, r_p = 0.878), (Yadagiri *et al*., 2017), vine length (r_g = 0.93, r_p = 0.913) (Rani *et al.* , 2015), number of fruits plant^{-1} (r_g = 0.919, r_p = 0.916) (Khan *et al.*, 2015) , average fruit weight (r_g = 0.493, r_p = 0.459) (Gupta *et al*., 2015), leaf area (r_g = 0.518, r_p = 0.51), number of seeds fruit^{-1} (r_g = 0.591, r_p = 0.587), seed weight fruit^{-1} (r_g = 0.429, r_p = 0.419) and fruit yield plant^{-1} (r_g = 0.997, r_p = 0.973) both at genotypic and phenotypic levels. A positive and significant phenotypic correlation of this trait with fruit length (r_p = 0.295) and fruit diameter (r_p = 0.294) was also observed. Similar results were observed by Prasad *et al.* (2018), Prasanth *et al.* (2020) and Reddy *et al.* (2022).Also, the traits days to appearance of 1st male flower (r_g = -0.71, r_p = -

0.693), days to appearance of 1st female flower (r_g = -0.435, r_p =- 0.42), node number at which 1st female flower appeared (r_g = -0.361, r_p = -0.39) and days to 1st fruit harvest (r_g = -0.396, r_p =- 0.39) exhibited negative and significant genotypic as well as phenotypic correlation with fruit yield hectare^{-1}. These findings were similar to those reported by Yadav *et al.* (2013), Singh *et al.* (2015) and Prasad *et al.* (2018). These mentioned traits may be given primary importance during the course of selection to enhance the yield of Bitter gourd.

Correlation analysis indicates the association pattern of component traits with yield, it simply represents the overall association of a particular trait with yield rather than providing cause and effect relationship. The technique of path coefficient analysis developed by Wright (1921) and demonstrated by Dewey and Lu (1959) facilitates in partitioning the correlation coefficients into direct and indirect contribution of various traits on yield. As such, it measures the direct influence of one variable upon other. Such information would be of great value in enabling the breeder to specifically identify important component traits of yield and utilize the genetic stock for improvement in a planned way.Path coefficient can be simply defined as a standardized partial regression coefficient which in addition to measuring the direct effect of one variable on the other splits the correlation coefficients into measures of direct and indirect effects.

In the present study the path coefficient analysis (Table-2) disclosed that the highest direct positive effect on fruit yield ha^{-1} was exerted by number of fruits plant^{-1} (0.8504) (Khan *et al.*, 2015) followed by vine length (0.7102) (Reddy *et al.*, 2022), number of female flowers plant^{-1} (0.5603), average fruit weight (0.4844) (Gupta *et al.*, 2015) and number of seeds fruit^{-1} (0.3912). The genotypic correlation coefficients of these characters with fruit yield ha^{-1} were equal to 0.919, 0.93, 0.883, 0.493 and 0.591 respectively indicating that direct selection of these traits will be effective in developing bitter gourd cultivars with improved yield potential. Similar results were observed by Singh *et al.* (2015), Yadagiri *et al.* (2017) and Triveni *et al.* (2021). The direct effects of component traits like days to appearance of 1st male flower (-0.2539), days to appearance of 1st female flower (-0.1271), node number at which 1st female flower appeared (-0.1068) and days to 1st fruit harvest (-1204) were negative. Therefore, these traits should be considered of little importance in the selection programme of Bitter gourd. These results are in agreement with those reported by Islam *et al.* (2009), Singh *et al.* (2015), Prasanth *et al.* (2020) and Tiwari *et al.* (2021).

The residual effect value in the current study was 0.1023, indicating that the characters selected for the study are the primary contributors to yield and that the characters selected for the current study account for the variability in yield. Similarly, Mahesh *et al.* (2014), Prasanth *et al.* (2020) and Reddy *et al*. (2022) observed very few residual effects while working on the similar traits in bitter gourd.

Table 1: Estimates of genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients among different growth and yield attributing characters in Bitter gourd *(Momordica charantia L.)*

Parameters	DFMF	DFFF	NOMF	NFFF	NOFF	VL	FL	FD	NOF	AFW	LA	100 SW	NSPF	SWPF	DFFH	FYPP	FYPH
DFMF	**1.00**	0.662**	-0.58**	-0.1299	-0.65**	-0.69**	-0.374*	0.1742	-0.70**	-0.1617	-0.389*	-0.2721	-0.2398	-0.3266	0.578**	-0.68**	-0.71**
DFFF	0.647**	**1.00**	-0.51**	0.0438	-0.54**	-0.54**	-0.0549	0.2227	-0.57**	0.2147	-0.1243	-0.1066	-0.2963	-0.3212	0.791**	-0.41*	-0.435*
NOMF	-0.577**	-0.51**	**1.00**	-0.0124	0.927**	0.77**	-0.112	0.1287	0.911**	-0.0241	0.3242	0.1401	0.505**	0.3424	-0.462*	0.3742*	0.3911*
NFFF	-0.1302	0.0535	-0.0123	**1.00**	-0.0629	-0.1174	0.0035	-0.1602	-0.0382	0.1029	-0.0735	0.137	-0.0721	-0.1119	0.0069	-0.354*	-0.361*
NOFF	-0.643**	-0.54**	0.922**	-0.0571	**1.00**	0.91**	0.0409	0.139	0.983**	0.0587	0.431*	0.1146	0.576**	0.3941*	-0.49**	0.898**	0.883**
VL	-0.686**	-0.52**	0.759**	-0.122	0.887**	**1.00**	0.197	0.177	0.935**	0.2186	0.54**	0.0312	0.5243**	0.2804	-0.52**	0.936**	0.93**
FL	-0.364**	-0.0621	-0.1103	0.0209	0.0458	0.1807	**1.00**	-0.2168	0.1107	0.580**	0.1334	0.3196	0.1393	0.3907*	0.0575	0.2904	0.3011
FD	0.1559	0.2351*	0.1197	-0.1732	0.1148	0.1684	-0.2209*	**1.00**	0.1556	0.459**	0.2711	-0.2485	0.3992*	0.0267	0.1196	0.3491	0.3266
NOF	-0.701**	-0.56**	0.907**	-0.0374	0.975**	0.917**	0.1111	0.1342	**1.00**	0.1144	0.46*	0.1193	0.587**	0.4074	-0.52**	0.929**	0.919**
AFW	-0.1594	0.2111*	-0.0237	0.1045	0.0594	0.2129*	0.571**	0.424**	0.1144	**1.00**	0.2829	0.0531	0.224	0.2654	0.2355	0.4578*	0.493*
LA	-0.386**	-0.1237	0.323**	-0.0711	0.429**	0.533**	0.1313	0.2479*	0.459**	0.282**	**1.00**	-0.0605	0.3108	0.0822	-0.1944	0.52**	0.518**
100 SW	-0.2694*	-0.1031	0.1394	0.1321	0.1117	0.036	0.306**	-0.2317*	0.1161	0.052	-0.0598	**1.00**	0.1265	0.643**	0.1386	0.1946	0.1985
NSPF	-0.233*	-0.29**	0.499**	-0.0521	0.572**	0.499**	0.1443	0.3436**	0.579**	0.2237*	0.30**	0.1212	**1.00**	0.707**	-0.1692	0.615**	0.591**
SWPF	-0.324**	-0.30**	0.336**	-0.1214	0.379**	0.285**	0.366**	0.0513	0.396**	0.256*	0.079	0.634**	0.673**	**1.00**	-0.0376	0.4216*	0.4293*
DFFH	0.568**	0.772**	-0.45**	0.0161	-0.48**	-0.51**	0.0584	0.1012	-0.52**	0.235*	-0.1926	0.1383	-0.159	-0.0417	**1.00**	-0.371*	-0.396*
FYPP	-0.662**	-0.39**	0.3841*	-0.384*	0.874**	0.898**	0.279**	0.315**	0.901**	0.447**	0.50**	0.1871	0.5972**	0.405**	-0.35**	**1.00**	0.997**
FYPH	-0.693**	-0.42**	0.3922*	-0.35*	0.878**	0.913**	0.295**	0.294**	0.916**	0.459**	0.51**	0.197	0.587**	0.419**	-0.39**	0.973**	**1.00**

*, **= Significant at 5% and 1% respectively

DFMF: Days to appearance of 1st male flower
NFFF: Node number at which 1st female flower appears
FL: Fruit length (cm)
AFW: Average fruit weight (g)
NSPF: Number of seeds fruit^{-1}
FYPP: Fruit yield plant^{-1} (kg)

DFFF: Days to appearance of 1st female flower
NOF: Number of female flowers plant^{-1}
FD: Fruit diameter (cm)
LA: Leaf area (cm^2)
SWPF: Seed weight fruit^{-1} (g)
FYPH: Fruit yield hectare^{-1} (q)

NOMF: Number of male flowers plant-^{1}
VL: Vine length (m)
NOF: Number of fruits plant^{-1}
100SW: 100 seed weight(g)
DFFH: Days to 1st fruit harvest

Table 2:

Path matrix showing direct (diagonal) and indirect (off-diagonal) effects of different growth and yield attributing characters on fruit yield of Bitter gourd (*Momordica charantia* L.)

Parameters	DFMF	DFFF	NOMF	NFFF	NOFF	VL	FL	FD	NOF	AFW	LA	100 SW	NSPF	SWPF	DFFH	Corr. Q
DFMF	**-0.2539**	-0.1018	0.0895	0.0200	0.1005	0.1074	0.0575	-0.0268	0.1090	0.0249	0.0599	0.0419	0.0369	0.0503	-0.0890	-0.71**
DFFF	-0.0180	**-0.1271**	0.0140	0.0012	0.0149	0.0147	0.0015	-0.0060	0.0156	-0.0058	0.0034	0.0029	0.0080	0.0087	-0.0215	-0.435*
NOMF	0.2023	0.1800	**0.3476**	0.0043	-0.3226	-0.2677	0.0389	-0.0447	-0.3169	0.0084	-0.1127	-0.0487	-0.1755	-0.1190	0.1609	0.3911*
NFFF	0.0139	0.0047	0.0013	**-0.1068**	0.0067	0.0125	-0.0004	0.0171	0.0041	-0.0110	0.0079	-0.0146	0.0077	0.0120	-0.0007	-0.361*
NOFF	-0.1047	-0.0880	0.1478	-0.0101	**0.5603**	0.1459	0.0065	0.0223	0.1577	0.0094	0.0691	0.0184	0.0924	0.0632	-0.0794	0.883**
VL	0.0769	0.0596	-0.0848	0.0129	-0.1003	**0.7102**	-0.0217	-0.0195	-0.1031	-0.0241	-0.0599	-0.0034	-0.0578	-0.0309	0.0575	0.93**
FL	0.0564	0.0083	0.0169	-0.0005	-0.0062	-0.0297	**0.1509**	0.0327	-0.0167	-0.0876	-0.0201	-0.0482	-0.0210	-0.0590	-0.0087	0.3011
FD	-0.0106	-0.0135	-0.0078	0.0097	-0.0084	-0.0108	0.0132	**0.1608**	-0.0095	-0.0279	-0.0165	0.0151	-0.0243	-0.0016	-0.0073	0.3266
NOF	-0.7331	-0.5956	0.9433	-0.0395	0.7780	0.9679	0.1146	0.1610	**0.8504**	0.1184	0.4761	0.1234	0.6074	0.4215	-0.5462	0.919**
AFW	-0.0783	0.1040	-0.0117	0.0498	0.0284	0.1059	0.2814	0.2227	0.0554	**0.4844**	0.1370	0.0257	0.1085	0.1285	0.1141	0.493*
LA	0.0208	0.0066	-0.0173	0.0039	-0.0230	-0.0290	-0.0071	-0.0145	-0.0246	-0.0151	**0.3534**	0.0032	-0.0166	-0.0044	0.0104	0.518**
100 SW	-0.0317	-0.0124	0.0163	0.0160	0.0134	0.0036	0.0373	-0.0290	0.0139	0.0062	-0.0071	**0.1167**	0.0148	0.0751	0.0162	0.198
NSPF	-0.0458	-0.0567	0.0965	-0.0138	0.1102	0.1002	0.0266	0.0763	0.1122	0.0428	0.0594	0.0242	**0.3912**	0.1353	-0.0323	0.591**
SWPF	0.0816	0.0802	-0.0855	0.0279	-0.0984	-0.0700	-0.0975	-0.0067	-0.1017	-0.0663	-0.0205	-0.1608	-0.1767	**0.2497**	0.0094	0.4293*
DFFH	0.0118	0.0161	-0.0094	0.0001	-0.0101	-0.0106	0.0012	0.0024	-0.0108	0.0048	-0.0040	0.0028	-0.0034	-0.0008	**-0.1204**	-0.396*

RESIDUAL EFFECT= 0.1023

DFMF: Days to appearance of 1st male flower
DFFF: Days to appearance of 1st female flower
NOMF: Number of male flowers plant-1
NFFF: Node number at which 1st female flower appears
NOF: Number of female flowers plant-1
VL: Vine length (m)
FL: Fruit length (cm)
FD: Fruit diameter (cm)
NOF: Number of fruits plant-1
AFW: Average fruit weight (g)
LA: Leaf area (cm^2)
100SW: 100 seed weight(g)
NSPF: Number of seeds fruit-1
SWPF: Seed weight fruit-1 (g)
DFFH: Days to 1st fruit harvest
FYPP: Fruit yield plant-1 (kg)
FYPH: Fruit yield hectare-1 (q)

Conclusion

It is clear from the above discussion that tremendous potential exists for converging the elite allelic resources present in these bitter gourd genotypes through a systematic breeding and selection approach so as to recover high yielding recombinants, with good quality characteristics.The correlation coefficients obtained disclosed that the economically significant trait i.e., fruit yield hectare^{-1} (q) exhibited significant and positive association with number of male flowers plant^{-1}, number of female flowers plant^{-1}, vine length (m), fruit length (cm), fruit diameter (cm), number of fruits, average fruit weight (g), leaf area (cm^2), number of seeds fruit^{-1}, seed weight fruit^{-1} and fruit yield plant^{-1} both at genotypic and phenotypic levels. On the other hand, days to appearance of 1st male flower, days to appearance of 1st female flower, node number at which 1st female flower appeared and days to 1st fruit harvest showed negative and significant association with fruit yield ha^{-1} (q).According to the path coefficient analysis, the traits having highest positive direct effect on fruit yield ha^{-1} (q) were observed to benumber of fruits per plant followed by vine length (m), number of female flowers, average fruit weight(g) and number of seeds per fruit. These characteristics could thus be employed as direct selection criteria for breeding of high yielding bitter gourd genotypes.

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