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Genetic Variability, Correlation and Path Coefficient Analysis for Yield and Yield Attributing Traits in Bitter Gourd (*Momordica charantia* L.)

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Authors' contributions

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

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ABSTRACT

Bitter gourd (*Momordica charantia* L.) is an important commercial cucurbit of family *Cucurbitaceae*. For rational improvement of yield and its components in Bitter gourd, the understanding of nature and magnitude of variation in the available material and association of characters with yield and among themselves and the extent of environmental influence on the characters which is statistically determined by correlation coefficient is although useful in determining the relative influence of the various characters on yield they do not provide an exact picture of the relative importance of the direct and indirect influences of each of the characters towards the yield. Path coefficient analysis proved helpful in partitioning the correlation coefficient into direct and indirect effects. It gives an idea about the contribution of each independent character on dependent character i.e. yield. An experiment was conducted during 2017-18 at Vegetable Research farm, Bihar Agricultural University, Sabour (Bhagalpur) to study the existing genetic variability and to assess interrelationship among sixteen yield and its contributing traits in twenty eight genotypes of bitter gourd of Bihar. The analysis of variance revealed highly significant differences among the genotypes for all the sixteen characters studied indicating that a significant amount of genetic

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variability present in the material. High GCV and PCV were recorded for chlorophyll content, vine length and fruit weight. High estimates of heritability were observed for chlorophyll content, TSS, ascorbic acid, number of seeds per fruit, fruit weight, fruit length, fruit girth and number of fruit per plant is the characters under the study. High heritability accompanied with high genetic advance as percent of the mean were recorded for chlorophyll content this means that improvement in this trait made by simple selection. Correlation analysis revealed that total chlorophyll content; fruit weight and fruit length had a significant and positive association with yield per plant. Path analysis revealed that ascorbic acid, number of seeds per fruit, vine length, TSS, fruit weight, chlorophyll content, node number at which first female flower appear and days to 50% flowering had a positive direct effect on fruit yield. Correlation and path-coefficient analysis, concluded that, ascorbic acid, number of seeds per fruit, vine length, TSS, fruit weight, chlorophyll content, node number at which first female flower appear and days to 50% flowering exhibited maximum positive direct effect on grain yield seems to be primary yield contributing characters and could be relied upon for selection of genotypes to improve genetic yield potential of Bitter gourd. Hence, utmost importance should be given to these characters during selection for yield improvement.

Keywords: Variability; heritability; genetic advance; correlation coefficient and path coefficient analysis.

1. INTRODUCTION

Bitter gourd (*Momordica charantia* L.) is an important commercial cucurbit of family *Cucurbitaceae.* The origin of this crop is probably in India with secondary centre of diversity in China [1].The fruits of bitter gourd are similar in nutritional value compare to other cucurbits, with the notable exceptions that it is much higher in folate and vitamin C. The vine tips are an excellent source of vitamin A. The active constituents of bitter melon are not definitively determined, but we know the plant contains alkaloids, glycoside, peptides, acids, cucurbitins, charantin, cucurbitacins, momordine, momorcharins and proteins [2]. It is thought that the primary constituents responsible for the hypoglycemic properties are charantin, insulin-like peptide, cucurbutanoids, momordcin and oleanolic acids [3]. Bitter gourd is monoecious vine having unisexual flowers, highly cross-pollinated and bears male and female flowers separately on the same plant, which renders a considerable amount of variability.

In general, crop improvement involves the strategies to enhance the yield potentiality and quality components. The common approach of selecting parents on the basis of *per se* performance does not necessarily lead to fruitful results. The selection of best parents for hybridisation has to be based upon the complete genetic information and esteemed prepotency of potential parents. Improvement in yield is normally attained through the exploitation of the genetically diverse parents in breeding programmes. Genetic variability among parents is essential since the crossing programme involving genetically diverse parents is likely to produce high heterotic effects and also more variability could be expected in the segregating generations.

Yield is a complex character which is highly influenced by the 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. For rational improvement of yield and its components, the understanding of nature and magnitude of variation in the available material and association of characters with yield and among themselves and the extent of environmental influence on the characters which is statistically determined by correlation n coefficient is although useful in determining the relative influence of the various characters on yield and they do not provide an exact picture of the relative importance of the direct and indirect influences of each of the characters towards the yield. Path coefficient analysis proved helpful in partitioning the correlation coefficient into direct and indirect effects. It gives an idea about the contribution of each independent character on dependent character *i.e.* yield [4]. Hence, the present investigation was undertaken to study the genetic variability, association of yield and its component traits in bitter gourd.

2. MATERIALS AND METHODS

The experiment was conducted at the Vegetable Science Research Farm, Bihar Agricultural

University, Sabour (Bhagalpur), Bihar during 2017-18. The experiment comprised of twenty bitter gourd hybrids sown in a randomised block design with three replications. The p;ot size was 9.0 m^2 with a spacing of 1.5 cm x 1 cm. Recommended cultural practices were followed to raise a good crop. The quantitative characters viz. node number at which first female flower appear, Inter nodal length (cm), days to 50% flowering, vine length (cm), number of primary branches, days to first fruit harvest, days to last fruit harvest, number of fruits per plant, yield of marketable fruits per plant (kg), average fruit weight (g), fruit length (cm), fruit girth (cm), and number of seeds per fruit were recorded from five randomly selected plants from each replication, while days to 50% flowering were recorded on plot basis. The quality parameters viz., ascorbic acid, TSS (Brix) and total chlorophyll (mg/100 g) as per standard procedure. Analysis of variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance as per cent of mean were estimated by formula suggested by Singh and Chaudhary [5]. The phenotypic and genotypic correlation co-efficient was calculated as per formulae suggested by Al-Jibouri et al. [6] and Miller et al. [7]. The path coefficient analysis was performed according to Dewey and Lu [8].

3. RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the genotypes for all the characters under study (Table 1) indicating the presence of a significant amount of genetic variability present in the material. The phenotypic coefficient of variation was found to be higher than the genotypic coefficient of variation for all traits under study (Table 2). The genotypic coefficient of variation obtained for yield and its attributing traits ranged from 2.02-47.64. The highest genotypic coefficient of variation was observed for chlorophyl content (47.64) followed by vine length (20.24) and fruit wieght (20.07). The genotypic coefficient of variation was low for days to last fruit harvest (2.02) and days to first fruit harvest (3.81). Phenotypic coefficient of variation was high for chlorophyll content followed by fruit weight (22.1) and vine length (21.52) low for days to first female (5.63) and first male flower anthesis (5.60). Study on GCV and PCV indicated the extent of variability for different traits in bitter gourd and these results are in conformity with Islam et al. [9]. Higher Genotypic and phenotypic coefficient of variation was recorded for total chlorophyll (47.64 and 47.85), vine length (20.24 and 21.52) and fruit weight (20.07 and 22.17) indicated that, these test hybrids exhibited many variations among themselves with respect to these characters offering more scope for selection. Moderate GCV and PCV value s were observed for ascorbic acid, TSS, fruit length, fruit girth and number of seeds per fruit. PCV and GCV recorded for days to first male and female flower anthesis was low and in agreement with Islam et al. [9]. In the present investigation high heritability was recorded by total chlorophyll (99.14%) followed by TSS (96.24%), Ascorbic acid (91.38%), vine length (88.46%), number of seeds per fruit (83.54%), fruit weight (81.98%), fruit length (78.16%), yield of marketable fruit per plant (77.93%), fruit girth (74.78%), node number at first female flower appear (66.33%) and intermodal length (60.88%). The range of genetic advance as per cent of mean varied from 2.08 (days to last fruit harvest) to 97.72 (total chlorophyll per cent). The high genetic advance was recorded for chlorophyll content, vine length, ascorbic acid, TSS, Fruit weight, fruit length, fruit girth, number of seeds per fruit and fruit yield per plant,. High heritability estimates coupled with high genetic advance were observed for fruit yield per plant, vine length, fruit weight, fruit length, fruit girth, number of seeds per fruit, ascorbic acid, TSS and chlorophyll content this means that improvement in this trait made by simple selection. High heritability coupled with high genetic advance showed greater proportion of additive genetic variance and consequence a high genetic gain expected from selection [10]. Heritability in reality is a measure of the efficacy of the selection system in separating genotypes. It indicates the effectiveness with which selection of genotypes can be based on phenotypic selection. Thus heritable portion was estimated with the help of heritable estimates. Johnson et al. [11] stated that without genetic advance the estimates of heritability based on phenotypic appearances will not be of much practical importance and emphasized the importance of both the genetic advance as well as heritability in the selective breeding programme. The characters having heritability with low genetic advance as percent of mean appeared to be controlled by non-additive gene action and selection for such characters may not be effective [12]. High genetic advance indicated that, additive genes govern these characters and selection will be rewarding for improvement of these traits. Similar results were reported for fruit weight and fruit yield by Malek et al. [13], Sachan and Tikka [14] and Singh et al. [15] in pointed gourd, water melon and bitter gourd, respectively. Singh and Prasad [16] and Masud et al. [17] also reported high heritability for number of fruits per plant, fruit weight and fruit yield in pointed gourd and pumpkin, respectively.

Table 1. Analysis of variance for yield, its component and quality traits in bitter gourd

Sl. no.	Characters	MSS due to		
		Replication (d.f. 1)	Treatments (d.f. 27)	Error (d.f. 27)
1.	Node no. 1st female flower	0.1034	3.0201**	0.6113
2.	Internodal length (cm)	0.0476	1.1020**	0.2680
3.	Days to 50% flowering	0.1604	3.0417**	0.7949
4.	Vine length (cm)	0.0014	0.4692**	0.0287
5.	Primary branches	0.8329	1.1503**	0.6032
6.	Days to 1st fruit harvest	1.0241	10.3172**	2.8948
7.	Days to last fruit harvest	0.0918	20.8829**	12.7322
8.	No. of fruit /plant	0.8768	17.2196**	5.5810
9.	Fruit yield/plant (kg)	0.0001	0.2560**	0.0318
10.	Fruit weight (g)	0.3470	262.3827**	25.9828
11.	Fruit length (cm)	0.2055	8.3780**	1.0268
12.	Fruit girth (cm)	0.0004	8.3311**	1.2022
13.	No. of seeds /fruit	0.0158	22.7860**	2.0439
14.	Ascorbic acid (mg/100 g)	0.6135	398.2467**	17.9361
15.	TSS (brix)	0.0023	2.3072**	0.0443
16.	Total chlorophyll (mg/100 g)	0.0000	0.2634**	0.0011

***- Signifucant at 1%*

Table 2. Estimation of genetic parameters for yield and its attributing characters

S. N.	Characters	Range	VG (σ^2g)	VP (σ^2p)	GCV	PCV	h^2	GA as % of mean
1	Node no. 1st female flower	8.41-14.76	1.2044	1.8157	8.55	10.49	66.33	14.34
2	Inter nodal length (cm)	5.16-8.15	0.4170	0.6850	9.00	11.53	60.88	14.47
3	Days to 50% flowering	8.41-14.76	1.1234	1.9183	8.24	10.77	58.56	12.99
4	Vine length (cm)	1.16-3.49	0.2202	0.2489	20.24	21.52	88.46	39.21
5	Number of primary branches	11.16-14.26	0.2735	0.8767	3.98	7.12	31.20	4.58
6	Days to 1st fruit harvest	46.55-54.45	3.7112	6.6060	3.81	5.09	56.18	5.89
7	Days to last fruit harvest	89.24-103.55	4.0753	16.8076	2.02	4.17	24.25	2.08
8	No. of fruits /plant	29.25-38.66	5.8193	11.4003	7.06	9.89	51.05	10.40
9	Fruit yield/plant (kg)	1.92-3.50	0.1121	0.1439	13.12	14.86	77.93	23.86
10	Fruit weight (g)	26.56-82.93	118.1999	144.1827	20.07	22.17	81.98	37.44
11	Fruit length (cm)	6.08-14.91	3.6756	4.7024	15.40	17.42	78.16	28.05
12	Fruit girth (cm)	6.35-14.62	3.5645	4.7666	15.07	17.42	74.78	26.84
13	No. of seeds/fruit	17.58-30.02	10.3710	12.4150	13.09	14.32	83.54	24.65
14	Ascorbic acid (mg/100g)	45.27-90.31	190.1553	208.0914	19.09	19.97	91.38	37.59
15	TSS (Brix)	4.00-7.57	1.1315	1.1757	17.73	18.07	96.24	35.82
16	Chlorophyll (mg/100g)	0.12-1.25	0.1311	0.1323	47.64	47.85	99.14	97.72

Table 3. Phenotypic correlation co-efficient of yield and yield attributing in characters bitter gourd

S. N.	Characters	PB	NFFF	D50F	IL	DFH	DLH	NFP	FL	FG	FW	NS	AA	TSS	Tchl	YP
1	VL	0.47*	0.06	0.07	0.14	0.16	0.20	-0.05	-0.05	-0.00	0.22	0.03	-0.23	-0.08	-0.18	0.24
2	PB		0.24	0.28	0.28	0.13	0.05	-0.04	0.48*	0.76**	0.78**	-0.12	-0.08	0.42*	-0.12	-0.18
3	NFFF			0.13	0.01	0.57**	0.62**	0.41*	-0.53**	0.21	-0.41*	-0.47*	0.40	0.55**	0.08	-0.80**
4	DFF				-0.02	0.55**	0.61**	0.40*	-0.51**	0.24	-0.35	-0.42*	0.33	0.59**	0.05	-0.76**
5	IL					-0.68**	-0.06	-0.25	0.43*	0.49*	-0.15	-0.43*	0.12	0.62**	-0.82**	-0.47*
6	DFH						0.98**	0.22	-0.92**	-0.46*	-0.20	-0.56**	0.07	-0.19	0.26	-0.29
7	DLH							0.27	-0.46*	0.14	-0.03	-0.24	0.00	0.36	0.18	-0.42*
8	NFP								-0.56**	0.20	-0.04	0.59**	0.46*	0.48*	0.61**	0.14
9	FL									0.70**	0.58**	0.74**	-0.84**	-0.21	0.15	0.59**
10	FG										0.96**	0.20	0.22	0.12	0.29	0.05
11	FW											0.86**	-0.79**	0.32	0.43*	0.79**
12	NS												-0.63**	-0.15	0.75**	0.70**
13	AA													0.45*	0.35	-0.36
14	TSS														-0.31	0.02
15	Tchl															0.74**

Abbrevation: Vine length (VL), Number of primary branches (PB), node number at female flower (NFFF), Days to 50% flowering (D50F), Internodal length (IL), Days to first fruit harvest (DFH), Days to last fruit harvest (DLH), Number of fruit per plant (NFP), Fruit length (FL), Fruit girth (FG), Fruit weight (FW), Number of seeds per fruit (NS), Ascorbic acid (AA), Total soluble solid (TSS),Total chlorophyll (Tchl), Fruit Yield per plant (YP)

Table 4. Direct and indirect effects of component traits on fruit yield per plant at phenotypic level

S. N.	Characters	Vine length (cm)	Number of primary branches	Node no. 1^{st} female flower	Days to 50% flowering	Internodal length (cm)	Days to 1^{st} fruit harvest	Days to last fruit harvest	No.of fruit/plant	Fruit length (cm)	Fruit girth (cm)	Fruit wieght (g)	No.of seeds/ fruit	Aascorbic acid	Tss	Chlorophyll	Yield
1	Vine length (cm)	**1.0168**	-0.4553	0.0339	0.0383	-0.1245	-0.1525	-0.0063	0.1061	0.0172	0.0007	0.1722	0.0298	-0.2526	-0.0669	-0.1120	**0.2448**
2	Number of primary branches	0.4809	**-0.9629**	0.1317	0.1438	-0.2465	-0.1256	-0.0015	0.0992	-0.1570	-0.2283	0.6110	-0.1222	-0.0977	0.3690	-0.0727	**-0.1789**
3	Node no.1^{st} female flower	0.0641	-0.2357	**0.5381**	0.0646	-0.0074	-0.5576	-0.0197	-0.9130	0.1734	-0.0638	-0.3287	-0.4884	0.4398	0.4868	0.0518	**-0.7958**
4	Days to 50% flowering	0.0758	-0.2692	0.0676	**0.5141**	0.0156	-0.5398	-0.0198	-0.8992	0.1671	-0.709	-0.2820	-0.4312	0.3614	0.5161	0.0308	**-0.7638**
5	Internodal length (cm)	0.1429	-0.2679	0.0045	-0.0091	**-0.8858**	0.6647	0.0018	0.5640	-0.1435	-0.1486	-0.1163	-0.4395	0.1295	0.5466	-0.5140	**-0.4707**
6	Days to 1^{st} fruit harvest	0.1590	-0.1240	0.3076	0.2845	0.6036	**-0.9755**	-0.0314	-0.4993	0.3049	0.1387	-0.1580	-0.3638	0.0782	-0.1705	0.1609	**-0.2852**
7	Days to Last fruit harvest	0.2007	-0.0447	0.3321	0.3183	0.0504	-0.9599	**-0.0319**	-0.6074	0.1508	-0.0413	-0.0217	-0.2442	0.0021	0.3164	0.1116	**-0.4687**
8	No.of fruit/plant	-0.481	0.0426	0.2192	0.2063	0.2230	-0.2174	-0.0087	**-2.2406**	0.1837	-0.0591	-0.0298	0.5523	0.5063	0.4254	0.3837	**0.1388**
9	Fruit length (cm)	-0.0530	-0.4579	-0.2825	-0.2602	-0.3851	0.9007	0.0146	1.2464	**-0.3302**	-0.2094	0.4647	0.7660	-0.9259	-0.1816	0.2885	**0.5950**
10	Fruit girth (cm)	-0.0023	-0.7310	0.1141	0.1212	-0.4378	0.4498	-0.0044	-0.4404	-0.2299	**-0.3008**	0.7681	0.2047	0.2450	0.1071	0.1818	**0.0454**
11	Fruit weight (g)	0.2188	-0.7486	-0.2211	-0.1813	0.1288	0.2935	0.3279	0.0835	-0.1918	-0.2888	**0.7999**	0.8871	-0.8668	0.2824	0.2712	**0.7948**
12	No.of seeds/fruit	0.3593	0.1366	-0.2545	-0.2147	0.3770	0.5446	0.0075	-1.3212	-0.2450	-0.0596	0.6873	**1.0325**	-0.6921	-0.1312	0.4715	**0.6980**
13	Aascorbic acid (mg/100g)	-0.2335	0.0855	0.2151	0.1689	-0.1043	-0.0693	-0.0457	-1.0309	0.2778	-0.0674	-0.6302	-0.6494	**1.1003**	0.3987	0.2200	**-0.3644**
14	TSS (Brix)	-0.0772	-0.4031	0.2972	0.3010	-0.5494	0.1887	-0.0118	-1.0814	0.0680	-0.0365	0.2563	-0.1537	0.4977	**0.8813**	-0.1931	**-0.0159**
15	Chlorophyll (mg/100g)	-0.1819	0.1119	0.0445	0.0253	0.7274	-0.2507	-0.0057	-1.3736	-0.0509	-0.0874	0.3466	0.6977	0.3867	-0.2719	**0.6259**	**0.7439**
16	Yield kg)															**R2**	**0.7814**
																R.E.	**0.4676**

Correlation studies showed that for most of the characters, genotypic correlation was higher than the corresponding phenotypic correlation. This could be interpreted on the basis that there was a strong inherent genotypic relationship between the characters under study, but their phenotypic expression was impeded by the influences of environmental factors. Correlation analysis revealed (Table 3) that fruit yield per plant had highly significant and positively associated with fruit weight, total chlorophyll content, number of seeds per fruit and fruit length whereas negatively correlated with node number at which first female flower appear, days to 50% flowering, intermodal length and days to last fruit harvest. The trait total chlorophyll content was significant inter -related with number of seeds per fruit, number of fruits per plant, and fruit weight whereas significantly and negatively correlated with intermodal length. Total soluble solids had exhibited positive and significant association with intermodal length, days to 50% flowering, node to first female flower, number of primary branches, number of fruits per plant and ascorbic acid content. The trait ascorbic acid content was negatively and significantly correlated with fruit length, fruit weight and number of seeds per fruit whereas it showed positive and significant correlation with number of fruits per plant. Number of seeds per fruit had positive and significant correlation with fruit weight, fruit length and number of fruits per plant while it was significantly and negatively correlated with days to first harvest, inter nodal length, days to 50% flowering and node to first female flower appearance. Fruit weight had positive and significant association with fruit girth, number of primary branches and fruit length. Similarly fruit girth had positive and significant association with fruit length. The traits days to first harvest and days to last harvest had positive and significant association with node for first female flower appearance and days to 50% flowering. Vine length was positively and significantly correlated with number of primary branches at phenotypic level.

Fruit yield is a complex trait with polygenic inheritance and depends upon series of processes *viz*., phenological, canopy development, biomass production etc. that are driven by environmental influences. The performance of a genotype is determined by the integrated effect of genotype and environment. The end product such as fruit yield has often been described as the product of its related traits which show inter-dependence. The path coefficient analysis allows partitioning of correlation coefficients into direct and indirect effects of various traits towards dependent variable which is fruit yield in present study and thus, helps in calculating the cause-effect relationship. It plays an important role in determining the degree of relationship between yield and its component traits. The effects of yield components via path analysis were examined only for significantly correlated traits with fruit yield. Correlation measures the mutual association between two variables, which aids in determining the most effective procedures for selection of superior genotypes. When there is positive association for major yield trait components, breeding would be very effective but on the contrary, it becomes difficult to exercise simultaneous selection for them to develop a variety. According to Cramer and Weber [18] path coefficient analysis can be employed to partition the correlation between yield and its components into direct and indirect effects. Salahuddin et al. [19] affirm that path coefficient analysis provides an effective means of partitioning correlation coefficients into unidirectional and alternative pathways thus permitting a critical examination of specific factors that produce a given correlation, which can be successfully employed in formulating an effective selection programme.

Path analysis (Table 4) revealed that ascorbic acid, number of seeds per fruit, vine length, TSS, fruit weight, chlorophyll content, node number at which first female flower appear and days to 50% flowering had positive direct effect on fruit yield. Earlier researchers also corroborated their results on the similar pattern namely Islam et al. [9], Rani et al. [20] and Singh and Singh [21].

4. CONCLUSION

From the present study it can be inferred that the characters viz. that ascorbic acid, number of seeds per fruit, vine length, TSS, fruit weight, chlorophyll content, node number at which first female flower showed positive direct effect on yield. Therefore these characters should be considered for selection to improve yield of Bitter gourd.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Grubben GJN. Tropical vegetable and their genetic resources. IBPGR Rome. 1977;51-52.
2. Raman A, Lau C. Anti-diabetic properties and phytochemistry of *Momordica charantia* L. (Cucurbitaceae). Phytomedicine. 1996;2(4):349-662.
3. Wei L, Wang S, Shutao L, Zhou J, Lijing K, Rao P. Increase in the free radical scavenging capability of bitter gourd by a heat-drying process. Food and Function. 2013;4:1850-1855.
4. Jatav V, Singh DK, Panchbhaiya A. Character association and path co-efficient analysis for yield and yield related traits in bitter gourd (*Momordica Charantia* L.). International Quarterly Journal Life Science. 2016;11(4):2975-2980.
5. Singh RK, Chaudhary BD. Biometrical methods of quantitative genetic analysis. Haryana J. Hort. Sci. 1985;12(2):151-156.
6. Al-Jibouri HA, Miller PA, Robinson HF. Genetic and environmental variances and covariances in upland cotton cross of interspecific origin. Agron. J. 1958;50:633-37.
7. Miller PA, Williams CV, Robinson HF, Comstock RE. Estimates of genotypic and environmental variance and covariance in upland cotton and their implication in selection. Agron. J. 1958;50:126-31.
8. Dewey DR, Lu KH. A correlation and path analysis of components of crested wheat grass seed production. Agron. J. 1959;51:515-518.
9. Islam MR, Hossain MS, Buiyan MSR, Husna A, Syed MA. Genetic variability and path coefficient analysis of bitter gourd (*Momordica charantia* L.). Intl. J. Sustainable Agric. 2009;1(3):53-57.
10. Devi ND, Mariappan S. Genetic variability, heritability and genetic advance for yield and its components snake gourd (*Trichosanthes anguina* L.). African J. Agric. Res. 2013;8(26):3857-3859.
11. Johnson HW, Robinson HF, Comstock RE. Estimation of genetic variability and environmental variability in soybean. J. Agron. 1955;47:314-318.
12. Singh AK, Singh N. Studies on genetic variability and heritability in balsam (*Impaties balsamina*). J. Ornamental Hort. 2007;10:128-130.
13. Malek MA, Bari Miah MA, Islam MO, Mosiul AMM, Gomes R. Genetic variability, heritability and genetic advance in pointed gourd (*Trichosanthes dioica* Roxb.). Bangladesh J. Pl. Breed. Genet. 2007;20(1):47-52.
14. Sachan SCP, Tikka SBB. Genetic variability and correlation studies in water melon. Rajasthan J. Agric. Sci. 1971;2:91-96.
15. Singh HN, Srivastava JP, Prasad R. Genetic variability and correlation studies in bitter gourd. Indian J. Agril. Scientist. 1977;47:604-07.
16. Singh DP, Prasad VSRK. Variability and correlation studies in pointed gourd (*Trichosanthes diocica* Roxb). Indian J. Hort. 1989;46(2):204-209.
17. Masud MAT, Ahmed SU, Saha SR. Variability and association of yield and yield attributes in pumpkin land races. Bangladesh Hort. 1998;26(1-2):5-8.
18. Cramer CS, Wehner TC. Path analysis of the correlation between fruit number and plant traits of cucumber populations. Hort Sci. 2000;35(4):708-11.
19. Salahuddin S, Abro M, Kandhro M, Salahuddin L, Laghari S. Correlation and path coefficient analysis of yield components of upland cotton [*Gossypium hirsutum* (L.)] symp odial. World Appl. Sci. J. 2010;8:71-75.
20. Rani KR, Raju SC, Reddy KR. Variability, correlation and path analysis studies in bitter gourd (*Momordica charantia* L). Agriculture Science Digest. 2015;35(2):106-110.
21. Singh HK, Singh DR. Association and path coefficient analysis among yield and its components in bitter gourd (*Momordica charantia* L.). Asian Journal of Horticulture. 2015;10(2):212-215.