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Estimation of character association and path coefficient in bottle gourd *Lagenaria siceraria* (Mol.) Standl

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Abstract
The present investigation was conducted to assess the genetic variability among 24 genotypes collected from different institute/SAUs during kharif season (2018-2019). Genotypic correlation coefficient were found to higher than phenotypic correlation coefficients for most of the characters, indicating a strong inherent association between various characters and significantly affected by environmental components in regard to phenotypic expression. Based on correlation coefficient, fruit yield per plant showed positive and highly significant correlation with number of fruit per plant, days to first fruit set at both genotypic and phenotypic level, which implies that these characters were the primer contributing factors to fruit yield. Path coefficient analysis showed highest positive direct effect on fruit yield was observed for fruit weight, days to first fruit set, fruit girth and fruit length. By improving other characters fruit yield in bottle gourd might be improved.

Keywords: Bottle gourd, correlation coefficient, genotype, phenotype, characters

Introduction
Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] is locally known as Lauki. It is an important cucurbitaceous fruit vegetable having a total number of chromosomes i.e., 2n=22. It is a fast-growing vine crop that originated from tropical Africa. It is well grown in both rainy and summer seasons around the world and its fruits are available in the market round year. Bottle gourd pulp is good for overcoming constipation, cough, and night blindness and as an antidote against certain poison (Chauhan, 1972) [2]. According to Ayurveda and Unani, it acts as a cardiotonic, laxative, cooling effect, diuretic, antebellum wholesome to the focus, tonic to the liver, anti-periodic, antipyretic (Kirtikar and Basu, 1991) [6]. The edible portion of the fruit contains 96.3 percent moisture, 2.9 per cent carbohydrates, 0.2 per cent protein, 0.1 per cent fat, 0.5 per cent mineral matter and 11 mg of vitamin C per 100 g fresh fruit pulp. It also contains various minerals like Ca (12 mg), P (37 mg), Na (1.7 mg), K (87 mg), Cr (0.05 mg), Fe (0.8 mg), per 100 gm of bottle gourd pulp (Thamburaj and Singh, 2005) [16].
It is an annual, vigorous climbing species, monoecious and highly cross pollinated crop having a wide range of genetic variability across the globe. Genetic improvement of any crop is largely dependent on the magnitude of a number of genetic parameters *viz*, phenotypic and genotypic coefficient of variation (PCV and GCV), broad-sense heritability in a broad sense and genetic gain; on which the breeding methods are formulated for its further improvement. Analysis of genetic variability reveals its presence and is of utmost importance as it provides a clear idea for effective selection. The great extent of variability is measured by the genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) which provides information about the relative amount of variation in different characters. Hence, to obtain a comprehensive idea, it is necessary to agree on an assessment of quantitative traits. Since heritability is also influenced by environmental factors, the information on heritability alone may not help in problem-solving characters enforcing selection. However, heritability estimates in conjunction with the predicted genetic gain will be more reliable (Johnson *et al*., 1955) [5]. Path analysis deals with a system of variables that are linearly related. It specifies the cause and effect relationships and generally measures their relative importance. Path analysis splits the correlation co-efficient into the measures of the direct and indirect contribution of various characters towards yield.

Material and Methods
An experiment was conducted at the Horticulture Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.) during the Kharif season. The present study comprised of 24 diverse genotypes of Bottle gourd and replicated three times in

a Randomized block design. The experimental field was prepared by employing one ploughing with a disc harrow followed by three ploughing with cultivator and planking to make fine tilth of the soil and then levelled. Fertilizers were incorporated. Before the layout of the experimental plot, weed and other unwanted vegetation were removed from the field. Analysis for estimation of correlation coefficient and path coefficient of different characters [days to first fruit set, days to first fruit harvest, fruit length (cm), fruit girth (cm), number of fruit per plant, fruit weight (g), fruit yield per plant (kg)] was done.

Estimation of Correlation coefficient

Correlation was estimated the association between various character-pairs. The correlations at genotypic, phenotypic and environmental levels were estimated from the analysis of variance and covariance as suggested by Searle (1961). Phenotypic correlation between character x and y

$$r_{xy}(p) = \frac{CoV_{XY}(p)}{\sqrt{Var_x(p) \times Var_y(p)}}$$

Where

Covxy (p) = Phenotypic covariance between two characters x and y.

Varx (p) = Phenotypic variance for characters x.

Vary (p) = Phenotypic variance for characters y. Genotypic correlation between character x and y

$$r_{xy}(g) = \frac{CoV_{XY}(g)}{\sqrt{Var_x(g) \times Var_y(g)}}$$

Where,

Covxy (g) = Genotypic covariance between two character x and y

Varx (g) = Genotypic variance for characters x

Vary (g) = Genotypic variance for characters y

The significance of correlation coefficient (r) was tested by comparing the observed value of correlation coefficient with the tabulated value for (n-2) degree of freedom. If the observed value is more than the table value, the correlation coefficient is said to be significant.

$$tc = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

Where

r = correlation coefficient, n = number of genotypes tc = t calculated.

Path coefficient analysis

The analysis of path-coefficient was worked out by using the estimates of correlation coefficients. All possible correlation among the dependent and independent variables was worked out with the following three steps: the calculation of direct effect, calculation of indirect effect and calculation of residual effects. These effect were calculate by employing the method suggested by Wright (1921) [17] and as elaborated by Dewey and Lu (1959) [3].

ry1 = Py1 + Py1r12 +Py3r13 + …….Pynr1n

ry2 = Py2 + Py1r21 +Py3r23 + …….Pynr2n

ryn = Pyn + Py1rn1 +Pynrn2 + …….Pynrn(n-1)

Where

ry1, ry2……. ryn are the correlation coefficient of dependent variable (y) with various independent variables (1, 2,..... n).

Py1, Py2…….. Pyn are the direct path effects of independent variables (1,2,.....n) on dependable variable (y).

r12, r13……. r1n…….. rn(n-1) are the correlation coefficient between various independent variables (1, 2,……..n).

Path coefficients were obtained by replacing the corresponding elements in A and matrix by correlation coefficients. B matrix was inverted and the inverted B matrix was multiplied by matrix to obtain path coefficients.

Residual factor which measures the contribution of rest on the characters of causal scheme was obtained as given below:

$$Pxy = \sqrt{1-R^2}$$

Where, $R^2 = \sum i = 1 Piy\ riy$

Where Riy denotes correlation between all possible combinations of independent character Y. The correlation is r12 to r11 12 P = direct effect of with character on Y. riy = coefficient correlation between i^{th} and y factor.

Result and Discussion

The result revealed that the genotypic and phenotypic correlation coefficient for all seven characters is present. The estimation of the correlation coefficient revealed that the genotypic correlation was higher in magnitude than the phenotypic correlation coefficient.

Fruit yield per plant showed a positive and significant correlation with fruit girth (0.509**), positive and non-significant with fruit weight (0.146), and number of fruit per plant (0.144). Negative and significant correlation with days to first fruit set (-0.345**), fruit length (-0.341**), days to first fruit harvest (-0.307**).

Days to first fruit set showed Positive and significant relation with the number of fruit per plant (0.801**), fruit length (0.400**) and a Negative and significant correlation with days to first fruit harvest (-0.475**), fruit weight (-0.370**), fruit yield per plant (-0.345**), fruit girth (-0.208*) at the phenotypic level.

Days to first fruit harvest showed a positive and significant correlation with fruit weight (0.540**), fruit length (0.333**), fruit girth (0.203*); a significant negative correlation with days to first fruit set (-0.475**), fruit yield per plant (-0.307**), days and a negative and non-significant correlation with the number of fruit per plant (-0.134) at the phenotypic level. Fruit length showed a significant positive correlation with days to first fruit set (0.400**), days to first fruit harvest (0.333**) and fruit weight (0.222*). This trait showed a significant negative correlation with the number of fruit per plant (-0.604**), fruit girth (-0.470**) and fruit yield per plant (-0.341**) at the phenotypic level.

Fruit girth showed a positive and significant correlation with fruit yield (0.509**), number of fruit per plant (0.339**), fruit weight (0.305**), days to first fruit harvest (0.203*) and a negative and significant with fruit length (-0.470**) and days to first fruit set (-0.208*). Number of fruit per plant showed positive and significant correlation with days to the first fruit set (0.801**), fruit girth (0.339**) while a positive and non-

significant correlation with fruit yield per plant (0.144). The above trait exhibited a significant negative correlation with fruit length (-0.604**), fruit weight (-0.301**) and non-significant negative correlation with days to first fruit harvest (-0.134) at the phenotypic level. Fruit weight showed a significant positive correlation with days to first fruit harvest (0.540**), fruit length (0.222*) and a positive and non-significant correlation with fruit yield per plant (0.146). Moreover, for this trait, days to first fruit set (-0.370**) and number of fruit per plant (-0.301**) showed a negative and significant correlation at the phenotypic level.

Among genotypic correlation, Fruit yield per plant was found to be in a positive and significant correlation with the number of fruit per plant (0.809**), days to first fruit set (0.703**) and fruit weight (0.492**) and a non-significant positive correlation with days to first fruit harvest (0.080) and fruit girth (0.077). Besides, for the above trait, fruit length (-0.521**) showed a significant negative correlation.

The result obtained from the genotypic and phenotypic coefficient of correlation for seven characters under study is given in table 1.

These results were close in conformity with findings of Prakash *et al*. (2000) [12], Rahman *et al*. (1986) [14], Pandit *et al.* (2008) [10], Narayanan kutty *et al*. (2006) [9], Miah, *et al*. (2000) [8], Rao *et al*., (2000) [15], Hazra *et al*. (2003) [4]. Kumar and Singh (1998) [7], Ahmed *et al*. (2005) [1], Parvathi and Reddy (2006) [11].

Table 1: Estimates of correlation both at genotypic and phenotypic level

Traits	Level	Days to first fruit set	Days to first fruit harvest	Fruit length	Fruit girth	No. of fruit/plant	Fruit weight	Duration of the crop	Fruit yield/plant
Days to first fruit set	G	1.00	-0.550**	-0.022	-0.890**	0.497*	-0.187	0.470**	0.703**
	P	1.00	-0.475**	0.400**	-0.208*	0.801**	-0.370**	-0.207*	-0.345**
Days to first fruit harvest	G		1.00	0.407**	0.304**	-0.342**	0.908**	-0.287**	0.080
	P		1.00	0.333**	0.203*	-0.134	0.540**	0.517**	-0.307**
Fruit length	G			1.00	-0.743**	-0.959**	0.432**	-0.193**	-0.521**
	P			1.00	-0.470**	-0.604**	0.222*	0.431**	-0.341**
Fruit girth	G				1.00	0.645**	0.186	0.175	0.077
	P				1.00	0.339**	0.305**	-0.202*	0.509**
No. of fruit/plant	G					1.00	-0.988**	0.210*	0.809**
	P					1.00	-0.301**	-0.428**	0.144
Fruit weight	G						1.00	-0.508**	0.492**
	P						1.00	0.308**	0.146
	P							1.00	-0.245**

Path coefficient analysis

The path coefficient analysis was done with the method as advocated by Dewey and Lu (1959) [3]. Partitioning of the correction coefficient of the various characters under study was done with the help of path coefficient analysis to express the direct and indirect effect of all studied character on fruit yield. The path coefficient analysis was done for both genotypic and phenotypic level. The result obtained at the genotypic and phenotypic levels.

Genotypic and phenotypic path analysis

Direct effect

The highest positive direct effect on fruit yield was observed for fruit weight (0.877), days to first fruit set (0.639) and fruit girth (0.501). Negative direct effect was noted for the number of fruit per plant (-0.408) and days to first fruit harvest (-0.349) on fruit yield at the genotypic level. On the other hand, a high positive direct effect on fruit yield was observed for days to first fruit harvest (0.278) and fruit weight (0.102). The negative direct effect was recorded for fruit length (-0.799), fruit girth (-0.706), days to first fruit set (-0.461) and number of fruit per plant (-0.117) at the phenotypic level.

Indirect effect

Days to the first fruit set indicated an indirect positive effect with a number of fruit per plant (0.368) while the other characters showed a negative indirect effect at the genotypic level. However, at the phenotypic level, an indirect positive effect was noted for days to first fruit harvest (0.208) followed by fruit weight (0.168), fruit girth (0.131) while the rest of the characters showed negative indirect effect.

Days to first fruit harvest gave an indirect positive effect with days to first fruit set (0.635) followed by number of fruit per plant (0.574) while the rest of all the characters showed negative indirect effect at the genotypic level. Considering the phenotypic level, an indirect positive effect was indicated by fruit weight (0.149), fruit length (0.093), fruit girth (0.057), while the other characters expressed a negative indirect effect.

Fruit length showed an indirect positive effect with fruit weight (0.995) followed by days to first fruit harvest (0.923) although the other traits exhibited a negative indirect effect at the genotypic level. Whereas at the phenotypic level, indirect positive effect was given by fruit girth (0.559), number of fruit per plant (0.480) and the rest showed a negative indirect effect. Fruit girth gave an indirect positive effect with fruit weight (0.713), the number of fruit per plant (0.608) and days to first fruit harvest (0.217) while the rest of the characters indicated a negative indirect effect at the genotypic level. Whereas at the phenotypic level, indirect positive effect given by fruit length (0.494) followed by days to first fruit set (0.200) while the rest showed a negative indirect effect.

Number of fruit per plant showed an indirect positive effect with fruit weight (0.399) followed by fruit length (0.388), days to first fruit harvest (0.137) while the other parameters were responsible for exhibiting a negative indirect effect at the genotypic level. At the phenotypic level, an indirect positive effect was expressed by fruit length (0.070), fruit weight (0.036) and days to first fruit harvest (0.016) whilst the other traits showed a negative indirect effect.

Fruit weight expressed an indirect positive effect with fruit length (0.803), followed by days to first fruit harvest (0.617), fruit girth (0.336), days to first fruit set (0.218) although the other characters gave a negative indirect effect at the genotypic level. On the contrary, an indirect positive effect was expressed by days to first fruit harvest (0.055), fruit length (0.023) and fruit girth (0.005) whereas the rest of the traits showed negative indirect effect at the phenotypic level.

Similar results were earlier reported by Rao *et al.* (2000) [15], Prasana *et al*. (2002), Hazra *et al*. (2003) [4], Ahmed *et al.* (2005) [1], Rahaman *et al*., (1986), Kumar and Singh (1998) [7].

Table 2: Path coefficient analysis at genotypic level on fruit yield

Traits	Days to first fruit set	Days to first fruit harvest	Fruit length	Fruit girth	No. of fruit/plant	Fruit weight	r with Fruit yield/plant
Days to first fruit set	0.639	0.635	-0.048	-0.574	-0.202	-0.218	-0.786**
Days to first fruit harvest	-0.176	-0.349	0.923	0.217	0.1373	0.617	0.082
Fruit length	-0.802	-0.954	0.305	-0.996	0.388	0.803	-0.524**
Fruit girth	-0.424	-0.370	-0.717	0.501	-0.263	0.336	0.078
No. of fruit/plant	0.368	0.574	-0.188	0.608	-0.408	-0.834	0.803**
Fruit weight	-0.365	-0.509	0.995	0.713	0.399	0.877	0.496**

Table 3: Path coefficient analysis at phenotypic level on fruit yield

Traits	Days to first fruit set	Days to first fruit harvest	Fruit length	Fruit girth	No. of fruit/plant	Fruit weight	r with Fruit yield/plant
Days to first fruit set	-0.461	-0.126	0.000	0.200	-0.001	-0.037	-0.355*
Days to first fruit harvest	0.208	0.278	-0.267	-0.144	0.016	0.055	-0.076
Fruit length	0.000	0.093	-0.799	0.494	0.070	0.023	-0.310*
Fruit girth	0.131	0.057	0.559	-0.706	-0.045	0.005	0.091
No. of fruit/plant	-0.005	-0.038	0.480	-0.272	-0.117	-0.032	0.140
Fruit weight	0.168	0.149	-0.180	-0.037	0.036	0.102	0.162

Conclusion

The correlation coefficient studies clearly indicates that the genotypic correlation coefficients were found to higher than phenotypic correlation coefficients for most of the characters, thus depicting a strong inherent association between various characters which are significantly affected by environmental components in regard to phenotypic expression. Fruit yield per plant showed positive and highly significant correlation with number of fruit per plant, days to first fruit set which implies that these characters were the prime contributing factors to fruit yield. All the combination of traits should be considered while selecting a breeding programme for high yielding genotypes so that it is suitable for the breeders to identify improved and superior plant type. Path coefficient analysis showed highest positive direct effect on fruit yield for fruit weight, days to first fruit set, fruit girth and fruit length. By improving other characters fruit yield in bottle gourd can be improved.

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