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Estimation of direct and indirect association of independent traits with seed yield in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.)

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Abstract
An experiment was executed at Main Experiment Station of Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya (U.P.) during *Zaid* 2019, path analysis among different character. Experimental material for the study consisted of 36 genotypes including two checks (Pusa Naveen and Narendra Rashmi). The experiment was conducted in Randomized Complete Block Design with three replications. Single row plot of 3 m length spaced 3 m apart with 50 cm plant to plant distance was maintained. Observations were recorded on 14 quantitative traits *viz*. days to first staminate flower and pistillate flower anthesis, node number to first staminate and pistillate flower appearance, days to first fruit harvest, green fruit length (cm), green fruit circumstances (cm), mature fruit length (cm), mature fruit circumstances (cm), mature fruit weight(kg), seed weight per fruit(g), number of seed per fruit(g), 100-seed weight(g), seed yield per plant(g). Seed weight per fruit and days to first fruit harvest, node number to staminate flower appearance were identified as most important traits with positive direct effect on seed yield per plant. However, no of seed per fruit and mature fruit weight were found as important indirect contributor towards high seed yield per plant via seed weight per fruit at both phenotypic and genotypic level.

Keywords: path coefficient, direct and indirect, bottle gourd or *Lagenaria siceraria*

Introduction
Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.) is one of the most valuable member of family cucurbitaceae having somatic chromosome number 2n=22. The bottle gourd or white flowered gourd is commonly known as Lauki or Ghiya in India. It is an annual plant with very large leaves and branched tendrils, spreading or climbing up to 15 meters. The study of extent of correlation of various traits with each other is an important strategy designated to break genetic barriers of yield. This study is helpful in determining the components of a complex trait like yield. However, only correlation does not provide an exact magnitude of direct and indirect effect towards the yield. In this context, path coefficient analysis is an important tool to partition the correlation coefficient into direct and indirect effect of the independent variables on the dependent. This information may be useful to breeder in selecting high yielding genotypes in a crop. Keeping this in view, the present investigation was conducted to determine the characters and their direct and indirect effects on yield.

Material and Methods
The present investigation was conducted during *Zaid*, 2019-20 at Main Research Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, (Kumarganj) Ayodhya (U.P.). Narendra Nagar is situated at 26.470N latitude and 82.120E longitude at an altitude of 113 metres above the mean sea level. The soil type of experimental site was sandy-loam. The experiment was laid out in completely Randomized Block Design with three replications on March 4th, 2019. Each genotype was planted in 3m x 3m plot size. The distance between rows and plants was kept at 3m and 50cm, respectively. Six plants were maintained in each plot. The recommended agronomic practices were followed to raise a good crop. Observations were recorded on six randomly selected plants from each replication on 14 quantitative traits such as days to first staminate flower and pistillate flower anthesis, node number to first staminate and pistillate flower appearance, days to first fruit harvest, green fruit length (cm), green fruit circumstances (cm), mature fruit length (cm), mature fruit circumstances (cm), mature fruit weight(kg), seed weight per fruit(g), number of seed per fruit(g), 100-seed weight(g), seed yield per plant(g). The data were subjected to analysis of variance as per the procedure described by Panse and Sukhate (1967).

Path coefficients were calculated according to method suggested by Dewey and Lu (1959) respectively.

Results and discussion

The analysis of variance for different characters had been presented in Table-1. The mean sums of squares due to genotypes/treatments were highly significant for all the characters. In other words, the performances of the genotypes with respect to these characters were statistically different indicating the variability among the genotypes due to genetic constitution of materials as well environmental fluctuation for that particular character. These findings suggested that there is ample scope for selection in the available germplasm of bottle gourd as it had been also reported by Panigrahi and Duhan, (2018).

Table 1: Analysis of variance for fourteen quantitative characters in bottle gourd

S. No.	Characters	Source of variation		
		Replications	Treatments	Error
	d.f.	2	35	70
1.	Node no. to staminate flower appearance	0.129	237.225**	13.054
2.	Node no. to pistillate flower anthesis	4.166	697.317**	37.503
3.	Days to staminate flower anthesis	2.907	601.657**	250.426
4.	Day to pistillate flower	8.019	1,250.55**	169.981
5.	Days to first fruit harvest	34.389	2,522.00**	271.611
6.	Fresh fruit length	51.151	3,967.85**	389.401
7.	Fresh fruit girth	19.896	3,116.32**	160.357
8.	Mature fruit length	14.385	7,784.44**	323.796
9.	Mature fruit diameter	0.873	6,178.62**	224.688
10.	Mature fruit wt. (kg)	0.093	14.803**	2.545
11.	Seed wt./fruit (g)	245.685	37,097.07**	3,690.32
12.	No. of seed /fruit	2,314.46	2,419,975.66**	30,168.20
13.	100 seed wt. (g)	0.074	3,250.85**	61.536
14.	Seed yield /plant (g)	16.143	169,465.90**	921.783

*Significant at 5% level of probability, **Significant at 1% level of probability

Path coefficient analysis was carried out from phenotypic and genotypic correlation coefficient to resolve direct and indirect effect of fourteen characters on seed yield per plant. The direct and indirect effects of different characters on seed yield per plant at phenotypic and genotypic level are presented in Table -2 and 3. At phenotypic level (Table- 2) the highest positive direct effect on seed yield per plant was exerted by seed weight per fruit (0.788) followed by day to first fruit harvest (0.279), node number to staminate flower appearance (0.095), number of seed per fruit (0.075), day to staminate flower anthesis (0.003). However, very negligible negative direct effect on seed yield per plant was exerted by mature fruit diameter (- 0.011), mature fruit length (-0.013), mature fruit weight (0.024), fresh fruit length (-0.082), 100 seed weight (-0.157), day to pistillate flower (-0.207), fresh fruit girth (-0.244).

Number of seed per fruit (0.402), mature fruit weight (0.211), 100 seed weight (0.170), mature fruit diameter (0.135) and node number to pistillate flower anthesis (0.130), have considerable positive indirect effect on seed yield per plant via seed weight per fruit. Fresh fruit length (-0.110), day to first fruit harvest (-o.192), day to pistillate flower (-0.073) and fresh fruit girth (-0.085), have considerable negative indirect effect on seed yield per plant via seed weight per fruit.

The direct and indirect effects of different characters on seed yield per plant at genotypic level are presented in Table 3**.** At the genotypic level, highest positive direct effect on seed yield per plant was exerted by seed weight per fruit (3.500) followed by mature fruit length (1.707), mature fruit diameter (0.577), fresh fruit girth (0.548), day to first fruit harvest (0.318), day to pistillate flower (0.185), day to staminate flower anthesis (0.182) and node number to staminate flower appearance (0.095). However, the highest negative direct effect on seed yield per plant was exerted by fresh fruit length (-0.409), followed by node number to pistillate flower anthesis (-0.746), mature fruit weight (-0.789), number of seed per fruit (-2.852), 100 seed weight (-2.864). Muralidharan *et al*. (2017) also estimated path analysis and revealed that the characters like number of seeds per fruit and number of pickings were the most important yield determinants, because of their high direct effects and high indirect effects via., many other yield improving characters. This suggests that emphasis must be given on such traits while exercising selection to improve the yield in bottle gourd.

Table 2: Direct and indirect effects of fourteen characters on seed yield per plant (g) at phenotypic level in bottle gourd

Characters	Node no to staminate flower appearance	Node no to pistillate flower anthesis	Days to staminate flower anthesis	Day to pistillate flower	Days to first fruit harvest	Fresh fruit length	Fresh fruit girth	Mature fruit length	Mature fruit diameter	Mature fruit wt. (kg)	Seed wt./fruit (g)	No. of seed /fruit	100 seed wt. (g)	Correlation with Seed yield /plant (g)
Node no to staminate flower appearance	0.095	-0.036	0.000	-0.053	-0.004	-0.014	0.033	-0.003	0.001	-0.001	0.085	0.010	-0.004	0.109
Node no to pistillate flower anthesis	0.030	-0.116	0.000	-0.041	0.005	-0.006	-0.019	-0.001	-0.001	0.001	0.130	0.027	0.044	0.052
Days to staminate flower anthesis	0.013	0.000	0.003	-0.115	0.018	-0.005	0.066	-0.002	0.003	-0.004	-0.065	-0.003	0.004	-0.089
Day to pistillate flower	0.024	-0.023	0.002	-0.207	0.067	-0.017	0.089	-0.002	0.003	0.002	-0.073	-0.006	-0.014	-0.155
Days to first fruit harvest	-0.001	-0.002	0.000	-0.050	0.279	-0.001	-0.050	0.003	-0.003	0.003	-0.192	-0.024	-0.027	-0.066
Fresh fruit length	0.017	-0.009	0.000	-0.042	0.005	-0.082	0.083	-0.008	0.007	0.005	-0.110	-0.002	0.003	-0.132
Fresh fruit girth	-0.013	-0.009	-0.001	0.076	0.058	0.028	-0.244	0.009	-0.008	0.002	-0.085	-0.020	-0.021	-0.228*
Mature fruit length	0.024	-0.009	0.000	-0.033	-0.057	-0.050	0.172	-0.013	0.008	-0.004	-0.045	0.021	0.038	0.052
Mature fruit diameter	-0.009	-0.011	-0.001	0.063	0.068	0.055	-0.177	0.009	-0.011	-0.005	0.135	-0.002	-0.014	0.100
Mature fruit wt. (kg)	0.005	0.005	0.000	0.017	-0.038	0.016	0.020	-0.002	-0.002	-0.024	0.211	0.025	0.036	0.269**
Seed wt./fruit (g)	0.010	-0.019	0.000	0.019	-0.068	0.011	0.026	0.001	-0.002	-0.007	0.788	0.038	-0.034	0.765**
No. of seed /fruit	0.013	-0.041	0.000	0.016	-0.089	0.002	0.065	-0.004	0.000	-0.008	0.402	0.075	0.103	0.535**
100 seed wt. (g)	0.003	0.032	0.000	-0.018	0.048	0.002	-0.033	0.003	-0.001	0.006	0.170	-0.049	-0.157	0.003

Residual effect- 0.28184

Table 3: Direct and indirect effects of fourteen characters on seed yield per plant (g) at genotypic level in bottle gourd

Characters	Node no to staminate flower appearance	Node no to pistillate flower anthesis	Days to staminate flower anthesis	Day to pistillate flower	Days to first fruit harvest	Fresh fruit length	Fresh fruit girth	Mature fruit length	Mature fruit diameter	Mature fruit wt. (kg)	Seed wt./fruit (g)	No. of seed /fruit	100 seed wt. (g)	Correlation with Seed yield /plant (g)
Node no to staminate flower appearance	0.095	-0.248	0.037	0.057	-0.012	-0.084	-0.091	0.469	-0.064	-0.061	0.493	-0.407	-0.065	0.119
Node no to pistillate flower anthesis	0.032	-0.746	0.009	0.037	0.006	-0.032	0.048	0.158	0.063	0.012	0.720	-1.090	0.842	0.059
Days to staminate flower anthesis	0.020	-0.037	0.182	0.143	0.047	-0.057	-0.196	0.343	-0.194	-0.101	-0.576	0.100	0.212	-0.114
Day to pistillate flower anthesis	0.029	-0.149	0.141	0.185	0.085	-0.109	-0.215	0.303	-0.196	0.075	-0.269	0.245	-0.298	-0.172
Days to first fruit harvest	-0.004	-0.014	0.027	0.050	0.318	-0.010	0.118	-0.373	0.146	0.122	-0.916	0.981	-0.517	-0.073
Fresh fruit length	0.019	-0.059	0.025	0.049	0.008	-0.409	-0.235	1.171	-0.426	0.201	-0.615	0.097	0.031	-0.142
Fresh fruit girth	-0.016	-0.065	-0.065	-0.072	0.068	0.175	0.548	-1.284	0.446	0.057	-0.406	0.821	-0.442	-0.235*
Mature fruit length	0.026	-0.069	0.037	0.033	-0.069	-0.280	-0.413	1.707	-0.450	-0.113	-0.284	-0.802	0.725	0.047
Mature fruit diameter	-0.011	-0.081	-0.061	-0.063	0.080	0.302	0.424	-1.332	0.577	-0.175	0.574	0.115	-0.256	0.094
Mature fruit wt. (kg)	0.007	0.012	0.023	-0.018	-0.049	0.104	-0.040	0.244	0.128	-0.789	0.926	-1.070	0.819	0.299**
Seed wt./fruit (g)	0.013	-0.154	-0.030	-0.014	-0.083	0.072	-0.064	-0.139	0.095	-0.209	3.500	-1.545	-0.634	0.809**
No. of seed /fruit	0.014	-0.285	-0.006	-0.016	-0.109	0.014	-0.158	0.480	-0.023	-0.296	1.896	-2.852	1.881	0.538**
100 seed wt. (g)	0.002	0.219	-0.013	0.019	0.057	0.004	0.085	-0.432	0.052	0.226	0.775	1.873	-2.864	0.003

Residual Effect = -0.00837

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