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Character association and path coefficient analysis of bottle gourd (*Lagenaria siceraria* (Molina.) Standl.) Genotypes

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Abstract
Thirty four diverse genotypes of bottle gourd collected from different indigenous sources were planted in randomized complete block design and were assessed to know character association and path coefficient analysis for different horticultural traits. Fruit yield per vine was positively and significantly correlated with number of primary branches per vine, number of secondary branches per vine per vine, internodal length, sex ratio, fruit girth, fruit weight, number of fruits per vine, pericarp thickness and vine length at final harvest at both phenotypic and genotypic levels. Path analysis revealed that the direct effects through number of primary branches per vine, days to first fruit harvest, fruit girth, fruit weight, number of fruits per vine, cavity diameter and hundred seeds weight positively contributed towards fruit yield per vine at both genotypic and phenotypic level.

Keywords: *Lagenaria siceraria* (Molina.) Standl., Bottle gourd, Genotypic, Phenotypic, Correlation, Path coefficient analysis

Introduction
Bottle gourd is known as poor man's vegetable or white flowered gourd belongs to the family Cucurbitaceae, with a chromosome number 2n=22. In India it is grown throughout the country for its tender fruits. It is one of humankind's first domesticated plants with high genetic diversity for fruit shape and other fruit characteristics, resulting in a variety of uses (Bisognin, 2002) [1]. Though bottle gourd is one of the common cucurbits in the country, it has been neglected by the plant breeders. Most of the bottle gourd varieties available for cultivation in our country have lost their potentiality. Therefore, it is essential to increase its productivity through various new strategies of crop improvement. For crop improvement, Knowledge of degree of yield association with its components is of great importance, because yield is the resultant of the interaction of number of characters and these components are likely to be modified by action of genes present in the genotypes of plant and also by the environment. Therefore, correlation study of yield with its component traits has been executed. Path coefficient analysis devised by Dewey and Lu (1959) [3], however, provides a realistic basis for allocation of appropriate weightage to various attributes while designing a pragmatic programme for the improvement of yield.

Materials and Methods
The present research study was carried out at Department of Vegetable science, Kittur Rani Channamma College of Horticulture, Arabhavi during 2020-21. The material used for research work consisted thirty four cultivars of bottle gourd which were procured from different sources (Table 1). The experiment was laid out in accordance with Randomized Complete Block Design (RCBD) comprising of thirty four treatments and two replications. All the cultural practices were same for all the cultivars used. Observations on growth, flowering and yield parameters were recorded and subjected to statistical analysis.

Results and Discussion
Correlation study showed that, at both genotypic and phenotypic level fruit yield per vine positively and significantly (at p=0.01) correlated with number of primary branches per vine (0.787 and 0.709), number of secondary branches per vine (0.476 and 0.448), inter nodal length (0.416 and 0.418), sex ratio (0.751 and 0.553), vine length at final harvest (0.589 and

0.664), fruit girth (0.317 and 0.320), fruit weight (0.867and 0.852) and number of fruits per vine (0.829 and 0.822). Negative and significant association was noticed with days to first female flower appearance (-0.384 and -0.343) at both genotypic and phenotypic levels, respectively (Tables 2 & 3).

Positive and significant (at p=0.01) association of days to first male flower appearance was recorded with days to first female flower appearance (0.603 and 0.535) and fruit girth (0.533 and 0.505). Days to first female flowering recorded positive and significant (at p=0.01) association with days to first harvest (0.709 and 0.748). Negative and significant (at p=0.01) association was recorded with sex ratio (-0.430 and -0.384), vine length at final harvest (0.428 and =-0.366) and pericarp thickness (0.579 and =-0.479). Sex ratio was positively and significantly (at p = 0.01) correlated with fruit weight (0.604 and 0.441), number fruits per vine (0.683 and 0.479), vine length at final harvest (0.651 and 0.445) and number of seeds per fruit (0.523 and 0.399) at both genotypic and phenotypic level, respectively (Tables 2 & 3).

At both genotypic and phenotypic level, fruit length was positively and significantly (at p = 0.01) correlated with number of seeds per fruit (0.316 and 0.305). It was negatively and significantly (at p = 0.01) associated with fruit girth (-0.540 and -0.528) and cavity diameter (-0.472 and - 0.466). Positive and significant (at p=0.01) association of fruit girth with cavity diameter (0.689 and 0.665) was recorded (Tables 2 & 3).

Fruit weight had positive and significant (at p=0.01) association with number of fruits per vine (0.455 and 0.419) and vine length at final harvest (0.495 and 0.426). Number of fruits per vine had positively and significantly (at p = 0.01) correlated with vine length at final harvest (0.636 and 0.544). Positive and significant (at p=0.05) association was also observed with rind thickness (0.304 and 0.261). Rind thickness was negatively and significantly (at p = 0.01) associated with pericarp thickness (-0.406 and -0.368) at both genotypic and phenotypic level, respectively (Tables 2 & 3).

The correlation results obtained in the present study indicated that parameters like number of primary branches per vine, number of secondary branches per vine, inter nodal length, sex ratio, vine length at final harvest, fruit girth, fruit weight and number of fruits per vine are the important components of fruit yield as they have shown positive and significant association with fruit yield per vine (Tables 2 & 3). Therefore, to increase the yield in bottle gourd, selection for above mentioned parameters can be considered. The results were in line with the findings of Suchitra and Haribabu, (2006) [7] where they observed positive association of fruit length with fruit yield in bottle gourd, Mladenovic *et al*. (2012) [6] who recorded positive correlation between number of branches per vine with fruit yield per vine in bottle gourd. Similar findings were also reported by Ahirwar and Singh. (2018) [1] who observed positive correlation of number of fruits per vine in cucumber with fruit yield per vine, Vijayakumar *et al*. (2020) [9] who recorded that, fruit yield in ridge gourd was significantly and positively correlated with fruit weight and sex ratio.

Path coefficient analysis between the components of bottle gourd was worked out for fruit yield per vine at genotypic and phenotypic level (Table 4 &5). Out of seventeen characters studied, the direct effects *via* number of primary branches per vine, days to first fruit harvest, fruit girth, fruit weight, number of fruits per vine, cavity diameter and hundred seeds weight positively contributed towards fruit yield per vine at both genotypic and phenotypic level. Days to first female flower opening, sex ratio, fruit length and vine length positively contributed towards fruit yield per vine only at genotypic level. Number of secondary branches per vine, days to first male flower opening, pericarp thickness and number of seeds per fruit positively contributed towards fruit yield per vine at phenotypic level. This indicates the true positive association with fruit yield per vine. Therefore, direct selection for these traits would reward for improvement of yield. This is in confirmation with the study of Khan *et al*., 2016 [5] in snake gourd where fruit yield had a highest, direct, positive effect with number of fruits per vine. Thakur *et al*., (2017) [8] found that, number of fruits per vine in bottle gourd and average fruit weight had highest significant positive association with yield. Similar findings were also reported by Jain *et al*. (2017) [4] in bottle gourd and Ahirwar and Singh. (2018) [1] in cucumber.

The present work character association studies in bottle exhibited yield contributing traits in bottle gourd and their effects individually and in combination with other characters on the expression of on fruit yield. It provided information that the selection for one character will result in progress for all correlated characters. Hence these traits can be used as selection criteria in bottle gourd breeding for higher yield with quality fruits.

Table 1: List of genotypes used in the study

Sl. No.	Genotype	Sl. No.	Genotype
1.	Kashi Ganga	18.	HUB-3
2.	Arka Bahar	19.	HUB-4
3.	Pusa Santhushti	20.	HUB-5
4.	Pusa summer prolific long	21.	HUB-6
5.	Pusa Sandesh	22.	HUB-7
6.	Punjab Bahar	23.	IC392392A
7.	Pant Lauki -3	24.	IC339199
8.	Samrat	25.	IC392392
9.	G-7	26.	IC2878953
10.	G-7-1	27.	NBB212
11.	G-4-1	28.	IC4211962
12.	G-6	29.	IC342078
13.	G-6-1	30.	IC342079
14.	L-1	31.	IC308564A
15.	G-2	32.	Warnad
16.	HUB-1	33.	Anand
17.	HUB-2	34.	Andra-1

Table 2: Genotypic correlation coefficients among growth and yield parameters of bottle gourd

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	r_g
1	1.000	0.643**	0.314**	0.108	-0.343**	0.931**	0.036	0.194	0.056	0.633**	0.677**	0.629**	-0.159	0.207	0.199	0.338**	-0.000	0.787**
2		1.000	-0.016	0.279*	0.179	0.727**	0.453**	0.225	0.051	0.377**	0.424**	0.277*	-0.249*	0.075	-0.106	0.182	0.140	0.476**
3			1.000	-0.024	-0.287*	0.205	-0.046	0.036	-0.073	0.458**	0.214	0.271*	-0.024	-0.069	0.326**	0.387**	0.376**	0.416**
4				1.000	0.603**	0.221	0.310*	-0.097	0.533**	0.303*	0.063	0.296*	0.346**	-0.027	-0.367**	0.025	-0.079	0.235
5					1.000	-0.430**	0.709**	-0.292*	0.185	-0.347**	-0.306*	-0.428**	0.105	-0.166	-0.579**	-0.121	-0.004	-0.384**
6						1.000	-0.081	0.275*	0.233	0.604**	0.683**	0.651**	-0.115	0.304*	0.241*	0.523**	0.024	0.751**
7							1.000	-0.367**	0.121	-0.008	0.082	-0.203	-0.038	-0.199	-0.367**	-0.056	0.014	0.0061
8								1.000	-0.540**	0.021	0.061	0.176	-0.472**	-0.035	0.155	0.316**	0.202	0.034

9									1.000	0.307*	0.198	0.180	0.689**	-0.162	-0.001	-0.131	-0.303*	0.317**
10										1.000	0.455**	0.495**	0.154	0.088	0.243*	-0.016	0.046	0.867**
11											1.000	0.636**	0.157	0.304*	0.276*	0.052	0.120	0.829**
12												1.000	0.077	0.121	0.233	0.171	-0.018	0.664**
13													1.000	-0.046	-0.230	-0.200	-0.074	0.184
14														1.000	-0.406**	0.093	0.106	0.205
15															1.000	0.128	0.118	0.295*
16																1.000	0.036	0.046
17																	1.000	0.098

Critical $r_g$value at 5% =0.238* Significant at p=0.05 Critical r_g value at 1% =0.310 **Significant at p=0.01

1. Number of primary branches
2. Number of secondary branches
3. Intermodal length (cm)
4. Days to first male flower opening
5. Days to first female flower opening
6. Sex ratio
7. Days to first harvest
8. Length of the fruit (cm)
9. Girth of the fruit (cm)
10. Fruit weight (g)
11. Number of fruits vine
12. Vine length at final harvest (m)
13. Cavity diameter (cm)
14. Rind thickness (mm)
15. Pericarp thickness (mm)
16. Number of seeds per vine
17. Weight of 100 seeds

Table 3: Phenotypic correlation coefficients among growth and yield parameters of bottle gourd

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	r_p
1	1.000	0.577**	0.296*	0.110	-0.284*	0.652**	0.052	0.186	0.053	0.569**	0.590**	0.590**	-0.149	0.191	0.098	0.312**	0.007	0.709**
2		1.000	-0.019	0.252*	0.150	0.511**	0.392**	0.192	0.061	0.373**	0.361**	0.253*	-0.232	0.072	-0.127	0.180	0.150	0.448**
3			1.000	-0.015	-0.231	0.119	-0.011	0.038	-0.054	0.433**	0.246*	0.244*	-0.039	-0.039	0.270*	0.373**	0.350**	0.418**
4				1.000	0.535**	0.141	0.290*	-0.072	0.505**	0.276*	0.105	0.292*	0.306*	-0.000	-0.331*	0.019	-0.066	0.241*
5					1.000	-0.384**	0.748**	-0.233	0.160	-0.288*	-0.278*	-0.366**	0.076	-0.124	-0.479**	-0.111	-0.010	-0.343**
6						1.000	-0.159	0.180	0.172	0.441**	0.479**	0.445**	-0.078	0.237	0.163	0.399**	-0.002	0.553**
7							1.000	-0.292*	0.103	-0.049	0.055	-0.152	-0.051	-0.152	-0.304*	-0.050	0.020	0.006
8								1.000	-0.528**	0.004	0.040	0.178	-0.466**	-0.029	0.142	0.305*	0.183	0.015
9									1.000	0.300*	0.205	0.170	0.665**	-0.137	-0.011	-0.126	-0.283*	0.320**
10										1.000	0.419**	0.426**	0.135	0.087	0.187	-0.016	0.057	0.852**
11											1.000	0.544**	0.126	0.261*	0.187	0.049	0.119	0.822**
12												1.000	0.069	0.108	0.187	0.164	-0.005	0.589**
13													1.000	-0.040	-0.198	-0.197	-0.064	0.162
14														1.000	-0.368**	0.092	0.056	0.187
15															1.000	0.114	0.089	0.224
16																1.000	0.038	0.044
17																	1.000	0.104

Critical r_p value at 5% =0.238 Critical r_g value at 1% =0.310 *Significant at p=0.05 **Significant at p=0.01

1. Number of primary branches per vine
2. Number of secondary branches per vine
3. Inter nodal length (cm)
4. Days to first male flower opening
5. Days to first female flower opening
6. Sex ratio
7. Days to first fruit harvest
8. Length of the fruit (cm)
9. Girth of the fruit (cm)
10. Average fruit weight (g)
11. Number of fruits per vine
12. Vine length at final harvest (m)
13. Cavity diameter (cm)
14. Rind thickness (mm)
15. Pericarp thickness (mm)
16. Number of seeds per vine
17. Weight of 100 seed

Table 4: Genotypic path coefficient analysis for fruit yield per vine in bottle gourd

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**r_g**
1	0.073	0.047	0.023	0.007	-0.025	0.068	0.002	0.014	0.004	0.046	0.049	0.046	-0.011	0.015	0.014	0.024	0.000	0.787**
2	-0.056	-0.087	0.001	-0.024	-0.015	-0.063	-0.039	-0.019	-0.004	-0.032	-0.037	-0.024	0.021	-0.006	0.009	-0.015	-0.012	0.476**
3	0.005	-0.000	0.016	-0.000	-0.004	0.003	-0.000	0.000	-0.001	0.007	0.003	0.004	-0.000	-0.001	0.005	0.006	0.006	0.416**
4	-0.013	-0.034	0.003	-0.124	-0.075	-0.027	-0.038	0.012	-0.066	-0.038	-0.008	-0.037	-0.043	0.003	0.046	-0.003	0.010	0.235
5	-0.042	0.022	-0.035	0.074	0.123	-0.053	0.087	-0.036	0.023	-0.042	-0.038	-0.053	0.013	-0.020	-0.071	-0.015	-0.000	-0.384**
6	0.073	0.057	0.016	0.017	-0.034	0.079	-0.006	0.022	0.018	0.047	0.054	0.051	-0.009	0.024	0.019	0.041	0.002	0.751**
7	0.001	0.018	-0.002	0.012	0.028	-0.003	0.039	-0.014	0.005	-0.003	0.003	-0.008	-0.001	-0.008	-0.014	-0.002	0.000	0.006
8	0.009	0.011	0.002	-0.005	-0.015	0.014	-0.019	0.050	-0.027	0.001	0.003	0.009	-0.023	-0.002	0.008	0.016	0.010	0.034
9	0.004	0.003	-0.005	0.036	0.012	0.016	0.008	-0.037	0.068	0.021	0.013	0.012	0.047	-0.011	-0.000	-0.009	-0.020	0.317**
10	0.388	0.231	0.281	0.186	-0.212	0.371	-0.049	0.013	0.188	0.613	0.279	0.303	0.095	0.054	0.149	-0.010	0.028	0.867**
11	0.305	0.192	0.097	0.028	-0.138	0.309	0.037	0.028	0.089	0.206	0.451	0.287	0.071	0.137	0.125	0.024	0.054	0.829**
12	0.046	0.020	0.020	0.021	-0.032	0.048	-0.015	0.013	0.013	0.036	0.047	0.073	0.006	0.009	0.017	0.013	-0.001	0.664**
13	-0.003	-0.005	-0.000	0.006	0.002	-0.002	-0.001	-0.009	0.013	0.003	0.003	0.001	0.019	-0.001	-0.004	-0.004	-0.001	0.184
14	0.002	0.001	-0.001	-0.000	-0.002	0.004	-0.002	-0.000	-0.002	0.001	-0.004	0.001	0.004	0.012	-0.005	0.001	0.001	0.205
15	-0.000	0.000	-0.001	0.001	0.001	-0.001	0.001	-0.000	0.000	-0.001	-0.001	-0.001	0.000	0.001	-0.002	-0.000	-0.000	0.295**
16	-0.007	-0.004	-0.008	-0.000	0.002	-0.010	0.001	-0.006	0.003	0.000	-0.001	-0.004	0.004	-0.002	-0.002	-0.020	-0.001	0.046
17	0.000	0.003	0.008	-0.002	-0.000	0.000	0.000	0.004	-0.006	0.001	0.002	-0.000	-0.002	0.002	0.002	0.001	0.022	0.098

R SQUARE = 0.9907 RESIDUAL EFFECT = 0.09 *Significant at p=0.05 **Significant at p=0.01

r_g = genotypic correlation coefficients with fruit yield per vine. Diagonal values indicate direct effects

1. Number of primary branches per vine
2. Number of secondary branches per vine
3. Inter nodal length (cm)
4. Days to first male flower opening
5. Days to first female flower opening
6. Sex ratio
7. Days to first fruit harvest
8. Length of the fruit (cm)
9. Girth of the fruit (cm)
10. Average fruit weight (g)
11. Number of fruits per vine
12. Vine length at final harvest (m)
13. Cavity diameter (cm)
14. Rind thickness (mm)
15. Pericarp thickness (mm)
16. Number of seeds per vine
17. Weight of 100 seed

Table 5: Phenotypic path coefficient analysis for fruit yield per vine in bottle gourd

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	r_p
1	0.071	0.041	0.021	0.008	-0.020	0.047	0.004	0.013	0.004	0.041	0.042	0.042	-0.011	0.014	0.007	0.022	0.000	0.709**
2	0.015	0.026	-0.000	0.006	0.004	0.013	0.010	0.005	0.002	0.010	0.009	0.006	-0.006	0.002	-0.003	0.005	0.004	0.447**
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.418**
4	0.010	0.022	-0.001	0.089	0.048	0.012	0.026	-0.006	0.045	0.025	0.009	0.026	0.027	0.000	-0.029	0.002	-0.006	0.240*
5	0.044	-0.023	0.036	-0.083	-0.155	0.060	-0.116	0.036	-0.025	0.045	0.043	0.057	-0.012	0.019	0.074	0.017	0.002	-0.343**
6	-0.036	-0.028	-0.006	-0.008	0.021	-0.055	0.009	-0.010	-0.009	-0.024	-0.026	-0.024	0.004	-0.013	-0.009	-0.022	0.000	0.552**
7	0.003	0.026	-0.000	0.019	0.049	-0.010	0.065	-0.019	0.007	-0.003	0.004	-0.010	-0.003	-0.010	-0.020	-0.003	0.001	0.006
8	-0.002	-0.002	-0.000	0.001	0.003	-0.002	0.004	-0.014	0.007	-0.000	-0.000	-0.002	0.006	0.000	-0.002	-0.004	-0.002	0.015
9	0.002	0.002	-0.001	0.015	0.005	0.005	0.003	-0.015	0.030	0.009	0.006	0.005	0.012	-0.004	-0.000	-0.004	-0.008	0.320**
10	0.309	0.202	0.235	0.150	-0.157	0.240	-0.027	0.002	0.163	0.543	0.227	0.231	0.073	0.047	0.102	-0.009	0.031	0.852**
11	0.305	0.187	0.127	0.054	-0.144	0.248	0.029	0.020	0.106	0.216	0.517	0.281	0.065	0.135	0.097	0.025	0.061	0.822**
12	-0.017	-0.007	-0.007	-0.008	0.010	-0.013	0.004	-0.005	-0.005	-0.012	-0.016	-0.029	-0.002	-0.003	-0.005	-0.005	0.000	0.589**
13	-0.001	-0.002	-0.000	0.002	0.000	-0.000	-0.000	-0.003	0.005	0.001	0.001	0.000	0.007	-0.000	-0.001	-0.001	-0.000	0.162
14	0.000	0.000	-0.000	0.000	-0.000	0.000	-0.000	-0.000	0.000	0.000	0.000	0.001	0.000	-0.017	0.000	0.000	0.000	0.187**
15	0.001	-0.001	0.003	-0.004	-0.006	0.002	-0.004	0.002	-0.000	0.002	0.002	0.002	-0.002	-0.004	0.011	0.001	0.001	0.224
16	0.006	0.003	0.007	0.000	-0.002	0.007	-0.001	0.006	-0.002	-0.000	0.001	0.003	-0.004	0.002	0.002	0.019	0.001	0.044
17	0.000	0.003	0.007	-0.001	-0.000	0.000	0.000	0.004	-0.006	0.001	0.002	-0.000	-0.001	0.001	0.002	0.001	0.020	0.104

R SQUARE = 0.9940 RESIDUAL EFFECT = 0.077 *Significant at p=0.05 **Significant at p=0.01

r_p = phenotypic correlation coefficients with fruit yield per vine. Diagonal values indicate direct effects

1. Number of primary branches per vine
2. Number of secondary branches per vine
3. Inter nodal length (cm)
4. Days to first male flower opening
5. Days to first female flower opening
6. Sex ratio
7. Days to first fruit harvest
8. Length of the fruit (cm)
9. Girth of the fruit (cm)
10. Average fruit weight (g)
11. Number of fruits per vine
12. Vine length at final harvest (m)
13. Cavity diameter (cm)
14. Rind thickness (mm)
15. Pericarp thickness (mm)
16. Number of seeds per vine
17. Weight of 100 seed

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