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Studies on genetic variability, heritability, genetic advance and character association for various quantitative traits in bottle gourd [*Lagenaria siceraria* (Mol.) Standl.] genotypes

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Abstract

Thirty-sevendiverse genotypes of bottle gourdwere evaluated to access the relative performance, genetic variability, heritability, genetic advance and simultaneously to study the nature and magnitude of associations between yield and its contributing characters. The genotypes were sown under RBD in three replications at Vegetable Research Farm, CCS Haryana Agricultural University, Hisar during the *Spring Summer* season of 2017-18. Results attained from analysis of variance reportedthat there were substantial differences among the genotypes unveiling the plausible presence of significant genetic variability, which could be positively exploited in crop improvement programmes. The highest GCV (18.90) and PCV (18.96) were observed for vine length. In addition to this, fruit yield was found significantly and positively correlated with number of fruits per vine, number of primary branches per vine and average fruit weight. The path analysis indicated that the days to first female flowering, number of fruits per vine, nodes to first female flower, length of fruit and average fruit weight were the most propitious characters directly influencing the dependent variable *viz*. fruit yield/ha.

Keywords: Variability, heritability, GA, phenotypic correlation coefficient and path analysis

Introduction

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl.], having chromosome number 2n = 2x = 22, is one of humankind's first domesticated plants. It is also known as white flower gourd, calabash or Lauki, is an important cucurbitaceous vegetable crop belonging to family Cucurbitaceae. Among the popular gourd crops, it could be grown in India, China and South-East Asia. The cultivated *Lagenaria* species, which is an annual, monoecious and highly cross-pollinated crop, are indigenous to tropical Africa. This crop has great economic importance as it has multifarious uses at varying stages of fruit growth. Its fruit at tender stage are cooked as a vegetable, whereas, hard shells of mature fruits are used for domestic utensils, floats for fishing nets *etc*. It can be used for making sweets (e.g., halva, *kheer* and *burfi*). Other than the culinary uses, it is also well known for its medicinal uses and health benefits. A decoction made from its leaf is very good medicine for curing jaundice. The pulp is good for overcoming constipation, cough, night blindness and as an antidote against certain poisons. The plant extract is used as a cathartic and the seeds are used in dropsy. The fruit contain 95.54 per cent moisture, vitamin C (10.1 g), vitamin A (16 IU),thiamine (0.029 g),riboflavin (0.022 g), niacin (0.320 g), carbohydrates (3.39 g), fats (0.02 g)and potassium (150 mg) per 100 g fresh weight (USDA 2018).

Estimation of genetic parameters is needed to understand the genetic architecture of yield and its contributing components. The main purpose of bottle gourd breeding is to increase fruit yield. However, fruit yield being a complex trait and multiplicative end product of large number of contributing characters and their interactions, have polygenic inheritance. Therefore, understanding the genetic parameters, character association and their interaction with the environment becomes

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immensely important as it assists a breeder in simultaneous selection of efficient traits for desired improvement and allocation of resources accordingly under a crop improvement or selection programme to result in the desired direction.

Materials and Methods

The present experiment was carried out at Vegetable Research Farm Chaudhary Charan Singh Haryana Agricultural University, Hisar during the Spring-Summer season of 2017-18.The experimental location stands at 29º 43' in the North and 76º 58' East, at 243 meters elevation above mean sea level and the area of research station is characterized by sub-tropical and semi-arid climate with mean maximum temperature ranging between 35-41ºC in Summer season and mean minimum temperature ranging between 6-9ºC in winter. The selected germplasm consists of thirty-seven genotypes collected from various sources. The crop was sown in randomized block design in three replications. The investigation involved thirteen parameters which were observed and recorded. Five plants were randomly selected for recording of various growth characters and likewise ten fruits were picked randomly to record fruit characters in every genotype for each replication.

The data collected for various characters was statistically analyzed in order to achieve the objectives of study. Analysis of Variance was done using the method suggested by Fisher (1963) later described by Panse and Sukhatme (1967). Heritability and Genetic advance was estimated using the formula given by Burton and Devane (1953), Johnson et al. (1955) and Hanson et al. (1956). Genotypic and phenotypic coefficients of correlation were determined using the variance and covariance components as suggested by Al-Jibouri et al. (1958) and path coefficient analysis was computed as per the method of Dewey and Lu (1959).

Results and Discussion

Highly significant differences among genotypes for all the quantitative characters were recorded in analysis of variance (Table 1), which unveiled the presence of considerable variability in these genotypes of bottle gourd that can be utilized in crop improvement programmes by selecting genotypes through characters studied hereby. The per se performance of genotypes revealed a wide range for characters such as days to 1st male flowering (ranging from 45.3 to 62.3), days to 1st female flowering (ranging from 48.6 to 65.0), days to first fruit harvest (ranging from 57.3 to 77.0), vine length (ranging from 361.8 to 777.7), number of fruits per vine (ranging from 4.4 to 11.1), fruit yield per hectare (ranging from 172.5 to 358.5), number of

Table 1: Analysis of variance (ANOVA)

Characters	Mean Sum of Squares		
	Treatments	Replications	Error
Degree of freedom (df)	36	2	72
Days to 1st male flowering	50.92**	0.10	0.72
Days to 1st female flowering	50.81**	0.09	0.56
Days to first fruit harvest	60.17**	0.44	0.88
Vine Length	31773.31**	2.14	74.43
Number of fruits/vine	5.52**	0.12	0.09
Yield per hectare	5817.96**	2.71	16.81
Number of primary branches	12.32**	0.01	0.06
Nodes to 1st male flower	4.73**	0.02	0.14
Nodes to 1st female flower	5.84**	0.01	0.15
Length of fruit	27.58**	0.02	0.17
Diameter of fruit	1.30**	0.01	0.14
Average fruit weight	38460.87**	1352.78	2091.71
Crop maturity	69.19**	0.27	9.52

*, **: Significant at 5% and 1% level, respectively

primary branches per vine (ranging from 8.7 to 16.1), nodes to 1st male flower (ranging from 8.8 to 13.9), nodes to 1st female flower (ranging from 9.8 to 15.2), length of fruit (ranging from 24.2 to 36.8), diameter of fruit (ranging from 7.3 to 10.5), average fruit weight (ranging from 530.0 to 1100.0) and crop maturity (ranging from 107.0 to 133.0) days (Table 2).

From the findings of present experiment, it was evident that genotypic and phenotypic coefficients of variation showed a wide range of values (Table 3)

Table 2: Mean, range, variance, coefficients of variation (GCV & PCV), heritability and genetic advance as % of mean for various characters in bottle gourd genotypes

Characters	Mean	Range		Variance		Coefficient of variation		Heritability % (Broad sense)	Genetic advance (% of mean)
		Max.	Min.	Genotypic	Phenotypic	Genotypic	Phenotypic		
DMF	51.29	62.33	45.33	16.73	17.46	7.97	8.15	96	16.08
DFF	55.12	65.00	48.67	16.75	17.31	1.36	7.55	97	15.04
DFH	66.02	77.00	57.33	19.76	20.64	6.73	6.88	96	13.57
VL	543.94	777.70	361.80	10566.29	10640.73	18.90	18.96	99	38.80
NFV	7.51	11.10	4.40	1.81	1.91	17.90	18.37	95	35.90
YPH	275.81	358.50	172.50	1933.72	1950.53	15.94	16.01	99	32.70
NPB	12.36	16.15	8.76	4.09	4.15	16.36	16.49	98	33.43
NMF	10.98	13.94	8.85	1.53	1.67	11.28	11.78	92	22.23
NFF	12.48	15.20	9.85	1.90	2.05	11.03	11.47	92	21.84
LF	30.40	36.80	24.20	9.14	9.31	9.94	10.04	98	20.30
DF	8.90	10.57	7.30	0.38	0.53	6.97	8.20	72	12.19
AFW	828.14	1100.00	530.00	12123.05	14214.77	13.30	14.40	85	25.29
CM	120.53	133.00	107.00	19.89	29.42	3.70	4.50	68	6.27

DMF: Days to first male flower opening; DFF: Days to first female flower opening; DFH: Days to first fruit harvest; VL: Vine length at the time of final harvest (cm); NFV: Number of fruits per vine; YPH: Yield per hectare (q); NPB: Number of primary branches; NMF: Nodes to first male flower; NFF: Nodes to first female flower; LF: Length of fruit (cm); DF: Diameter of fruit (cm); AFW: Average fruit weight (g); CM: Crop maturity (days)

Table 3: Genotypic (above diagonal) and Phenotypic (below diagonal) correlation-coefficients within various characters

Characters		DMF	DFF	DFH	VL	NFV	NPB	NMF	NFF	LF	DF	AFW	CM	YPH
DMF	G	1.000	0.937**	0.713 **	-0.363 *	-0.017	-0.249	0.201	0.256	-0.101	0.332 *	-0.297	0.082	-0.040
	P	1.000	0.902 **	0.692 **	-0.353 **	-0.016	-0.240*	0.203*	0.245**	-0.096	0.279 **	-0.262 **	0.084	-0.037
DFF	G		1.000	0.789 **	-0.273	-0.066	-0.369*	0.307	0.380 *	-0.229	0.260	-0.401 *	0.257	-0.094
	P		1.000	0.764 **	-0.264 **	-0.077	-0.361**	0.293**	0.357**	-0.220 *	0.211 *	-0.358 **	0.192 *	-0.095
DFH	G			1.000	0.015	-0.321	-0.243	0.297	0.305	-0.242	0.289	-0.354 *	0.270	-0.321
	P			1.000	0.015	-0.310**	-0.236*	0.294 **	0.282**	-0.224 *	0.262 **	-0.317 **	0.225 *	-0.310**
VL	G				1.000	-0.194	0.101	-0.095	-0.087	0.145	-0.215	-0.171	-0.125	-0.191
	P				1.000	-0.192*	0.099	-0.091	-0.078	0.143	-0.187 *	-0.155	-0.097	-0.191
NFV	G					1.000	0.513 **	-0.703 **	-0.658 **	0.413 **	-0.002	0.697 **	-0.468 **	0.932 **
	P					1.000	0.497**	-0.640**	-0.610**	0.396 **	-0.001	0.613**	-0.382**	0.904 **
NPB	G						1.000	-0.861 **	-0.895 **	0.489 **	-0.170	0.675**	-0.497 **	0.602 **
	P						1.000	-0.817**	-0.857**	0.479 **	-0.135	0.613**	-0.399 **	0.595 **
NMF	G							1.000	0.945 **	-0.534 **	0.182	-0.760**	0.532 **	-0.785 **
	P							1.000	0.870 **	-0.501 **	0.152	-0.674**	0.430 **	-0.745**
NFF	G								1.000	-0.554 **	0.260	-0.781**	0.588 **	-0.702 **
	P								1.000	-0.529 **	0.226 *	-0.676**	0.447 **	-0.674 **
LF	G									1.000	-0.259	0.375 *	-0.424 **	0.539 **
	P									1.000	-0.219*	0.347**	-0.325**	0.535 **
DF	G										1.000	-0.052	-0.133	0.001
	P										1.000	-0.070	-0.121	0.001

AFW	G	1.000	-0.393 **	0.712**
	P	1.000	-0.288**	0.656**
CM	G		1.000	-0.531 **
	P		1.000	-0.435 **

*, **: Significant at 5% and 1% level, respectively; G: Genotypic correlation coefficient; P: Phenotypic correlation coefficient

for all the characters under the study. In general, narrow difference between GCV and PCV for any character denotes that environment had very little influence in expression of that character and phenotype truly represents the genotype whereas, wide difference among PCV and GCV indicates high susceptibility of that character towards environmental fluctuations.The statistical analysis of recorded observations showed that the magnitude of phenotypic coefficient of variation was relatively higher than the corresponding values of genotypic coefficient of variation signifying the influence of environment on the expression of characters observed in the study. The high value of GCV and PCV in order of their magnitude was recorded for characters vine length (18.90% and 18.96%), number of fruits per vine (17.90% and 18.37%), number of primary branches per vine (16.36% and 16.49%) and fruit yield per hectare (15.94% and 16.01%) respectively. Rest all the characters observed medium to low magnitude of GCV and PCV. The results of the present study are in consonance with results of previous studies carried by Premalakshmi et al. (2014) and Sherpa et al. (2014) in tomato, Panigrahi and Duhan (2018) and Rashid et al. (2020) in bottle gourd.

Heritability is the degree to which variability present in a character can be transferred from one generation to another or it is an indicator of reliability with which a genotype can be identified by the expression of its phenotype. Hence, it plays an important role in determining whether the phenotypic difference found among various individuals are new to difference in their genetic makeup or simply a result of environmental factors. Based on the observations recorded it can be inferenced that all the characters under study, except for diameter of fruit (72%) and crop maturity (68%), have high heritability (i.e. ≥75%) and maximum values for heritability were reported in traits vine length (99%), fruit yield per hectare (99%), length of fruit (98%) and number of primary branches per vine (98%). Similar results in bottle gourdwere also reported by Abhishek et al. (2020), Venkatraman and Haripriya (2021), Singh et al. (2021) and Anoj and Yadav (2022).

The effectiveness of selection at any given level of selection intensity is regarded as genetic advance. The study of heritability estimates coupled with genetic advance is more dependable than heritability alone in envisaging the consequential effects of selection (Johnson et al. 1955). The Categorization of Genetic Advance (Johnson et al. 1955): High >20%, Moderate 10-20% and Low <10%. Based on the above categorization, vine length (38.8%), number of fruits per vine (35.9%), fruit yield/ha (32.7%), number of primary branches per vine (33.43%), average fruit weight (25.29%), nodes to 1st male flower (22.2%), nodes to 1st female flower (21.84%) and length of fruit (20.3%) falls under the group of high genetic advance, whereas, days to 1st male flowering (16.0%), days to 1st female flowering (15.0%), days to first fruit harvest (13.57%) and diameter of fruit (12.1%) falls under medium genetic advance group and only crop maturity (6.2%) comes under low genetic advance category.The results obtained from the study are in close conformity with the results of previous researchers result as reported by Venkatraman and Haripriya (2021) and Singh et al. (2021) in bottle gourd.

The values for correlation coefficients were figured at both phenotypic and genotypic levels for all the characters under study (Table 3) with fruit yield per hectare as well as among the characters themselves. The comparison of values revealed that genotypic correlation coefficient estimates were relatively higher than their counterpart estimates of phenotypic correlation coefficient for almost all the characters, implying that the environmental influence reduced the phenotypic expression even under a strong inherent association of characters. The findings of this study were in concurrence with Meena and Bahadur (2015) in tomato and Rehan et al. (2020), Chouhan et al. (2020) and Kumari et al. (2021) in bottle gourd. This implies that there exists an impregnable genetic relationship between the characters, although their phenotypic expression was hindered by environmental factors. It was also evident from the results that nature and direction of genotypic and phenotypic correlation coefficients remained same for all the traits under consideration.

Fruit yield per hectare evinced a significant positively correlated relationship with number of fruits per vine (0.932, 0.904), average fruit weight (0.712, 0.656), number of primary branches per vine (0.602, 0.595) and length of fruit (0.539, 0.535) at both the levels viz., genotypic and phenotypic, respectively.A positive association of days to first female flowering was observed with days to first fruit harvest (0.789, 0.764), nodes to first male flower (0.307, 0.293), nodes to first female flower (0.380, 0.357), diameter of fruit (0.260, 0.211) and crop maturity (0.257, 0.192) at both the levels, respectively, but it observed a significantly negative association with vine length (-0.273, -0.264), number of primary branches per vine (-0.369, -0.361) and average fruit weight (-0.401, -0.358). Moreover, vine length observed a significantly positive correlation with number of branches per vine (0.101, 0.099) andlength of fruit (0.930, 0.820) while it had a significantly negative correlation with number of fruits per vine (-0.194, -0.192), diameter of fruit (-0.215, -0.187) and average fruit weight (-0.171, -0.155) at both the levels viz., genotypic and phenotypic, respectively.

Number of fruits per vine had a significant positive correlation with number of primary branches per vine (0.513, 0.497), length of fruit (0.413, 0.396), average fruit weight (0.697, 0.613) and fruit yield per hectare (0.932, 0.904) but had a significant negative association with nodes to first male flower(-0.703, -0.640), nodes to first female flower (-0.658, -0.610) and crop maturity (-0.468, -0.382) at both the levels viz genotypic and phenotypic, respectively. Number of primary branches per vine observed a significantly positive association with length of fruit (0.489, 0.479), average fruit weight (0.675, 0.613)and fruit yield per hectare (0.602, 0.595) but it showed a significant negative association for nodes to first female flower (-0.895, -0.857),diameter of fruit (-0.170, -0.135) and crop maturity (-0.497, -0.399) at both the levels viz., genotypic and phenotypic, respectively.

A significantly positive association of nodes to first female flower was revealed with days to first female flowering (0.380, 0.357), days to first fruit harvest (0.305, 0.282), diameter of fruit (0.226, 0.225) and crop maturity (0.588, 0.447) while, it had a significantly negative correlation with number of fruits/ vine (-0.658, -0.610), number of primary branches per vine (-0.895, -0.857), length of fruit (-0.554, -0.529) and average fruit weight (-0.781, -0.676). Length of fruit had a significantly positive correlation with vine length (0.145, 0.143), number of fruits/vine (0.413, 0.396), number of primary branches per vine (0.489, 0.479) and average fruit weight (0.375, 0.347) while it had negative association with days to first female flowering (-0.229, -0.220), days to first fruit harvest (-0.242, -0.224), nodes to first female flower (-0.554, -0.529) and crop maturity (-0.424, -0.325). Further, significantly positive association of fruit diameter was revealed with days to first female flowering (0.260, 0.211), days to first fruit harvest (0.289, 0.262), and nodes to first female flower (0.226, 0.226), whereas, it had a negative correlation with vine length (-0.215, -0.187) and length of fruit (-0.259, -0.219).Based on the analysed observations, crop maturity depicted a significant positively correlated relationship with nodes to first male flower (0.532, 0.430) at both the levels and there was a significantly negative correlation for number of fruits per vine (-0.468, -0.382), number of primary branches per vine (-0.497, -0.399) and average fruit weight (-0.393, -0.288).

Path analysis is a standardized partial regression coefficient analysis which measures the influence of one variable upon another and facilitates the partitioning of correlation coefficients into direct and indirect effects of various characters on yield or any other attribute. The path coefficients were computed using the corresponding values of genotypic correlation coefficients taking the fruit yield (q/ha) as dependent variable and rest all the characters as independent variable (Table 4).

Results from path coefficient analysis showed that the highest positive direct effect towards fruit yield per hectare was exerted by days to first female flowering (0.751) followed by nodes to first female flower (0.596), number of fruits per vine (0.481), length of fruit (0.234) and number of primary branches per vine (0.132). However, highest negative direct effect towards fruit yield per hectare was contributed by days to first male flowering (-0.671) which was followed by nodes to first male flower (-0.650), crop maturity (-0.232), vine length (-0.190) and days to first fruit harvest (-0.088). Similar trend in results were reported by Janaranjani and Kanthaswamy (2015), Abhishek et al. (2020), Rehan et al. (2020) and Kumari et al. (2021) in bottle gourd.

Table 4: Path analysis coefficients depicting direct effects over fruit yield

Characters	DMF	DFF	DFH	VL	NFV	NPB	NMF	NFF	LF	DF	AFW	CM	Corr. Yield
DMF	-0.661	0.704	-0.062	0.069	-0.008	-0.033	-0.130	0.152	-0.023	0.009	-0.036	-0.019	-0.040
DFF		0.751	-0.069	0.051	-0.031	-0.049	-0.199	0.226	-0.053	0.007	-0.048	-0.059	-0.094
DFH			-0.088	-0.003	-0.154	-0.032	-0.193	0.182	-0.056	0.008	-0.043	-0.062	-0.321
VL				-0.190	-0.093	0.013	0.061	-0.052	0.034	-0.006	-0.020	0.029	-0.191
NFV					0.481	0.068	0.457	-0.393	0.096	0.001	0.085	0.108	0.932**
NPB						0.132	0.560	-0.534	0.114	-0.005	0.082	0.115	0.602**
NMF							-0.650	0.564	-0.125	0.005	-0.092	-0.123	-0.785**
NFF								0.596	-0.129	0.007	-0.095	-0.136	-0.702**
LF									0.234	-0.007	0.045	0.098	0.539**
DF										0.029	-0.006	0.031	0.001
AFW											0.122	0.091	0.712**
CM												-0.232	-0.531**

*, **: Significant at 5% and 1% level, respectively

Conclusion

Considering the observations in the study, it can be inferenced that there exist significant genetic variability and considerable positive as well as negative direct effects by various characters on the fruit yield through one or other characters. And characters namely days to first female flowering, days to first fruit harvest, number of fruits per vine, nodes to first female flowering and length of fruit are the most propitious characters influencing the yield hence, deserves greater weightage for efficient selection in any bottle gourd improvement programme.

सारांश

यह प्रयोग लौकी के 37 प्रभेदों के साथ किया गया था। पूर्ण यादृच्छिक ब्लॉक डिजाइन विश्लेषण विधि का उपयोग करते हुए वर्ष 2017–18 में उपरोक्त प्रभेदों के मूल्यांकन सम्बंधित सापेक्ष प्रदर्शन, आनुवंशिक विविधता, आनुवंशिकता, आनुवंशिक प्रगति तक पहुंचने के लिए किया गया था और साथ ही साथ उपज और इसके योगदान के बीच संबंधों की प्रकृति और परिमाण का अध्ययन किया गया। लौकी की बिजाई वसंत, ग्रीष्म ऋतु के दौरान सब्जी अनुसन्धान विभाग, चौधरी चरण सिंह हरियाणा कृषि विश्वविद्यालय, हिसार (हरियाणा) में तीन प्रतिकृतियों में यादृच्छिक ब्लॉक डिजाइन (आरबीडी) विधि के तहत की गयी। अध्ययन के विश्लेषण के आंकड़ों से महत्वपूर्ण आनुवंशिक विविधता की उपस्थिति का अनावरण करने वाले प्रभेदों के बीच पर्याप्त अंतर दर्ज किया गया, जिसका फसल सुधार कार्यक्रमों में सकारात्मक रूप से दोहन किया जा सकता है। बेल की लंबाई के लिए उच्चतम जीसीवी (18.90) और पीसीवी (18.96) दर्ज किया गया। इसके अलावा, प्रति बेल फलों की संख्या, प्रति बेल शाखाओं की संख्या और औसत फलों का वजन की उपज पर सकारात्मक एवं महत्वपूर्ण सहसंबद्ध पाया गया। पथ गुणांक विश्लेषण के आधार पर पहली बार मादा फूल आने के दिन, प्रति बेल फलों की संख्या, पहली मादा फूल के लिए गांठें, फलों की लंबाई और औसत फल वजन सबसे अनुकूल लक्षण थे जो सीधे प्रति हेक्टेयर उपज को प्रभावित करते थे। अतः लौकी की उच्च उपज वाली किस्मों को विकसित करने के लिए उपरोक्त सूचकांकों को चयन मापदंड के रूप में प्रयोग किया जाना चाहिए।

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