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Exploitation of additive and non-additive gene action for qualitative and quantitative traits in bottle gourd (*Lagenaria siceraria* (Mol.) Standl.)

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Abstract
To achieve desirable improvements in crop plants, it is essential to carefully select appropriate breeding methodologies. This selection process necessitates a comprehensive understanding of the gene activity underlying the inheritance of both quantitative and qualitative traits. In the case of bottle gourd (*Lagenaria siceraria* (Mol.) Standl.), understanding about the gene action associated with both quantitative and qualitative traits becomes particularly important. This knowledge will serve as a foundation for making informed decisions in crop improvement programmes. Forty-five F_1 hybrids resulted from crossing of 10 parental lines were analysed using half diallel analysis. Based on the GCA to SCA ratio variances, it has been determined that non-additive gene action implies a larger significant role than additive gene action in the inheritance of all the studied characters, except for fruit diameter and vitamin-C. Consequently, for the exploitation of these traits, it is recommended to adopt heterosis breeding. Heterosis breeding involves crossing genetically diverse parents to capitalize on the phenomenon of hybrid vigour, which can lead to superior offspring with enhanced traits.

Keywords: Gene action, half diallel analysis, fruit yield, bottle gourd

Introduction

Bottle gourd (*Lagenaria siceraria* (Mol.) Standl.) is both tropical as well as subtropical vine, belongs to the family cucurbitaceae with chromosome number 2 n = 22 and cultivated as annual monoecious species. It is commonly known as ghia, lauki etc. Bottle gourd is widely grown for edible fruit. It has cardiotonic properties. (Barot *et al*., 2015) [3].

While developing promising potential hybrids through hybridization, the plant breeder must carefully choose right parents. The mechanism of gene activity that governs the expression of diverse features might help anticipate how successful selection is. A successful and resilient breeding program will be facilitated by efficiently dividing genetic variation into its components, such as additive, dominance, and epistasis. The effectiveness of a selective hybridization scheme depends on the successful combination of genes in high combining inbred lines. Plant breeders need to grasp the relative significance of additive and non-additive gene actions to design a productive hybridization strategy. To understand more about the extent of gene activity affecting bottle gourd yield and its component parts, a series of half diallel crosses were done in this study. The findings will contribute to the formulation of an appropriate breeding strategy.

Material and Methods

In this study, 10 genotypes of bottle gourd were selected, including Pusa Naveen, Pusa Samridhi, Pusa Santhusti, Pusa Sandesh, Arka Bahar, Kashi Ganga, Punjab Bahar, Pant Lauki-3, Local Round, and Local Long. For a variety of quantitative variables, these genotypes were chosen to reflect a sizable degree of genetic variability. Throughout 2019-20, they underwent crossing maintenance. The 45 F_1 hybrids were developed by crossing these ten genotypes in a 10 × 10 half-diallel combination during *Summer*, 2019. Subsequently, all the parents along with 45 F_1 hybrids were evaluated in Randomized Block Design with two replications during *kharif*, 2019. The plants were grown with a spacing of 3.0 m x 0.9 m.

Five plants per treatment had observations made on 21 distinct traits, which were averaged, and the data collected was utilized for statistical analysis. Data were examined using Panse and Sukhatme (1978) [7] ANOVA procedures to identify the significant genotype differences for each feature. According to Singh and Chaudhary (1979) [9], elements of genetic variation were evaluated from the information collected on the diallel crosses using Griffing's Method-II and Model-I (Griffing, 1956) [5].

Results and Discussion

Table 1 contains the results of the ANOVA performed for the bottle gourds qualitative and quantitative characteristics. The findings showed that all of the characters GCA variances are extremely significant. With the exception of total soluble solids, all of the examined characters SCA variances are very significant, showing the significance of both additive and non-additive genetic components for the majority of the characters. This suggests that the material under study exhibits a large and extensive range of variability, and that there is a significant opportunity to find viable parents and cross combinations and to boost the yield by changing its component traits. These research results are consistent with prior findings in bottle gourd by Adarsh *et al*., (2017) [1] and Malviya *et al*., (2017) [6].

The estimates of *gca* and *sca* variances, their ratios and gene action are given in table 1. Genetically, GCA is linked to additive gene action, whereas SCA is responsible for dominance and epistasis. An indication of additive and non-additive gene action is the ratio of $\sigma^2 gca$ and $\sigma^2 sca$. When gca/sca variance ratio is less than unity, it implies that non-additive gene action predominates; when it is more than unity, additive gene action predominates. In the present study, there was a greater amount of sca variation than gca variation, indicating that non-additive gene action predominates for most of the traits. Nevertheless, the larger amount of gca variance than sca variance for fruit diameter and vitamin -C shows that additive gene action predominates. These research outcomes were consistent with prior findings in bottle gourd by Ray *et al*., (2015) [8], Geeta *et al*., (2020) [4], Balat *et al*., (2021) [2] regarding this type of gene action.

Table 1: ANOVA of combining ability analysis, combining ability variances and gene action for qualitative and quantitative traits in 10x10 half diallel of bottle gourd

Source of variation	Mean sum of squares			Combining ability variances		Gene action
	Gca	Sca	Error	σ^2 *gca*	σ^2 *sca*	*gca/sca*
Degrees of freedom	9	45	54			
Characters						
Growth parameters						
Vine length (cm)	135009.80**	56159.70**	443.55	11213.86	55716.14	0.20
Number of nodes per vine	464.57**	400.10**	3.86	38.39	396.23	0.09
Internodal length (cm)	5.33**	2.67**	0.64	0.39	2.03	0.19
Number of secondary branches (lateral branches) per plant	2.34**	0.54**	0.13	0.18	0.41	0.44
Node number at which first male flower appear	4.88**	2.17**	0.10	0.39	2.06	0.19
Node number at which first female flower appear	34.69**	11.26**	0.60	2.84	10.65	0.26
Days to first appearance of male flower	24.25**	4.55**	0.31	1.99	4.23	0.47
Days to first appearance of female flower	18.44**	6.16**	0.18	1.52	5.97	0.25
Sex ratio (m:f)	40.59**	25.65**	0.63	3.33	25.02	0.13
Days to first fruit harvest	17.91**	5.10**	0.45	1.45	4.65	0.31
Yield parameters						
Number of fruits per vine	2.02**	1.91**	0.12	0.15	1.79	0.08
Fruit length (cm)	740.50**	71.95**	2.94	61.46	69.01	0.89
Fruit diameter (cm)	58.88**	4.14**	0.35	4.87	3.79	1.28
Fruit volume (cc)	245216.30**	165314.10**	6028.25	19932.34	159285.80	0.12
Average fruit weight (g)	87129.79**	211851.70**	581.69	7212.34	21127.00	0.03
Number of seeds per fruit	8476.87**	5749.65**	49.52	702.27	5700.13	0.12
Fruit yield per vine (kg)	4.34**	4.69**	0.28	0.33	4.40	0.07
Fruit yield per plot (kg)	156.46**	169.04**	10.43	12.16	158.61	0.07
Estimated yield per hectare (q)	5958.92**	6438.82**	254.33	475.38	6184.48	0.07
Quality parameters						
Total soluble solids (° B)	1.41**	0.00	0.00	0.11	-0.002	-49.86
Vitamin –C (mg $100g^{-1}$)	3.20**	0.08**	0.00	0.26	0.07	3.46

Conclusion

The research demonstrated that additive together with non-additive gene action were found in bottle gourd. While simple selection is advised for characters influenced by additive gene action, for traits impacted by non-additive gene action, heterosis breeding is advised. The ten different bottle gourd genotypes used in the half diallel mating strategy produced enough genetic variation for yield and characteristics linked to yield. This genetic diversity offers potential for further improvement of bottle gourd through breeding programs.

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