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Deepak Kumar Gautam
Research scholar, Department of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh, India

GC Yadav
Assistant Professor, Department of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh, India

Correspondence
Deepak Kumar Gautam
Research scholar, Department of Vegetable Science, Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad, Uttar Pradesh, India

Gene action for growth, yield and quality traits in bottle gourd [*Lagenaria siceraria* (Mol.) Standl]

Deepak Kumar Gautam and GC Yadav

Abstract

The present investigation was carried out in two different seasons with aim to find out the gene action for inheritance of morphological, yield and quality traits in bottle gourd. The present study was comprised of 45 crosses developed through diallel mating design using 10 parents namely, NDBG-49-2 (P_1), N. Rashmi (P_2), N. Prabha (P_3), N. Pooja (P_4), Pusa Naveen (P_5), Pb. Komal (P_6), NDBG S-1 (P_7), PBOG-3 (P_8), NDBG-11 (P_9) and Faizabadi Local (P_{10}) at MES, Vegetable Science, NDUA.&T, Kumarganj, Faizabad (U.P.) India during *kharif* 2015 (E_1), and *Rabi*, 2015-16 (E_2). The experiments were laid out in RBD with three replications having each experimental unit of single row with spacing of 3.0 m × 0.5 m. The observations were recorded on parents and F_1's for eighteen quantitative traits including six quality traits *viz* days to first staminate flower anthesis, days to first pistillate flower anthesis, node number to first staminate flower, node number to first pistillate flower appearance, days to first fruit harvest, vine length at last picking stage (m), number of primary branches per plant, fruit length (cm), fruit circumference (cm), fruit weight (kg), number of fruits per plant, fruit yield per plant (kg), total soluble solids (°B), ascorbic acid (mg/100 g fresh fruit), reducing sugar (%), non-reducing sugar (%), total sugars (%) and dry matter content in fruit (%). The present study revealed that Highly significant values for additive ($\hat{D}$) and dominance ($\hat{H}_1$ and $\hat{H}_2$) effects of components were observed for most of the eighteen traits in both the seasons (E_1, E_2) except the values of $\hat{D}$ for days to first staminate flower anthesis, number of fruit per plant, reducing sugar and total sugars and node number to first staminate flower appearance and days to first fruit harvest in E_1 and values of $\hat{H}_1$ for node number to first staminate flower appearance, node number to first pistillate flower appearance in E_1 which showed non-significant Both additive and dominance variance were found important in the inheritance of most of the traits, whereas dominance variance were more prominent than the additive variance. Average degree of dominance revealed the presence of over dominance for all the characters in during both the seasons (E_1, E_2). The proportions of genes ($\hat{H}_2/4\hat{H}_1$) in the parents were less than 0.25 for all the traits indicating asymmetrical distribution of alleles at loci showing dominance during both the seasons (E_1, E_2).

Keywords: Bottle gourd, gene action, quality attributes fruit yield and diallel mating

Introduction

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl., 2n =2x= 22] is an important cultivated annual cucurbitaceous crop grown throughout the country. Being warm season vegetable crop it thrives well in warm and humid climate but at present it's off season cultivation has progressively stretched throughout the year in northern Indian plains. According to De Candolle (1882), bottle gourd has been found in wild form in South Africa and India. However, Cutler and Whitaker (1961) [2] are of the view that probably it is indigenous to tropical Africa on the basis of variability in seeds and fruits. The tender fruits of bottle gourd can be used as a vegetable or for making sweets (e.g. *Halva, kheer, petha* and *burfi* etc.), kofta and pickles. The fruit is rich in pectin also, which showed good prospects for jelly preparation. A decoction made from the leaf is a very good medicine for jaundice. The fruit has cooling effect, it is a cardiotonic and diuretic, good for people suffering from biliousness, indigestion and convalescences *i.e.*, regain health after illness. The pulp is good for overcoming constipation, cough, and night blindness and as an antidote against certain poisons. The plant extract is used as a cathartic and seeds are used in dropsy. In addition, the seeds and seed oil are edible. The fruits contain 96.3 per cent moisture, 2.9 per cent carbohydrate, 0.2 per cent protein, 0.1 per cent fat, 0.5 per cent mineral matter and 11 mg of vitamin C (Ascorbic acid) per 100 g fresh weight (Thamburaj and Singh, 2005) [11]. The existence of significant amount of non-additive gene action is a prerequisite for exploitation of heterosis. The specific combining ability variance largely is the measure of dominance variance. If heterosis is high for specific cross and observations made are true for economic trait like yield, it is possible to utilize the cross as a commercial hybrid provided that the pollination system of the crop permits commercial seed production of hybrids or there exists a male sterility, fertility restoration system.

Materials and Methods

The experimental materials consisted of 10 promising parental lines of bottle gourd and their F_1 progenies. The selected parental lines *i.e.* NDBG-49-2 (P_1), N. Rashmi (P_2), N. Prabha (P_3), N. Pooja (P_4), Pusa Naveen (P_5), Pb. Komal (P_6), NDBG S-1 (P_7), PBOG-3 (P_8), NDBG-11 (P_9) and Faizabadi Local (P_{10}) were crossed in the all possible combinations, excluding reciprocals. At NDUA&T, Kumarganj, Faizabad (U.P.). These experimental materials were grown under Randomized Block Design (RBD) with three replications at Main Experiment Station, Department of Vegetable Science, Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Faizabad (U.P.) India. The treatments were sown in rows spaced 3.0 meters apart with a plant to plant spacing of 0.5 meter. The experiments were laid out during the *Kharif* season of 2015-16 and and off season in winter 2015-16 seeds for the study of heterosis. All the recommended agronomic package of practices and protection measures were followed to raise a good crop. Fertilizers and manures were applied as per recommended dose. Observations were recorded on all the six plants maintained carefully in each plot for eighteen quantitative characters *viz*., days to first staminate flower anthesis, days to first pistillate flower anthesis, node number to first staminate flower, node number to first pistillate flower appearance, days to first fruit harvest, vine length at last picking stage (m), number of primary branches per plant, fruit length (cm), fruit circumference (cm), fruit weight (kg), number of fruits per plant, fruit yield per plant (kg), total soluble solids (°B), ascorbic acid (mg/100 g fresh fruit), reducing sugar (%), non-reducing sugar (%), total sugars (%) and dry matter content in fruit (%).genetic components of variation were calculated for the analysis of numerical approach followed the method given by Jinks and Hayman (1953) [5], Hayman (1954a) [3] and Askel and Johnson (1963) [1].

Results and Discussion

The estimates of components of variation provide detailed accounts of additive and dominant components and allied statistics. The genetic progress in a population largely depends upon the relative values of these components. The diallel cross analysis through analytical method is based on a number of assumptions regarding applicability of this method as advocated by Hayman (1954 a) [1] *viz*., homozygous parents, diploid segregation, no reciprocal differences, no multiple allelism, no epistasis and absence of linkage, absence of epistatic and random mating. The validity of specific assumptions of diploid segregation, lack of reciprocal differences and multiple allelism were presumed. Bottle gourd being cross pollinated crop it is tedious to get complete homozygous parents for all the characters. However, if some traits exhibit the partial non fulfillment of assumption, the estimates of population parameters are still possible (Hayman, 1954 a) [1]. However, the results in such cases are less reliable than would have been if all the assumptions are completed. The estimates of the components of variation and their related statistics for different traits of bottle gourd have been presented in Table-1.

Highly significant values for additive ($\hat{D}$) and dominance ($\hat{H}_1$ and $\hat{H}_2$) effects of components were observed for most of the eighteen traits in both the seasons (E_1, E_2) except the values of $\hat{D}$ for days to first staminate flower anthesis, number of fruit per plant, reducing sugar and total sugars and node number to first staminate flower appearance and days to first fruit harvest in E_1 and values of $\hat{H}_1$ for node number to first staminate flower appearance, node number to first pistillate flower appearance in E_1 which showed non-significant. The significant values of $\hat{D}$, $\hat{H}_1$ and $\hat{H}_2$ indicated the importance of both additive and dominance gene action in the expression of these traits, which is in consonance with the findings of Hayward (1979) [4]; Reys *et al.* (1993) [6] and Sit and Sirohi (2000) [9]. However, additive ($\hat{D}$) genetic variance components were lower in magnitude than dominant component of genetic variance for all the eighteen traits over both the seasons which showed preponderance of dominance components of variance in expression of fruit yield and its attributing traits in both the seasons. In bottle gourd similar findings was also recorded by Sirohi *et al.* (1986) [8]. The positive values of $\hat{F}$ were found for all the traits in both the seasons, which indicated that there were an excess of dominance gene in the inheritance of these traits among the parents. The average degree of dominance $\hat{H}_1/\hat{D})^{1/2}$ revealed the presence of over dominance for all the traits during both the seasons (E_1, E_2). This suggested that heterosis breeding might be advantageous for improvement of yield and its attributing traits in bottle gourd. The findings are in agreement with Sirohi *et al.* (1986) [8]; Sit and Sirohi (2000) [9] and Sharma *et al.* (2010) [7]. Ratio of ($\hat{H}_2/4\hat{H}_1$) which estimates frequency of alleles with positive and negative effects in the parents were less than 0.25 in both the seasons (E_1, E_2) for all the traits which showed asymmetrical distribution of loci showing dominance for all the traits (Table-1). The ratio of $(4\hat{D}\hat{H}_1)^{1/2} + \hat{F}$ / $(4\hat{D}\hat{H}_1)^{1/2} - \hat{F}$ indicated that the dominant alleles were more frequent than recessive alleles for all the traits studied in both the seasons (E_1, E_2) (Table-1). These findings are similar to that of Sharma *et al.* (2010) [7]. The proportion of $\hat{h}^2/\hat{H}_2$, which provides information about groups of gene exhibiting little or no dominance. The less than one $\hat{h}^2/\hat{H}_2$ ratio suggested that atleast one gene group mainly governed the characters under study for most of traits. The positive correlation (r) between parental order of dominance (Wr + Vr) and parental measurement (Yr) were showed for most of the characters during both the seasons (E_1, E_2) except days to first staminate flower anthesis, fruit circumference and fruit weight during both the seasons and node number to first staminate flower appearance in E_1..The negative correlation suggesting the preponderance of dominant genes while positive values suggested preponderance of recessive genes. The results of present investigation suggested preponderance of dominant genes in the expression of most of the traits studied. Therefore, heterosis breeding approach could be advantageous rather than selection to produce superior hybrids for high fruit yield in bottle gourd. The above findings are in agreement with that of Singh *et al.* (2005) [11]. The non-significant values of 't^2' or (1-b/SEb) indicates the validity of assumptions pertaining to diallel analysis, while significant values of 't^2' or (1-b/SEb) showed failure of hypothesis or null hypothesis for diallel cross analysis (Table-1). The result of present study suggested preponderance of dominance genes in the expression of most of the component traits studied. Therefore, heterosis breeding approach might be advantageous rather than selection to develop superior hybrids for high fruit yield in bottle gourd.

Table 1: Estimates of components of variation and their related statistics in 10 x 10 diallel crosses of bottle gourd over two seasons (E_1, E_2)

Components of variation and related statistics	seasons	Days to first staminate flower anthesis	Days to first pistillate flower anthesis	Node number to first staminate flower appearance	Node number to first pistillate flower appearance	Days to first fruit harvest	Vine length (m)	Number of primary branches per plant	Fruit length (cm)	Fruit circumferene (cm)
$\hat{D}$ (Additive effect)	E_1	2.82 ±3.36	5.27* ±2.59	1.18 ±1.52	9.89* ±2.79	3.72 ±2.38	1.93* ±0.46	6.30* ±1.53	53.73* ±8.83	30.89* ±4.95
	E_2	0.66 ±2.40	11.15* ±2.65	0.87* ±0.39	0.55* ±0.23	12.73* ±2.36	2.17* ±0.37	1.87* ±0.8	14.50* ±5.49	39.36* ±4.45
$\hat{H}_1$ (Dominance effect)	E_1	20.20* ±7.15	26.23* ±5.52	10.37 ±3.24	19.74 ±5.94	21.90* ±5.07	5.81* ±0.98	16.75* ±3.26	61.13* ±18.12	30.29* ±10.54
	E_2	22.19* ±5.12	33.68* ±5.64	4.51* ±0.82	2.94* ±0.50	28.14* ±5.02	4.67* ±0.78	12.77* ±1.70	42.32* ±11.69	58.31* ±9.47
$\hat{H}_2$ (Dominance indicating asymmetry of +/- effect of genes)	E_1	19.78* ±6.07	22.96* ±4.69	8.29* ±2.76	15.22* ±5.04	19.89* ±4.31	4.97* ±0.84	14.06* ±2.77	54.51* ±16.00	28.71* ±8.96
	E_2	18.81* ±4.35	27.86* ±4.79	3.72* ±0.70	2.24* ±0.42	19.65* ±4.26	3.50* ±0.66	8.51* ±1.45	35.27* ±9.94	40.47* ±8.05
$\hat{F}$ (Mean Fr over arrays)	E_1	1.03 ±7.75	2.72 ±5.99	0.24 ±3.52	4.97 ±6.43	0.72 ±5.50	1.77 ±1.07	4.65 ±3.53	28.54 ±20.40	7.90* ±11.42
	E_2	3.42 ±5.55	11.03 ±6.11	1.52 ±0.89	1.13* ±0.54	10.8* ±5.44	2.37* ±0.85	4.77* ±1.85	10.22 ±12.67	46.66*
$\hat{h}^2$	E_1	16.2 ±7.28	30.6** ±1.42	40.70** ±2.80	54.20** ±1.33	28.80** ±1.38	27.50** ±1.50	36.70** ±1.22	52.20** ±1.11	61.50** ±0.70
	E_2	4.20 ±9.26	24.50** ±0.94	7.00 ±9.82	9.20 ±5.32	34.30** ±0.33	35.10** ±1.44	23.30** ±2.08	37.50** ±2.32	33.30** ±1.59
$\hat{E}$ (Environmental component)	E_1	0.76 ±1.01	0.86 ±0.78	0.13 ±0.46	0.17 ±0.84	1.23 ±0.72	0.09 ±0.14	0.23 ±0.46	0.92 ±2.67	0.52 ±1.49
	E_2	2.30 ±0.73	2.19 ±0.8	0.05 ±0.12	0.09 ±0.07	5.08 ±0.71	0.02 ±0.11	0.11 ±0.24	0.63 ±1.6	0.45 ±1.34
$(\hat{H}_1/\hat{D})^{1/2}$ (Mean degree of dominance)	E_1	2.68	2.23	2.96	1.41	2.43	1.73	1.63	1.07	1.00
	E_2	5.82	1.74	2.28	2.32	1.49	1.47	2.61	1.71	1.22
$\hat{H}_2/4\hat{H}_1$ (Proportion of genes with +/- effects in parents)	E_1	0.25	0.22	0.20	0.19	0.23	0.21	0.21	0.22	0.24
	E_2	0.21	0.21	0.21	0.19	0.18	0.19	0.17	0.21	0.17
$(4\hat{D}\hat{H}_1)^{1/2} + \hat{F}/(4\hat{D}\hat{H}_1)^{1/2} - \hat{F}$ (Proportion of dominant and recessive genes in parents)	E_1	1.14	1.26	1.07	1.43	1.10	1.72	1.59	1.66	1.30
	E_2	2.63	1.80	2.24	2.60	1.80	2.18	2.91	1.52	2.90
$\hat{h}^2/\hat{H}_2$ (Number of gene groups)	E_1	0.10	0.02	-0.00	0.03	-0.00	0.68	0.04	0.02	0.02
	E_2	-0.04	0.04	0.18	0.84	0.05	0.02	0.29	0.00	-0.00
r (Correlation coefficient)	E_1	-0.30	0.28	0.41	0.33	0.31	0.40	0.61	0.15	0.87
	E_2	0.02	0.72	-0.43	0.18	0.89	0.57	-0.10	0.40	0.38
t^2	E_1	17.69	2.95	53.96	5.84	3.34	0.46	0.63	0.07	1.81
	E_2	6.81	0.98	5.85	0.00	1.17	0.02	0.71	0.32	0.02
(1-b/SEb)	E_1	10.25	4.31	14.04	5.28	4.39	2.61	2.28	2.70	2.25
	E_2	6.41	0.26	7.75	2.32	1.86	1.62	4.09	2.48	2.04

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.

Table 1: cont…

Components of variation and related statistics	Seasons	fruit weight (kg)	Number of fruits per plant	Fruit yield per plant (kg)	T.S.S. (%)	Ascorbic acid (mg/100g)	Sugars			Dry matter (%)
							Reducing sugar (%)	Non-reducing sugar (%)	Total Sugar (%)	
$\hat{D}$ (Additive effect)	E_1	0.01* ±0.01	0.74 ±0.47	0.30 ±0.19	0.22* ±0.02	0.51* ±0.02	0.042 ±0.02	0.01* ±0.01	0.01 ±0.01	0.26* ±0.11
	E_2	0.09* ±0.03	0.65 ±0.49	0.24 ±0.20	0.18* ±0.08	0.52* ±0.10	0.04 ±0.2	0.01* ±0.01	0.01 ±0.01	0.26* ±0.10
$\hat{H}_1$ (Dominance effect)	E_1	0.08* ±0.03	5.52* ±0.02	2.79* ±0.41	0.27* ±0.04	1.39* ±0.28	0.24* ±0.05	0.07* ±0.01	0.07* ±0.01	1.04* ±0.23
	E_2	0.30* ±0.05	6.69* ±1.05	3.04* ±0.42	0.75* ±0.17	1.22* ±0.21	0.24* ±0.05	0.09* ±0.01	0.13* ±0.02	1.40* ±0.22
$\hat{H}_2$ (Dominance indicating asymmetry of +/- effect of genes)	E_1	0.08* ±0.03	5.18* ±0.86	2.66* ±0.35	0.22* ±0.03	1.06* ±0.24	0.18* ±0.04	0.05* ±0.01	0.6* ±0.01	0.85* ±0.20
	E_2	0.23* ±0.05	5.53* ±0.89	2.85* ±0.35	1.61* ±0.14	1.0* ±0.18	0.19* ±0.04	0.08* ±0.01	0.12* ±0.02	1.18* ±0.18
$\hat{F}$ (Mean Fr over arrays)	E_1	0.01* ±0.03	0.64 ±1.10	2.28 ±0.44	0.07 ±0.04	0.41 ±0.31	0.10 ±0.05	0.03 ±0.01	0.02 ±0.02	0.32 ±0.25
	E_2	0.14* ±0.06	1.26 ±1.14	0.38 ±0.45	0.22 ±0.18	0.55* ±0.23	0.09 ±0.06	0.03* ±0.01	0.02 ±0.02	0.41 ±0.23
$\hat{h}^2$	E_1	10.30 ±24.06	13.20** ±3.15	9.00** ±2.92	62.60** ±0.51	43.10** ±1.21	11.20 ±13.70	10.20 ±19.73	13.20 ±18.66	20.90** ±5.28
	E_2	15.10* ±7.47	15.30** ±2.91	3.30 ±7.81	21.60** ±4.41	25.90** ±2.10	8.00 ±19.65	6.10 ±15.38	4.90 ±14.55	9.70 ±5.58
$\hat{E}$ (Environmental component)	E_1	0.00 ±0.00	0.15 ±0.14	0.08 ±0.06	0.01 ±0.01	0.02 ±0.04	0.00 ±0.01	0.00 ±0.00	0.00 ±0.00	0.01 ±0.03
	E_2	0.00 ±0.01	0.12 ±0.15	0.04 ±0.06	0.01 ±0.02	0.02 ±0.03	0.00 ±0.01	0.00 ±0.00	0.00 ±0.00	0.01±0.03
$(\hat{H}_1/\hat{D})^{1/2}$ (Mean degree of dominance)	E_1	3.88	2.72	3.05	1.10	1.66	2.40	2.43	2.53	2.02
	E_2	1.77	3.21	3.59	2.04	1.53	2.41	2.77	3.38	3.32
$\hat{H}_2/4\hat{H}_1$ (Proportion of genes with +/- effects in parents)	E_1	0.24	0.24	0.24	0.20	0.19	0.18	0.18	0.20	0.20
	E_2	0.19	0.21	0.23	0.20	0.21	0.19	0.21	0.23	0.21
$(4\hat{D}\hat{H}_1)^{1/2}+\hat{F}/(4\hat{D}\hat{H}_1)^{1/2}-\hat{F}$ (Proportion of dominant and recessive genes in parents)	E_1	1.25	1.38	1.36	1.31	1.64	2.28	2.71	2.25	1.96
	E_2	2.49	1.87	1.58	1.88	2.06	2.62	2.26	1.75	2.03
$\hat{h}^2/\hat{H}_2$ (Number of gene groups)	E_1	0.03	1.84	2.38	0.51	0.03	0.69	0.03	2.64	0.00
	E_2	-0.00	2.09	3.73	0.07	0.15	0.80	2.15	5.35	0.05
r (Correlation coefficient)	E_1	0.35	0.48	0.25	0.88	0.28	-0.41	0.12	-0.31	0.03
	E_2	0.65	0.45	0.64	0.37	0.76	-0.60	0.49	0.19	-0.51
t^2	E_1	251.22	5.25	1.89	2.27	1.01	0.00	0.01	4.03	3.97
	E_2	0.00	1.22	7.54	2.65	2.70	0.00	0.01	12.46	0.80
(1-b/SEb)	E_1	30.93	4.69	3.88	2.41	1.28	4.40	2.40	6.52	5.36
	E_2	1.25	3.04	4.98	3.96	-0.28	5.56	1.76	7.54	5.43

*, ** Significant at 5 per cent and 1 per cent probability levels, respectively.

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