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Genetic analysis in bitter gourd (*Momordica charantia* L.) for yield and component characters

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ABSTRACT : In a full diallel analysis ten parents of bitter gourd were used to study the inheritance of yield, yield contributing characters and quality characters. Data from the ten parents and their resultant 90 hybrids were analyzed. The estimates of $\hat{D}$ (additive effects) were significant for 13 characters in season I and 15 characters in season II out of 17 characters studied. The estimates of 'H_1' and 'H_2' were positive and significant for all the traits. It indicated that there was unequal frequency of alleles at all loci. Further the proof for the unequal distribution of the alleles over loci was obtained by the ratio of $H_2/4H_1$. The estimates of 'F' were positive for all the traits studied. It indicated the pre-dominance of dominant alleles in the parents and this was supported by the ratio (K_D/K_R) of dominant to recessive alleles in the parents, the ratio was more than one for all the traits studied. The mean degree of dominance over all loci indicated over dominance for 11 characters in season I and 10 characters in season II. Narrow sense heritability estimates were high for seven out of 17 characters studied and for the remaining ten characters it was low in both the seasons. The preponderance of dominant gene action coupled with low narrow sense heritability observed for the traits *viz*., days to first male and female flower appearance, fruit flesh thickness (season II), number of fruits per vine (season I), yield of fruits per vine, ascorbic acid and iron content revealed the importance of heterosis breeding for simultaneous improvement of yield and quality characters.

KEY WORDS : *Momordica charantia* L., Diallel analysis, Gene action, Earliness, Yield , Quality traits

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Among the cucurbits bitter gourd or '*balsam pear'* is a nutritionally rich vegetable of commercial importance. It is also known for its therapeutic properties and more attention is now being focused on its hypoglycemic properties. But only a few commercial varieties and hybrids exist in the market. In South India consumers prefer dark green colour, lengthy fruits having thick rind with less seeds. A precise knowledge on gene action responsible for the inheritance of yield and yield components and quality traits is a prerequisite to identify a suitable breeding methodology. Crop improvement through breeding methodology largely depends on the knowledge of nature and magnitude of gene action involved in the control of metric traits (Lawande and Patil, 1990). The genotypic variances were divided into three components *viz*., additive, dominance and interaction components. Additive variance is the component arising from differences between the two homozygotes for a gene. The dominance component is due to the deviation of heterozygote (Aa) from the average of two homozygotes for a gene (AA and aa). This is also referred as intra-allelic interaction. The interaction or epistatic component results from an interaction between two or more genes and is partitioned into three types of interactions *viz*., additive x additive, additive x dominance and dominance x dominance (Sundaram, 2006).

The diallel model developed by Hayman (1954 a and b) helps to analyse the genetics of the traits, which forms the basis for understanding the nature of inheritance. The present investigation was taken up to elucidate the gene action for yield and its component characters in bitter gourd.

RESEARCH METHODS

Ten genetically diversified lines of bitter gourd were chosen from the germplsam available at the College Orchard, Horticultural College and Research Institute, TNAU, Coimbatore and used as parents in the crossing programme. The parents *viz*., CO-1 and Green Long native of Coimbatore, Tamil Nadu, Priyanka and Preethi from Kerala, Karala Rakshuse (KR), Uchha Small Long (USL) and Uchha Bolder (UB) from West Bangal, MC-30, MC-105 and MC-10 from Palur, Tamil Nadu were subjected to crossing in a full diallel fashion (Method I, Model 1 Griffing,1956) in all possible combinations. The parents along with the resultant 90 F_1 hybrids were raised in a Randomized Block Design with three replications during two seasons *viz*., Aadi pattam (August – November) and Thai pattam (January – April). Thus, a total number of ninety crosses and their ten parents were evaluated for various quantitative and qualitative traits in two seasons.

Observations on yield and quality traits *viz*., vine length, days to first male and female flower appearance, node of first male and female flower appearance, number of male and female flowers per vine, sex ratio, days to first harvest, fruit length, fruit girth, fruit weight, fruit flesh thickness, number of fruits per vine, yield of fruits per vine, ascorbic acid and iron content were recorded on three randomly selected single plants in each replication. The mean values were utilized for statistical analysis. Genetic parameters were estimated ae per Haymen's analysis of diallel crosses (Haymen, 1954 a and b).

RESEARCH FINDINGS AND DISCUSSION

The estimates of $\hat{D}$ (additive effects) were significant for 13 out of 17 characters in season I and 15 out of 17 characters in season II, respectively. This indicated that the component of variation due to additive gene effects was important for vine length, days to first male flower appearance (season II), days to first female flower appearance, node of first male and female flower appearance, number of male and female flowers per vine, sex ratio, days to first harvest (season II), fruit length, fruit girth, individual fruit weight, fruit flesh thickness, number of fruits per vine and iron content (Table 1 and 1a). The results are in conformity with the findings of Devadass (1993).

The estimates of $\hat{H}_1$ and $\hat{H}_2$ were positive and significant for all the traits in both the seasons, thus indicated that there was unequal frequency of alleles at all loci. The similar results were obtained by Sit and Sirohi (2008) in bottle gourd. Further the proof for the unequal distribution of the alleles over loci was obtained by the ratio of $\frac{\hat{H}_2}{4\hat{H}_1}$ which is the estimate of proportion of alleles with increasing and decreasing effects. In the present study the estimates were in the range of 0.12 to 0.22, which is less than the maximum value 0.25. The maximum value of 0.25 arises when the increaser and decreaser alleles at the loci are in equal proportion in the parents. But in the present study the estimates were very low. This indicated that the positive and negative alleles at the loci exhibiting dominance were not in equal proportion in the parents. However, this estimate did not permit a determination as to which type of alleles occurred more frequently.

The estimates of $\hat{F}$ were positive for all the traits studied. It indicated the pre-dominance of dominant alleles in the parents for these traits in F_1 generation. In fact, the aforementioned trend was supported by the ratio of dominant to recessive alleles in the parents $\left(\frac{4(\hat{D}\hat{H}_1)^{0.5}+\hat{F}}{4(\hat{D}\hat{H}_1)^{0.5}-\hat{F}}\right)$ *i.e.* is (K_D/K_R). This ratio was more than one for all the traits studied, indicating the pre-dominance of dominant alleles (Table 2 and 2a). The result is in corroboration with the findings of Pandey *et al.* (2010) in bottle gourd.

The estimates of h^2 were positive and significant for vine length, days to first male flower appearance (season II), node of first male flower appearance, sex ratio, days to first harvest, fruit flesh thickness, number of fruits per vine (season II), yield of fruits per vine,

Table 1 : Estimates of genetic parameters (Season I)

Sr. No.	Characters	$\hat{D} \pm SE(\hat{D})$	$\hat{F} \pm SE(\hat{F})$	$\hat{H} \pm SE(\hat{H})$	$\hat{H}_2 \pm SE(\hat{H}_2)$	$\hat{h}^2 \pm SE(\hat{h}_2)$	$\hat{E} \pm SE(\hat{E})$
1.	Vine length	0.56** ± 0.03	0.14*±0.07	0.53**±0.07	0.40**±0.06	1.27**±0.04	0.008±0.009
2.	Days to first male flower appearance	16.66 ± 8.79	28.48±20.29	53.78**±18.72	39.08*±15.91	0.07±10.65	1.19±2.65
3.	Days to first female flower appearance	22.97** ± 5.66	31.74*±13.07	49.51**±12.06	36.11**±10.25	0.12±6.86	1.29±1.71
4.	Node of first male flower appearance	36.64** ± 2.87	45.43**±6.611	39.65**±6.099	23.44**±5.183	16.21**±3.469	0.17±0.86
5.	Node of first female flower appearance	22.69 ** ± 1.96	28.71 **±4.51	32.94**±4.16	19.61**±3.54	1.82±2.37	0.22±0.59
6.	Number of male flowers per vine	17980.22**± 792.60	15653.08**± 1828.76	13303.67**± 1687.12	7694.76**± 1433.87	294.b 06± 959.68	182.1682± 238.98
7.	Number of female flowers per vine	624.04**±15.06	473.68**±34.74	195.54**±32.05	96.80**±27.24	1.53±18.23	0.65±4.54
8.	Sex ratio (M/F)	42.19**±2.26	28.39**±5.22	52.85**±4.81	32.54**±4.09	45.14**± 2.74	0.17±0.68
9.	Days to first harvest	9.61±7.53	9.22±17.38	104.72**±16.03	75.89**±13.63	167.22**±9.12	2.32±2.27
10.	Fruit length	61.99**±2.54	42.78**±5.85	40.76**±5.40	28.41**±4.59	5.57± 3.07	0.18±0.76
11.	Fruit girth	5.52**±1.41	5.76±3.24	11.82**±2.99	9.20**±2.54	0.02± 1.70	0.09±0.42
12.	Individual fruit weight	854.53**±50.17	367.08*±115.76	380.34**±106.79	264.00*±90.76	2.15±60.75	3.64±15.13
13.	Fruit flesh thickness	0.0078**±0.002	0.0115±0.006	0.0356**±0.005	0.0260**±0.005	0.0294**±0.003	0.0002±0.001
14.	Number of fruits per vine	591.31**±16.47	339.43**±37.99	170.69**±35.05	120.26**±29.79	35.87±19.94	0.36±4.97
15.	Yield of fruits per vine	0.030±0.06	0.049±0.14	0.794**±0.13	0.710**±0.11	0.219**±0.07	0.001±0.018
16.	Ascorbic acid content	95.93±72.87	195.62±168.14	681.01**±155.11	567.08**±131.83	595.82**±88.23	3.11±21.97
17.	Iron content	0.138**±0.035	0.207*±0.082	0.496**±0.075	0.404**±0.064	1.279**±0.043	0.001±0.011

* and ** indicate significance of values at P=0.05 and 0.01, respectively

Table 1a : Estimates of genetic parameters (Season II)

Sr. No.	Characters	$\hat{D} \pm SE(\hat{D})$	$\hat{F} \pm SE(\hat{F})$	$\hat{H} \pm SE(\hat{H})$	$\hat{H}_2 \pm SE(\hat{H}_2)$	$\hat{h}^2 \pm SE(\hat{h}_2)$	$\hat{E} \pm SE(\hat{E})$
1.	Vine length	0.525** ± 0.02	0.061 ± 0.05	0.366* *± 0.04	0.290** ± 0.04	0.797** ± 0.03	0.007 ± 0.006
2.	Days to first male flower appearance	12.16** ± 4.38	17.03 ± 10.10	39.59** ± 9.32	30.30** ± 7.92	37.07** ± 5.3	1.68 ±1.32
3.	Days to first female flower appearance	10.03** ± 3.14	11.94 ± 7.24	30.63** ± 6.68	23.77** ± 5.68	2.02 ± 3.80	1.69 ± 0.95
4.	Node of first male flower appearance	31.80** ± 2.84	34.50** ± 2.84	33.61** ± 2.84	22.64** ± 2.84	24.02** ± 2.84	0.19 ± 2.84
5.	Node of first female flower appearance	20.06** ± 1.86	25.47** ± 4.30	30.13** ± 3.96	17.67** ± 3.37	1.00 ± 2.26	0.24 ± 0.56
6.	Number of male flowers per vine	17133.74**± 920.31	13935.11** ± 2123.42	12121.76** ± 1958.96	7485.98** ± 1664.89	18.90±1114.31	185.55±277.48
7.	Number of female flowers per vine	587.42**±13.35	431.31**±30.80	175.00**±28.41	87.41**±24.15	2.78 ± 16.16	0.62±4.03
8.	Sex ratio (M/F)	76.95** ± 2.91	48.58** ± 6.72	54.37**±6.20	33.95** ± 5.27	16.86**±3.52	0.20±0.88
9.	Days to first harvest	15.20** ± 5.13	19.36 ± 11.83	87.37**±10.91	59.75** ± 9.28	151.30**±6.21	2.19±1.55
10.	Fruit length	56.11** ± 2.02	36.08** ± 4.66	35.55**±4.30	24.78** ± 3.66	3.66±2.45	0.17±0.61
11.	Fruit girth	5.67** ± 1.20	6.06* ± 2.76	10.16**±2.55	7.60** ± 2.17	-0.03±1.45	0.09±0.36
12.	Individual fruit weight	811.43**±50.41	288.20*±116.30	360.89**±107.30	248.94**±91.19	3.53±61.03	3.50±15.20
13.	Fruit flesh thickness	0.0084** ±0.003	0.0131±0.007	0.0354**±0.007	0.0254**±0.006	0.0201**±0.004	0.0002±0.001
14.	Number of fruits per vine	538.23**±15.62	307.26**± 36.03	162.62**±33.24	117.04**±28.25	59.49**±18.91	0.33 ± 4.71
15.	Yield of fruits per vine	0.056±0.07	0.088±0.15	0.652** ±0.14	0.573**±0.12	0.210**±0.08	0.001 ± 0.02
16.	Ascorbic acid content	90.06 ± 61.32	189.66±141.49	663.60**±130.53	544.95**±110.94	639.41**±74.25	2.90 ± 18.49
17.	Iron content	0.119** ± 0.031	0.189*±0.073	0.429**±0.067	0.342**±0.057	1.028**±0.038	0.001 ± 0.009

* and ** indicate significance of values at P=0.05 and 0.01, respectively

ascorbic acid content and iron content. It indicated the dominance effect expressed as the algebraic sum over all loci as heterozygous phases in all the crosses (Table 1 and 1a). The mean degree of dominance over all loci $\left(\frac{\hat{H}_1}{\hat{D}}\right)^{\frac{1}{2}}$ indicated over dominance for the characters days to first male and female flower appearance, node of first male and female flower appearance, sex ratio (season I), days to first harvest, fruit girth, fruit flesh thickness, yield of fruits per vine, ascorbic acid and iron content (Table 2 and 2a). The estimates of number of gene groups

Table 2. Ratios of genetic parameters and heritability estimates (Season I)

Sr. No.	Characters	$\left(\frac{\hat{H}_1}{\hat{D}}\right)^{\frac{1}{2}}$	$\frac{\hat{H}_2}{4\hat{H}_1}$	$\frac{K_D}{K_R}$	$\frac{\hat{h}^2}{\hat{H}_2}$	Narrow sense heritability (%)
1.	Vine length	0.9775	0.1862	1.2944	3.2016	72.17
2.	Days to first male flower appearance	1.7969	0.1817	2.8146	0.0018	11.63
3.	Days to first female flower appearance	1.4680	0.1823	2.7779	0.0033	18.32
4.	Node of first male flower appearance	1.0402	0.1478	3.9493	0.6916	38.11
5.	Node of first female flower appearance	1.2048	0.1488	3.2105	0.0927	41.68
6.	Number of male flowers per vine	0.8602	0.1446	3.0489	0.0382	65.33
7.	Number of female flowers per vine	0.5598	0.1238	5.2112	0.0158	83.36
8.	Sex ratio (M/F)	1.1192	0.1539	1.8594	1.3873	67.26
9.	Days to first harvest	3.3018	0.1812	1.3399	2.2033	40.69
10.	Fruit length	0.8109	0.1742	2.4812	0.1961	68.43
11.	Fruit girth	1.4632	0.1946	2.1076	0.0016	81.26
12.	Individual fruit weight	0.6671	0.1735	1.9496	0.0082	30.66
13.	Fruit flesh thickness	2.1391	0.1822	2.0576	1.1318	83.25
14.	Number of fruits per vine	0.5373	0.1761	3.2937	0.2983	15.17
15.	Yield of fruits per vine	5.1787	0.2237	1.3833	0.3078	4.68
16.	Ascorbic acid content	2.6644	0.2082	2.2398	1.0507	9.74
17.	Iron content	1.8999	0.2037	2.3162	3.1646	33.24

Table 2a : Ratios of genetic parameters and heritability estimates (Season II)

Sr. No.	Characters	$\left(\frac{\hat{H}_1}{\hat{D}}\right)^{\frac{1}{2}}$	$\frac{\hat{H}_2}{4\hat{H}_1}$	$\frac{K_D}{K_R}$	$\frac{\hat{h}^2}{\hat{H}_2}$	Narrow sense heritability (%)
1.	Vine length	0.8342	0.1987	1.1504	2.7482	77.20
2.	Days to first male flower appearance	1.8043	0.1913	2.2677	1.2234	19.31
3.	Days to first female flower appearance	1.7478	0.1940	2.0338	0.0848	24.45
4.	Node of first male flower appearance	1.0280	0.1684	3.2334	1.0610	41.40
5.	Node of first female flower appearance	1.2256	0.1466	3.1496	0.0565	43.08
6.	Number of male flowers per vine	0.8411	0.1544	2.8720	0.0025	65.57
7.	Number of female flowers per vine	0.5458	0.1249	5.1091	0.0318	84.43
8.	Sex ratio (M/F)	0.8406	0.1561	2.2026	0.4968	73.75
9.	Days to first harvest	2.3973	0.1710	1.7235	2.5320	40.64
10.	Fruit length	0.7960	0.1743	2.3551	0.1476	70.75
11.	Fruit girth	1.3393	0.1870	2.3283	-0.0041	35.26
12.	Individual fruit weight	0.6669	0.1724	1.7259	0.0142	82.85
13.	Fruit flesh thickness	2.0518	0.1792	2.2210	0.7906	29.06
14.	Number of fruits per vine	0.5497	0.1799	3.1604	0.5083	82.37
15.	Yield of fruits per vine	3.4046	0.2195	1.5951	0.3662	14.28
16.	Ascorbic acid content	2.7145	0.2053	2.2675	1.1733	6.41
17.	Iron content	1.8947	0.1993	2.4312	3.0086	9.24

$\left(\frac{\hat{h}^2}{\hat{H}_2}\right)$ which control over trait were more than one for vine length, days to first male flower appearance (season II), node of first male flower appearance (season II), sex ratio (season I), days to first harvest, fruit flesh thickness (season I), ascorbic acid and iron content (Table 2 and 2a). It measures only those factors which show some degree of dominance. Accordingly, these characters were controlled by at least one effective block of genes. For the other characters, the ratio was less than one. This underestimation may be due to the fact that the dominance effects of the genes affecting remaining traits are not equal in size and distribution or if the distribution of the genes is correlated (Mather, 1949 and Jinks, 1954). Any of these two reasons mentioned, may be the cause for the low value of the ratio of $\frac{\hat{h}^2}{\hat{H}_2}$ for the remaining characters.

The narrow sense heritability estimates were high for vine length, number of male and female flowers per vine, sex ratio, fruit length, fruit girth (season I), individual fruit weight (season II), fruit flesh thickness (season I) and number of fruits per vine (season II). These characters are predominantly controlled by additive genetic variance. This indicated that the individual genotype can be evaluated readily from its phenotypic expression for these traits. Simple selection would be more effective in the sets of materials exhibiting greater additive genetic variability and desirable mean performance. On the other hand the remaining characters may be largely controlled by non- additive genetic variance or number of genes controlling these traits may be more, or these traits may largely be influenced by environment.

Present study revealed the importance of both additive and non-additive gene action in the improvement of the characters like earliness *i.e.* days first female flower appearance and yield contributing characters like number of female flowers per vine and number of fruits per vine, fruit length, fruit weight and quality characters. Dey *et al*. (2010) had also reported both additive and non additive type of gene action in bitter gourd with respect to earliness *i.e.* node number of first female flower appearance, days to open first female flower, days to fruit set to maturity and days to harvest.

The presence of both additive and dominant gene action and higher estimates of narrow sense heritability observed for the traits vine length, number of male and female flowers per vine, sex ratio, fruit length, fruit girth (season I), individual fruit weight (season II), fruit flesh thickness (season I) and number of fruits per vine (season II) indicated the possibility of isolating superior inbreds from the segregating generations. Reciprocal recurrent selection could advantageously be adopted to exploit both additive and non-additive gene effects. This is in corroboration with the earlier findings of Devadass (1993).

The preponderance of dominant gene action coupled with low narrow sense heritability observed for the traits *viz*., days to first male and female flower appearance, fruit flesh thickness (season II), number of fruits per vine (season I), yield of fruits per vine, ascorbic acid and iron content revealed the importance of heterosis breeding for simultaneous improvement of yield and quality characters which is in conformity to the earlier reports of Lawande and Patil (1990). The possibilities for the commercial exploitation of heterosis in bitter gourd had also been reported earlier by Tewari *et al*. (2001) and Sundaram (2006).

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