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ASSOCIATION OF FRUIT YIELD AND COMPONENT TRAITS IN SEGREGATING POPULATION OF BITTER GOURD

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Abstract

The present investigation was carried out to find out the nature and magnitude of genetic variability and association studies in segregating population of bitter gourd for yield and its attributing traits to select transgressive segregants for further breeding programme. The experiment was laid out in randomized block design with three replications during summer 2011. High heritability coupled with genetic advance as percent of mean were observed for number of fruits/vine, average fruit weight, fruit length and yield/vine indicating the role of additive gene effects in expression of these characters and therefore, they are more reliable for effective selection. Fruit length, number of fruits/vine, vine length, number of laterals/vine and average fruit weight were identified as major characters contributing to yield as these traits were significantly and positively associated with yield/vine. A significant negative correlation of yield was observed with Days to 1st male and female flower appeared, node number at which 1st male and female flower appeared and sex ratio. The path analysis study revealed that most of the characters indirectly influenced the yield through number of fruits/vine, average fruit weight and fruit length towards the favourable direction which had positive direct effect on yield/vine, suggesting that emphasis must be given characters having high direct effect, while exercising selection to improve the yield.

Key words : Bitter gourd, segregating population, genetic variability, character association, path analysis.

Introduction

Bitter gourd (*Momordica charantia* L.) is an important vegetable crop widely grown throughout India. It has wide variability in terms of vine growth, leaf and fruit characters like length, girth, colour etc. Yield being a complex character, is dependent upon a number of attributes. Before initiating an effective selection programme, it is necessary to know the importance and association of various component characters with yield and among each other. Bitter gourd being monoecious in nature it is easy to make large number of crosses. To manage large number of recombinant lines in later generation, it would be highly desirable to start selection among crosses as early as possible. Developments in biometrical genetics have led to the suggestion that early generation trails may be used to predict the ranking of the crosses according to their likelihood of producing superior recombinant lines (Singh *et al*., 2011). The F_2 or F_3 derived lines are far from being homozygous and early generation selection relies on the assumption that the performance of a line at an early generation of selfing is predictive of its performance at homozygosity (Chahota *et al*., 2007).

A simple measure of correlation of characters does not quantify the relative contribution of causal factors to the ultimate yield. Since the component traits themselves are inter-dependant, they often affect their direct relationship with yield and consequently restrict the reliability of selection indices based upon correlation coefficients (Thangamani and Jansirani, 2012). Path coefficient analysis has an advantage over estimation of simple correlation coefficients because it allows partitioning of the correlation coefficients into its components. These components are 1) the path coefficient that measures the direct effect of a predictor variable upon its response variable 2) the indirect effect(s) of a predictor variable on the response variable through other predictor variables (Dewey and Lu, 1959). Hence, the present study was undertaken to estimate the genotypic correlations and direct and to determine the indirect effects of component characters on yield in bitter gourd.

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Material and Methods

The experiment was conducted at Model Orchard, College of Horticulture, Rajendranagar, Hyderabad (A.P.), India during summer 2011 in a randomized block design with three replications. The experimental material consisted of 28 F_2 generation derived from 8 × 8 diallel mating (excluding reciprocals). The seeds were sown in rows with spacing of 0.5 m between vines and 2.0 m between rows. All the recommended package of practices was followed to raise healthy crop. Data were recorded on twenty vines in each population for fifteen characters viz., vine length (m), number of laterals/vine, internodal length (cm), days to 1st male flower appeared, days to 1st female flower appeared, node number at which 1st male flower appeared, node number at which 1st female flower appeared, sex ratio (male to female), number of fruits/vine, average fruit weight (g), fruit length (cm), fruit girth (cm), pulp thickness (cm), number of seeds/fruit and yield/vine (kg). Mean values were subjected to statistical analysis and the analysis of variance was worked out to test the significance f and t test according to the procedure of RBD analysis of Panse and Sukhatme (1985). The coefficient of phenotypic and genotypic variations was calculated according to Burton and De Vane (1953). Heritability and genetic advance were calculated according to the formula of given by Johnson *et al.* (1955). Genotypic and phenotypic correlation coefficients were estimated as formulae given by Johnson *et al.* (1955). Path coefficient analysis as applied by Dewey and Lu (1959) was used to partition the genotypic correlation into components of direct and indirect effects.

Results and Discussion

The results from Table 1 showed that the values of phenotypic coefficient of variation (PCV) were higher than the corresponding values of genotypic coefficient of variation (GCV) but the differences were narrow indicating low environmental influence in the expression of these characters. These results were in consonance with those of other workers Mangal *et al.* (1981). Comparatively wide differences between estimates of PCV and GCV for sex ratio and number of seeds/fruit indicated greater environmental effect on the expression of these traits. Genotypic coefficient of variation was high for yield/vine (23.14) while low for days to 1st male flower appeared (4.12) followed by days to 1st female flower appeared (4.30) and sex ratio (4.50).

Heritability in narrow sense showed moderately high values (above 50%) for vine length, days to 1st male flower, days to 1st female flower, node number at which 1st male and female flower appeared, sex ratio, number of fruits/vine, fruit length and fruit girth, indicating that the major part of phenotypic variability was of additive nature, hence, selection would be effective for improvement of these characters in bitter gourd. Low heritability estimate (below 50%) for number of laterals/vine, internodal length, average fruit weight, pulp thickness, number of seeds/fruit and yield/vine indicated that these characters were prone to environmental fluctuation and need to be tested under diverse environments for effective selection.

High heritability does not guarantee large gain from selection unless sufficient genetic advance attributable to additive gene action is present (Srivastava and Jain, 1994). High heritability value along with high value of genetic advance as per cent of mean is most effective condition for selection (Gandhi *et al*., 1964). In the present study, the parallelism in the magnitude of the values of heritability and genetic gain (per cent of mean) in respect of number of fruits/vine, average fruit weight, fruit length and yield/vine indicated that additive gene effects are important in determining the characters. Hence, there is an ample scope for selection for these traits. Similar results were reported by Srivastava and Srivastava (1976) in bitter gourd; Singh *et al*. (1996) in bottle gourd; Kumar *et al*. (2008) for fruit length and average fruit weight in cucumber.

High heritability accompanied with moderate genetic advance as per cent of mean for vine length, number of laterals/vine, node number at which 1st male and female flower appeared, and pulp thickness indicated major role of additive gene action hence, selection may be effective for these characters. Among the characters, days to 1st male and female flower appeared and fruit girth recorded high value of heritability accompanied with low genetic advance as per cent of mean indicated the presence of non-additive gene action in inheritance of these traits. These results are consonance with the findings of Sureja *et al*. (2010) for days to 1st male and female flower in ash gourd. The high heritability is being exhibited due to favourable influence of environment rather than genotype hence, selection for these traits may not be rewarding (Singh and Narayanan, 1993).

Medium value of heritability coupled with moderate value of genetic advance as per cent of mean was noticed for number of laterals/vine and internodal length. These results suggesting that equal contribution of additive and non-additive gene action and thus selection as well as heterosis breeding would be effective. Sex ratio recorded medium value of heritability along with low value of genetic advance as per cent of mean indicated the

Table 1 : Genetic parameters for yield and yield attributing characters of bitter gourd in F_2 progenies.

S. no.	Characters	GCV (%)	PCV (%)	Heritability % (narrow Sense)	Genetic advance	Genetic advance as % of Mean
1.	Vine length (m)	7.70	8.70	60.20	0.39	17.98
2.	No. of laterals/vine	8.13	9.13	42.86	1.10	19.10
3.	Internodal length (cm)	7.59	9.50	25.79	0.95	16.02
4.	Days to 1st male flower	4.12	5.03	76.57	3.76	8.89
5.	Days to 1st female flower	4.30	4.95	82.13	5.11	9.84
6.	Node No. at 1st male flower	7.08	9.45	73.85	1.20	14.01
7.	Node No. at 1st female flower	7.29	9.05	59.54	2.33	15.52
8.	Sex ratio	4.50	8.31	55.08	0.54	6.45
9.	Number of fruits/vine	16.06	16.61	53.16	7.99	41.02
10.	Average fruit weight (g)	10.29	11.08	38.54	16.75	25.21
11.	Fruit length (cm)	8.49	9.34	53.14	3.12	20.38
12.	Fruit girth (cm)	4.67	5.91	88.30	1.18	9.73
13.	Pulp thickness (cm)	5.20	5.60	37.80	0.44	12.74
14.	Number of seeds/fruit	5.26	8.63	19.26	1.66	8.47
15.	Yield/vine (kg)	23.14	23.59	44.30	0.78	59.94

inheritance of this trait is mostly by non-additive gene action. Hence, simple selection would be ineffective to improve this trait. Low heritability accompanied with low genetic advance was recorded for number of seeds/fruit suggested this trait is highly influenced by non-additive gene action thus, limits the chances of improvement of this trait through direct selection. Hence, heterosis breeding would be rewarding.

From the correlation studies (table 2), it is evident that the genotypic values were higher than the phenotypic values. Similar results were reported by Dey *et al*. (2005). This could be interpreted on the basis that there was strong inherent genotypic relation between the characters studied, but the phenotypic expression was impeded by the influence of environmental factors.

Yield had the highest positive and significant correlation with fruit length followed by number of fruits/vine, vine length, number of laterals/vine and average fruit weight. These results are in comparison with the findings of Srivastava and Srivastava (1976) and Ram *et al*. (2006). Hence, direct selection would be effective for these traits to improve the yield. These traits probably increase the number of leaves and hence the photosynthetic efficiency (Ramachandran and Gopalakrishnan, 1979). Arnan (1976) reported that an increase in photosynthetic efficiency increases the dry matter and finally the economic yield.

Yield had significant negative correlation with days to 1st male and female flower appeared, node number at which 1st male and female flower appeared and sex ratio (Bhave *et al*., 2003). Further, Dey *et al.* (2005) in bitter gourd and Joshi *et al.* (1991) in cucumber observed similar results and stated that the number of nodes to the first female flower is reasonably a good measure of earliness.

The direct and indirect effects of all the characters on yield/vine estimated at both phenotypic and genotypic levels (table 3) revealed that number of fruits exhibited maximum positive direct effect towards yield/vine followed by average fruit weight and fruit length, which also exhibited significant high positive correlation coefficients with yield/vine. The direct selection for these characters would be beneficial for crop improvement. The characters like node number at which 1st female flower appeared, sex ratio and number of seeds/fruit showed direct negative effect on yield/vine at both genotypic and phenotypic levels while days to 1st male and female flower appeared and node at which 1st male flower appeared had direct negative effect at genotypic level only. Similar results were reported earlier by Dey *et al*. (2005). Hence, effective selection can be done for lower node number of 1st female flower and sex ratio (male: female) to increase yield/vine.

The characters *viz.,* vine length, number of laterals/vine, internodal length, number of fruits/vine, average fruit weight, fruit length, fruit girth and pulp thickness which showed positive correlation with yield/vine also exhibited direct positive effects on yield/vine except pulp thickness. The positive correlation between pulp thickness and yield might be due to indirect positive effect on yield through number of fruits/vine and average fruit weight. Similar results are reported by Dey *et al*. (2005) for fruit weight

Table 2 : Phenotypic and genotypic correlation coefficients for fifteen characters of bitter gourd in F_2 progenies.

Character	Vine length (m)	No. of laterals/ vine	Inter nodal length (cm)	Days to 1st male flower	Days to 1st female flower	Node no. at 1st male flower	Node no. at 1st female flower	Sex ratio	No. of fruits/ vine	Ave. fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Pulp thick ness (cm)	No. of seeds/ fruit	Yield/ vine (kg)
Vine length (m)	**1.0000**	0.4740 (0.6795)**	0.0881 (0.1855)	-0.2774 (-0.4722)	-0.4185 (-0.5680)*	-0.0792 (-0.1004)	-0.1164 (-0.1378)	-0.4765 (-0.9896)**	0.6771** (0.8121)**	0.4601 (0.5518)*	0.6326* (0.7564)**	0.3771 (0.5582)*	0.6513** (0.7955)**	0.1399 (0.1970)	0.7144** (0.8304)**
No. of laterals/vine		**1.0000**	0.2694 (0.4590)	-0.1206 (-0.1992)	-0.4768 (-0.6443)**	-0.1693 (-0.3101)	-0.1694 (-0.2933)	-0.4245 (-0.8820)**	0.6756** (0.7771)**	0.4384 (0.5316)*	0.5642* (0.7196)**	0.1268 (0.3093)	0.3603 (0.4731)	0.2073 (0.5288)*	0.7077** (0.8062)**
Internodal length (cm)			**1.0000**	-0.2007 (-0.2299)	-0.2961 (-0.4336)	-0.1428 (-0.1333)	-0.1640 (-0.3505)	-0.1959 (-0.3188)	0.3408 (0.4446)	0.1481 (0.2081)	0.1727 (0.2989)	-0.1617 (-0.3502)	-0.1247 (-0.1995)	0.2351 (0.5039)	0.3256 (0.4239)
Days to 1st male flower				**1.0000**	0.6014* (0.7237)**	0.3292 (0.4892)	0.4727 (0.5966)*	0.2526 (0.8258)**	-0.3054 (-0.4050)	-0.1227 (-0.1368)	-0.0679 (-0.0753)	0.0424 (0.0859)	-0.1563 (-0.1521)	-0.0331 (0.0292)	-0.2709 (-0.3418)
Days to 1st female flower					**1.0000**	0.2377 (0.3091)	0.6068* (0.6873)**	0.4352 (0.1122)	-0.6225* (-0.7333)**	-0.2471 (-0.2866)	-0.3227 (-0.4347)	0.0156 (0.1087)	-0.1569 (-0.1846)	-0.0770 (-0.1438)	-0.5623* (-0.6444)**
Node no. at 1st male flower						**(1.0000**	0.4082 (0.4818)	0.2133 (0.3472)	-0.1281 (-0.2126)	-0.1928 (-0.1921)	-0.0607 (-0.0472)	-0.0501 (0.0022)	-0.1531 (-0.2126)	-0.1289 (-0.4255)	-0.1772 (-0.2262)
Node no. at 1st female flower							**1.0000**	0.3571 (0.6802)**	-0.3000 (-0.3886)	-0.1484 (-0.1780)	-0.1019 (-0.0977)	0.0100 (0.1180)	0.0473 (0.0571)	-0.0609 (-0.1000)	-0.2806 (-0.3518)
Sex ratio								**1.0000**	-0.4951 (-0.8416)**	-0.2361 (-0.6108)*	-0.2489 (-0.5235)*	-0.2440 (-0.7233)**	-0.4134 (-0.8878)**	-0.0336 (-0.1540)	-0.4637 (-0.8620)**
No. of fruits/vine									**1.0000**	0.3245 (0.4056)	0.6444** (0.7415)**	0.1778 (0.2232)	0.3524 (0.3882)	0.2368 (0.4728)	0.8599** (0.8802)**
Ave. fruit weight(g)										**1.0000**	0.6007** (0.7228)**	0.2942 (0.3989)	0.5241* (0.5724)*	0.0270 (0.0269)	0.7560** (0.7861)**
Fruit length (cm)											**1.0000**	0.1590 (0.2053)	0.3772 (0.4632)	0.2119 (0.2274)	0.7828** (0.8882)**
Fruit girth (cm)												**1.0000**	0.6933 ** (0.8579)**	-0.1445 (-0.3153)	0.2725 (0.3421)
Pulp thickness (cm)													**1.0000**	-0.0146 (0.0199)	0.5156* (0.5486)*
No. of seeds/fruit														**1.0000**	0.1743 (0.3302)

*Significant at 0.05% probability ** Significant at 0.01% probability The values in the parenthesis are genotypic correlation coefficients.

Table 3 : Phenotypic and genotypic path coefficients for fifteen characters of bitter gourd in F_2 progenies.

Character	Vine length (m)	No. of laterals/ vine	Inter nodal length (cm)	Days to 1st male flower	Days to 1st female flower	Node no. at 1st male flower	Node no. at 1st female flower	Sex ratio	No. of fruits/ vine	Ave. fruit weight (g)	Fruit length (cm)	Fruit girth (cm)	Pulp thick ness (cm)	No. of seeds/ fruit	Correlation with yield/ vine (kg)
Vine length (m)	**0.0067** **(0.1123)**	0.0032 (0.0763)	0.0006 (0.0208)	-0.0018 (-0.0530)	-0.0028 (-0.0638)	-0.0005 (-0.0113)	-0.0008 (-0.0155)	-0.0032 (-0.1111)	0.0045 (0.0912)	0.0031 (0.0619)	0.0042 (0.0849)	0.0025 (0.0627)	0.0043 (0.0893)	0.0009 (0.0221)	**0.7144**** **(0.8304)****
No. of laterals/vine	0.0087 (0.0193)	**0.0184** **(0.0284)**	0.0050 (0.0130)	-0.0022 (-0.0057)	-0.0088 (-0.0183)	-0.0031 (-0.0088)	-0.0031 (-0.0083)	-0.0078 (-0.0250)	0.0124 (0.0221)	0.0081 (0.0151)	0.0104 (0.0204)	0.0023 (0.0088)	0.0066 (0.0134)	0.0038 (0.0150)	**0.7077**** **(0.8062)****
Internodal length (cm)	0.0018 (0.0031)	0.0054 (0.0077)	**0.0201** **(0.0168)**	-0.0040 (-0.0039)	-0.0059 (-0.0073)	-0.0029 (-0.0022)	-0.0033 (-0.0059)	-0.0039 (-0.0054)	0.0068 (0.0075)	0.0030 (0.0035)	0.0035 (0.0050)	-0.0032 (-0.0059)	-0.0025 (-0.0034)	0.0047 (0.0085)	**0.3256** **(0.4239)**
Days to 1st male flower	0.0005 (-0.0100)	0.0002 (-0.0042)	0.0003 (-0.0048)	**-0.0017** **(0.0211)**	-0.0010 (0.0153)	-0.0006 (0.0103)	-0.0008 (0.0126)	-0.0004 (0.0174)	0.0005 (-0.0085)	0.0002 (-0.0029)	0.0001 (-0.0016)	-0.0001 (0.0018)	0.0003 (-0.0032)	0.0001 (0.0006)	**-0.2709** **(-0.3418)**
Days to 1st female flower	0.0039 (-0.0075)	0.0045 (-0.0085)	0.0028 (-0.0057)	-0.0056 (0.0095)	**-0.0094** **(0.0131)**	-0.0022 (0.0041)	-0.0057 (0.0090)	-0.0041 (0.0146)	0.0058 (-0.0096)	0.0023 (-0.0038)	0.0030 (-0.0057)	-0.0001 (0.0014)	0.0015 (-0.0024)	0.0007 (-0.0019)	**-0.5623*** **(-0.6444)****
Node no. at 1st male flower	-0.0011 (0.0010)	-0.0023 (0.0031)	-0.0019 (0.0013)	0.0044 (-0.0048)	0.0032 (-0.0030)	**0.0133** **(-0.0099)**	0.0054 (-0.0048)	0.0028 (-0.0034)	-0.0017 (0.0021)	-0.0026 (0.0019)	-0.0008 (0.0005)	-0.0007 (0.0000)	-0.0020 (0.0021)	-0.0017 (0.0042)	**-0.1772** **(-0.2262)**
Node no. at 1st female flower	0.0002 (0.0035)	0.0002 (0.0074)	0.0002 (0.0089)	-0.0007 (-0.0151)	-0.0009 (-0.0175)	-0.0006 (-0.0122)	**-0.0014** **(-0.0254)**	-0.0005 (-0.0173)	0.0004 (0.0099)	0.0002 (0.0045)	0.0001 (0.0025)	0.0000 (-0.0030)	-0.0001 (-0.0014)	0.0001 (0.0025)	**-0.2806** **(-0.3518)**
Sex ratio	0.0000 (0.0123)	0.0000 (0.0109)	0.0000 (0.0040)	0.0000 (-0.0102)	0.0000 (-0.0138)	0.0000 (-0.0043)	0.0000 (-0.0084)	**-0.0001** **(-0.0124)**	0.0000 (0.0104)	0.0000 (0.0076)	0.0000 (0.0065)	0.0000 (0.0090)	0.0000 (0.0110)	0.0000 (0.0019)	**-0.4637** **(-0.8620)****
No. of fruits/vine	0.4314 (0.4437)	0.4305 (0.4246)	0.2172 (0.2429)	-0.1946 (-0.2213)	-0.3966 (-0.4006)	-0.0816 (-0.1162)	-0.1911 (-0.2123)	-0.3155 (-0.4598)	**0.6372** **(0.5464)**	0.2068 (0.2216)	0.4106 (0.4051)	0.1133 (0.1220)	0.2246 (0.2121)	0.1509 (0.2583)	**0.8599**** **(0.8802)****
Ave. fruit weight(g)	0.2327 (0.2585)	0.2217 (0.2491)	0.0749 (0.0975)	-0.0620 (-0.0641)	-0.1250 (-0.1343)	-0.0975 (-0.0900)	-0.0750 (-0.0834)	-0.1194 (-0.2862)	0.1641 (0.1900)	**0.5058** **(0.4685)**	0.3038 (0.3386)	0.1488 (0.1869)	0.2651 (0.2682)	0.0136 (0.0126)	**0.7560**** **(0.7861)****
Fruit length (cm)	0.0320 (0.0491)	0.0285 (0.0467)	0.0087 (0.0194)	-0.0034 (-0.0049)	-0.0163 (-0.0282)	-0.0031 (-0.0031)	-0.0051 (-0.0063)	-0.0126 (-0.0340)	0.0326 (0.0482)	0.0303 (0.0469)	**0.0505** **(0.0649)**	0.0080 (0.0133)	0.0191 (0.0301)	0.0107 (0.0148)	**0.7828**** **(0.8882)****
Fruit girth (cm)	0.0009 (0.0016)	0.0003 (0.0009)	-0.0004 (-0.0010)	0.0001 (0.0002)	0.0000 (0.0003)	-0.0001 (0.0000)	0.0000 (0.0003)	-0.0006 (-0.0020)	0.0004 (0.0006)	0.0007 (0.0011)	0.0004 (0.0006)	**0.0024** **(0.0028)**	0.0017 (0.0024)	-0.0003 (-0.0009)	**0.2725** **(0.3421)**
Pulp thickness (cm)	-0.0020 (-0.0552)	-0.0011 (-0.0329)	0.0004 (0.0139)	0.0005 (0.0106)	0.0005 (0.0128)	0.0005 (0.0148)	-0.0001 (-0.0040)	0.0012 (0.0616)	-0.0011 (-0.0270)	-0.0016 (-0.0397)	-0.0011 (-0.0322)	-0.0021 (-0.0596)	**-0.0030** **(-0.0694)**	0.0000 (-0.0014)	**0.5156*** **(0.5486)***
No. of seeds/fruit	-0.0013 (-0.0012)	-0.0019 (-0.0033)	-0.0022 (-0.0031)	0.0003 (-0.0002)	0.0007 (0.0009)	0.0012 (0.0027)	0.0006 (0.0006)	0.0003 (0.0010)	-0.0022 (-0.0030)	-0.0002 (-0.0002)	-0.0020 (-0.0014)	0.0013 (0.0020)	0.0001 (-0.0001)	**-0.0093** **(-0.0062)**	**0.1743** **(0.3302)**

Genotypic residual effect = 0.0540; phenotypic residual effect = 0.0674; the values in the parenthesis are genotypic path coefficients.

in bitter gourd.

In the present investigation, regarding path coefficient analysis, most of the characters indirectly influenced the yield through number of fruits/vine, average fruit weight and fruit length towards the favourable direction which had positive direct effect on yield/vine, suggesting that preference should be given on these parameters in a selection programme. The residual phenotypic and genotypic effects were 0.0674 and 0.0540, respectively.

The results in the present study showed the possibility of improving bitter gourd by selection for number of fruits/vine, fruit weight and yield/vine. Based on high heritability in narrow sense and high genetic advance shown by these characters, it could conclude that the determinant genetic effects of the phenotypic expression of these characters are fundamentally of the additive type. For this reason, a high response should be achievable after several selection cycles. Based on correlation and path coefficient analysis results it can be concluded that besides more number of fruits/vine the ideal plant type in bitter gourd should have high average fruit weight, longer fruit length, longer vine length, more laterals, more fruit girth, less days required to 1st female flower, lower nodes to 1st female flower and low sex ratio for getting higher yields as well as earliness.

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