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Genotype x Environment Interaction in Relation to Diallel Crosses for Flower Characters in Bean (*Lablab purpureus*)

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Diallel analysis includes combining ability effects and components of genetic variation. They were estimated over two environments for flower characters from a half-diallel cross by involving six parents. Both general combining ability (gca) and specific combining ability (sca) were important for all characters with preponderance of additive gene actions. Environment had significant effect on all characters except flowers/inflorescence. Best general combiners were DS52, DS106, DS112 etc. Complete dominance was observed for flowering date in environment-2, flowers/inflorescence in environment-1 and pods/inflorescence in both environments. Over dominance was found for flowering date in environment-1 and partial dominance for flowers/inflorescence in environment-2 and for inflorescence/plant in both environments. Characters were governed by asymmetrical distribution of positive and negative alleles. Dominant and recessive genes were equally distributed for flowering date and inflorescence/plant whereas unequally distributed for flowers/inflorescence and pods/inflorescence. One or two gene groups were involved in flower characters of lablab bean.

Key words: Diallel analysis, Environmental heterogeneity, *Lablab purpureus*.

Introduction

Lablab bean is the most popular winter vegetable in Bangladesh. It is a multipurpose, leguminous crop adapted to dry areas (Kasno and Utomo 1991). Generally its yield, varies greatly with wide seasonal fluctuations mainly due to poor adaptation of cultivars. Genotype-environment interaction is an intrusive factor that plant breeders are to deal with, in developing a high potential variety for wide cultivation. Diallel analysis provides an effective means of obtaining a rapid picture of a genetic control of a character in a number of homozygous lines. It could successfully reveal the major features of a genetic system and predict the out come of the selection in early generations (Yates 1947; Hayman 1954; Griffing 1956; Jone's 1965). In a breeding programme, selection at the early stages is often restricted to a single environment, employing advanced agricultural practices. Selection for increased yield may produce lines adapted to these conditions but lacking the stability, required for commercial cultivation. For example, reselection in the parents of the diallel cross exhibited yield increase in singular experimental traits, but failed to maintain this in wide ranging traits covering diverse environments (Arnold *et al* 1970). G x E interaction have assumed greater importance in plant breeding, that they violently interfere with precise estimates of genetic parameters and with stability of genotype values under diverse environments. The objective of this study was to obtain information on the genetic architecture of the flower characters in two cultural environments and their interaction with environment and also to identify best parents and specific crosses.

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Materials and Methods

Six diverse genotypes of lablab bean (eg. KBS-1, DS-52, DS-106, DS-112, DS-161 and DS-167) were crossed in all possible combinations without reciprocals. Six parents and their 15 F_2s were grown on two cultured environments [eg. Environment-1 (E_1)-early sowing i.e. 20 August, 1996 with fertilizer @ 20g triple super phosphate, 20g muriate of potash and 5g Gypsum per pit and Environment-2 (E_2)-late, sowing i.e. 2 September, 1996 without fertilizer in the pit] in order to study environmental interaction during 1996-97 at the experimental farm of Genetics and Plant Breeding Department, Bangladesh Agricultural University, Mymensingh. A RCB design with five blocks, each representing replication was used for either of environments. Pits were prepared at a spacing of 2m x 2m, between and within the rows. Three to four seeds for each diallel family, including parents, were sown per pit. Necessary cultural operations were done as and when required. Data were recorded from all experimental plants on four characters i.e. flowering date, flowers/inflorescence, inflorescence/plant and pods/inflorescence. Diallel analysis was done following Griffing's (1956) method 2 model 1(fixed effect model). In model 1, the experimental material is regarded as the population about which inferences are to be made. The analysis of variance for combining ability was carried out by using block mean of each entry (diallel family) for individual environment as follows:

$$gca = 1/(p+2)\sum_{I}(Yi+Yii)^2 - 4/pY^2$$

$$sca = \sum_{i}\sum_{j}Y^2ij - 1/(p+2)\Sigma(Yi+Yij)^2 + 2/(p+1)(p+2)Y^2..$$

Error = SSe

where:

gca = general combining ability
sca = specific combining ability
p = number of parents
Yi = array total of the ith parent
Yii = mean value of the ith parent
Y.. = grand total of the 1/2p(p-1) crosses and parental values
Yij = progeny mean values in the diallel table
SSe = sum of square due to error (obtain from preliminary anova after dividing by the number of blocks)

The gca and sca effect of each character was calculated as follows:

$$gi = 1/(p+2)\Sigma(Yi.+Yii) - 2/pY..$$
$$sij = Yij - 1/(p+2)(Yi+Yii+Y.j+Yij) + 2/(p+1)(p+2)Y..$$

where:

gi = general combining ability effect
sij = specific combining ability effect

The genetic components of variation in F_2 population were calculated according to Jinks (1956) and heritability was estimated as out lined by Verhalen and Murray (1969) for F_2 population.

Results and Discussion

Mean values concerning flowering date and inflorescence/ plant suggested that genotypes on an average, performed better in environment-1 than in environment-2. The environmental effects on those traits were highly significant. In environment-1, flowering date was significant and required 14 days more to come to flower than in environment-2, except DS-52. It was probably because most of the bean genotypes in the study were timely fixed and photoperiod sensitive (with exception of KBS-1 and DS-167). Such flowering behaviour with differential sowing dates early with environment-1 and late with environment-2 could be anticipated. Flowering date ranged from 63.4 to 98.4 in E_1 and 47.4 to 105.0 in E_2 among the parental genotypes and from 64.0 to 99.8 in E_1 and 48.0 to 94.8 in E_2 in cross combination, Table 1. Result on the specific performance of genotypes in each environment showed lowest days for flowering, which was in the KBS 1, in environment-2. Whereas Begum and Newaz (2000) reported the

Table 1

Mean values of flower characters in *Lablab purpureus* bean conducted in two environments

Genotype	Flowering date		Flowers/inflorescence		Inflorescence/plant		Pods/plant	
	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2
KBS-1	63.4	47.4	8.9	7.6	52.2	17.6	5.2	4.1
DS-52	90.0	87.2	9.9	7.8	70.4	21.0	5.8	4.0
DS-106	98.4	83.8	13.3	12.8	44.4	39.2	9.6	7.9
DS-112	88.8	105.0	14.9	14.7	63.4	34.2	10.0	11.0
DS-161	87.8	73.4	10.8	10.6	48.8	33.8	6.6	7.1
DS-167	63.4	48.0	5.8	8.1	10.4	4.4	3.0	4.6
KBS-1 X DS-52	99.8	80.4	10.1	10.1	75.2	28.2	5.6	6.4
KBS-1 X DS-106	97.4	75.2	11.7	10.6	74.6	40.6	7.4	6.7
KBS-1 X DS-112	92.4	77.6	10.2	10.6	60.0	33.4	6.4	6.8
KBS-1 X DS-161	64.0	48.0	8.5	10.1	49.4	46.8	4.9	5.9
KBS-1 X DS-167	70.6	54.4	9.4	9.1	32.4	24.6	5.2	5.8
DS-52 X DS-106	92.8	82.2	10.3	10.6	61.4	28.4	5.2	7.3
DS-52 X DS-112	96.0	87.6	11.7	11.7	78.2	39.0	8.1	6.6
DS-52 X DS-161	99.4	75.8	10.3	9.6	57.2	41.4	7.1	5.5
DS-52 X DS-167	96.4	83.0	11.1	10.7	59.0	29.2	7.3	7.3
DS-106 X DS-112	88.4	77.4	10.3	11.1	51.0	38.6	6.7	8.0
DS-106 X DS-161	84.2	73.2	11.2	11.4	58.0	58.2	7.9	8.2
DS-106 X DS-167	87.2	71.4	10.5	11.3	34.6	24.0	6.0	8.3
DS-112 X DS-161	88.4	73.6	9.3	10.6	50.0	34.2	5.2	7.1
DS-112 X DS-167	90.6	94.8	8.8	9.1	46.4	30.0	5.7	6.0
DS-161 X DS-167	87.0	73.6	10.0	8.5	46.0	27.4	6.2	4.2
SE(±)	2.7		0.74		9.02		0.67	

lowest days for flowering in DS-167. Late sowing and absence of added fertilizer (environment-2), drastically reduced the number of inflorescence/plant. The lesser number of inflorescence meant lesser productive pods and finally lower yield. The analysis of variance for combining ability (Table 2) showed that both gca and sca variance were significant in both environments for flowering date, flowers/ inflorescence and pods/ inflorescence; indicating that additive as well as non-additive gene action were important for these characters. In inflorescence/plant, additive gene action was important for both the environments. Singh and Singh (1981) reported the predominant role of additive genetic variance for flowering date and non additive component to be more important for pods/inflorescence. Singh *et al* (1986) and Hossain (1993) reported additive and non-additive component to be important for flowers/ inflorescence, whereas Sharma and Pandey (1996) in Urd bean (*Vigna mungo*) reported inflorescence/plant to be principally affected by additive gene action. The gca x env. was highly significant for flowering date and inflorescence/plant, revealed the influence of environment on genetic parameters. Non significant gca x env. and significant sca x env. for pods/inflorescence, indicated that the non-additive effects were more influenced by environment than the additive effects, controlling this traits (Khanam *et al* 2000). Keeping in view, the result obtained in two environments for flowers/inflorescence, no significant interaction of heterogeneity between combining ability was observed. Most of the genotype for all the characters are selected on the basis of significant value except flowering date. It is selected by negative value because it indicates the general capacity of early parent to transmit its behaviour to progenies in cross combinations with other parents. Analysis of gca effects (Table 3) showed that KBS 1 and DS-167 emerged as the best general combiners for early flowering in both environments and DS-52 and DS-112 were the best combiners of lateness. Occasionally, late flowering and late fruiting into the season may also be considered desired characteristics, though not as much as earliness. These genotype may be used in breeding for early or late flowering behaviour. The estimation of sca effect in environment-1 (Table 3) revealed that KBS-1 x DS-161 that was the best specific cross, combining good and moderate parents followed by DS-106 X DS-112, in which cross combination of both parents were poor combiner for earliness. These two best specific crosses for earliness exchanged their position in environment-2. The latter cross was the best in environment-2, while DS-106 and DS-112 were by far the two best general combiners for flowers/ inflorescence and pods/inflorescence for environment-1 and environment-2, respectively. For both the characters, the highest sca effect was recorded from the cross DS-52 x DS-167, in both the environmental conditions. Interestingly, both of the parents in this cross were poor general combiner for flowers/ inflorescence. In pods/ inflorescence out of 15 crosses, 5 crosses KBS-1 x DS-161, DS-52 x DS-167, DS-106 x DS-112, DS-112 x DS-161 and DS-161 x DS-167 showed highest performance for pods/inflorescence. These crosses could be utilized for exploiting non-additive gene action for pod characters in further breeding programme. In case of inflorescence/ plant the best parents were DS-52 in environment-1 and DS-161 in environment-2, followed by DS-106 in both the environments. As regard sca effect, KBS-1x DS-106 and DS-106 x

Table 2
ANOVA (ms) for combining ability in two environments and their interaction for flower character in bean

Item	df	Flowering date	Flowers/inflorescence	Inflorescence/plant	Pods/plant
Environment 1					
gca	5	277.640***	6.86***	747.97***	5.17***
sca	15	89.950***	2.14***	82.27	1.73***
Error	80	10.560	0.44	109.20	0.30
Environment 2					
gca	5	647.410***	7.91***	296.94***	6.69***
sca	15	84.320***	1.20***	67.43	1.45***
Error	80	4.060	0.67	53.57	0.60
Item x *env. interaction*					
gca x env.	5	91.030***	0.68	307.63**	0.58
sca x env.	15	21.670***	0.56	37.58	1.03
pooled error	160	7.314	0.55	81.38	0.45

*,p<0.05; **,p<0.01; ***,p<0.001

Table 3

General and specific combining ability effects on flower character in *Lablab purpureus* bean

Genotype	Parameter	General combining ability		Specific combining ability											
				KBS-1		DS-52		DS-106		DS-112		DS-161		DS-167	
		E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2
KBS-1	Flowering	- 7.23***	- 11.74***	-	-	-	-	-	-	-	-	-	-	-	-
DS-52	date	6.95***	7.38***	- 0.05	0.25	-	-	-	-	-	-	-	-	-	-
DS-106		4.75***	2.83***	1.27***	0.45	- 0.34	- 0.09	-	-	-	-	-	-	-	-
DS-112		3.07***	12.08***	0.86*	1.34***	0.54	0.36	- 0.62	0.17	-	-	-	-	-	-
DS-161		- 1.27	- 4.17***	- 0.80*	0.54	- 0.21	- 0.23	1.54***	1.49***	- 1.07**	- 0.77*	-	-	-	-
DS-167		- 6.27***	- 6.39***	- 0.30	0.20	- 0.03	0.78*	- 0.28	0.29	- 0.18	0.03	0.57*	- 0.47	-	-
KBS-1	Flowers/	- 0.58***	- 0.88***	-	-	-	-	-	-	-	-	-	-	-	-
DS-52	inflorescence	0.13	- 0.52*	0.21	1.01	-	-	-	-	-	-	-	-	-	-
DS-106		1.03***	1.11***	0.88	0.03	- 1.23*	- 0.35	-	-	-	-	-	-	-	-
DS-112		0.98***	1.34***	- 0.48	- 0.25	0.23	0.57	- 2.08***	- 1.00	-	-	-	-	-	-
DS-161		- 0.18	- 0.12	- 1.04*	0.70	0.23	- 0.06	0.07	0.07	- 1.84***	- 0.95	-	-	-	-
DS-167		- 1.37***	- 0.93***	1.01*	0.53	2.06***	1.85**	0.53	0.76	- 1.17*	- 1.62**	1.19*	- 0.81	-	-
KBS-1	Inflorescence/	2.72	- 1.99	-	-	-	-	-	-	-	-	-	-	-	-
DS-52	plant	12.14***	- 2.07	6.85	0.15	-	-	-	-	-	-	-	-	-	-
DS-106		- 0.73	5.43*	19.12*	5.05	3.70	- 7.07	-	-	-	-	-	-	-	-
DS-112		4.79	2.36	- 1.00	0.93	7.77	6.60	- 6.15	- 1.30	-	-	-	-	-	-
DS-161		- 2.03	6.36**	- 4.78	10.33	- 6.40	5.00	7.27	14.30**	- 6.25	- 6.62	-	-	-	-
DS-167		- 16.88***	- 10.09***	- 6.73	4.58	10.25	9.25	- 1.28	- 3.45	4.5	5.63	11.42	- 0.97	-	-
KBS-1	Pods/	- 0.65***	- 0.81**	-	-	-	-	-	-	-	-	-	-	-	-
DS-52	inflorescence	- 0.03	- 0.65*	- 0.20	1.22*	-	-	-	-	-	-	-	-	-	-
DS-106		0.91***	1.02**	0.68	- 0.06	- 2.9	0.34	-	-	-	-	-	-	-	-
DS-112		0.90***	1.27***	- 0.27	- 0.27	0.77	- 0.63	- 1.53***	- 0.89	-	-	-	-	-	-
DS-161		- 0.05	- 0.16	- 0.84*	0.23	0.79	- 0.35	0.59	0.71	- 2.04***	- 0.62	-	-	-	-
DS-167		- 1.083***	- 0.66**	0.47	0.67	1.94***	2.05***	- 0.26	1.33*	- 0.53	- 1.22*	0.92*	- 1.56**	-	-

*,p<0.05; **,p<0.01; ***,p<0.001

DS-161 were the best cross combinations in both environments. The parent combination of these crosses was average x poor and good x good combiners. The importance of DS-106 and DS-161, was already indicated as good general combiner for inflorescence/plant as well. D measures only additive effect, H_1 and H_2 measure only dominance effect. Excess dominant allele was present in the parent of flowering date, flowers/inflorescence and pods/inflorescence (Table 4), because their F value was positively significant and excess recessive allele was present in inflorescence/plant. For all the characters, differences between parents and crosses were present which is measured by h^2 value. Degree of dominance was measured by $[(H_1/D)/4]^{1/2}$ parameter. Complete dominance was observed in flowering date for environment-2, flowers/ inflorescence for environment-1 and pods/ inflorescence for both environments due to the $[(H_1/D)/4]^{1/2}$ value which was equal to unity. Partial dominance was found for flowers/ inflorescence in environment-2 and for inflorescence/plant in both environments and over dominance was reported for flowering date in environment-1 and Khanam (1999) also reported the similar result. All traits were governed by asymmetrical distribution of positive and negative alleles as $H_2/4H_1$ values were smaller than 0.25. The dominant and recessive genes were equally distributed in flowering date for both environments and inflorescence/plant in environment-1because $[(4DH_1)^{1/2}+F]/[4DH_1)^{1/2}-F)]$ value was greater than one. Those genes were unequally distributed in flowers/ inflorescences and pods/ inflorescences for both environments and inflorescence/plant in environment-2 due to $[(4DH_1)^{1/2}+F]/[4DH_1)^{1/2}-F)]$ value which was less than unity. One or two gene groups were involved in all traits which are governed by h^2/H_2. High heritability was found in flowering date, flowers/ inflorescence and pods/inflorescences. Mode-rate heritability was observed in inflorescence/plant. Narrow sense heritability of 1.2 in both environments for flowers/inflorescences, must however, be treated as "Spurious" for heritability estimate cannot exceed 1. Singh and Singh (1981) and Reddy (1982) also reported high heritability for different cha-racters in *Lablab purpureus*. The characters that are gover-ned by the genetic system, predominantly of additive nature can be selected in early generation and those characters largely controlled by dominance or non-additive effects required to be selected in later generations. In the present study, number of inflorescence/plant was controlled by additive gene effects mostly and flowering date by non-additive effects largely, as suggested by the results obtained in both environments. For other character the genetic architecture appeared to have been influenced by the changes in environment.

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Table 4

Estimates of some genetic components for flower characters in bean conducted in two environments

Genetical parameter	Flowering date		Flowers/inflorescence		Inflorescence/plant		Pods/inflorescence	
	E_1	E_2	E_1	E_2	E_1	E_2	E_1	E_2
D	209.11	518.99	10.16**	8.08***	328.66***	117.96***	6.92***	6.94***
F	300.92*	686.18***	24.28***	14.44***	- 80.54	- 49.57	15.04***	13.47**
H_1	1309.28***	1497.22***	34.86***	2.16*	- 620.64**	5.18	26.82***	17.69
H_2	1058.09***	1072.13***	19.66***	5.71	- 299.63	136.38	18.68***	9.84
h^2	21848***	15659.85***	284.15***	290.87***	7127.0***	2675.6***	107.19***	115.6***
E	11.84	4.03	0.43	0.68	108.03	53.79	0.29	0.61
$[(H_1/D)/4]^{1/2}$	1.25	0.85	0.93	0.61	- 0.69	0.105	0.98	0.80
$\frac{H_2}{4H_1}$	0.20	0.18	0.14	0.12	0.12	6.58	0.17	0.14
$\frac{(4DH_1)^{1/2}/4+F/2}{(4DH_1)^{1/2}/4-F/2}$	3.71	8.03	- 7.89	- 5.37	1.43	- 0.34	- 20.19	- 10.29
$\frac{h^2}{H_2}$	20.65	14.61	14.45	50.95	- 23.79	19.62	5.74	11.76
h^2n (narrow sense heritability)	0.48	0.92	1.20	1.20	0.51	0.33	0.95	0.98
h^2b (broad sense heritability)	0.89	0.97	0.80	0.59	0.33	0.40	0.84	0.65

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