

## PROGENY TEST FOR THE "ESAL 501" x "A 354" COMMON BEAN (*Phaseolus vulgaris* L.) HYBRID AT DIFFERENT LOCATIONS\*

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### ABSTRACT

A progeny test for grain yield was carried out on the F<sub>7</sub> and F<sub>8</sub> generations of the "ESAL 501" x "A 354" common bean (*Phaseolus vulgaris* L.) population planted in July 1988 and February 1989, respectively, in Lavras and Patos de Minas. The experimental design consisted of a 12 x 12 triple lattice, with a plot consisting of a 3-meter row, with 15 seeds per meter. The progenies presented wide variability and potential for grain yield, confirming the good combining ability of the parents. Progeny behavior differed between locations, a fact emphasizing the need to evaluate the material at sites and during seasons that are representative for the region where the improved cultivar is to be used. The interactions also demonstrated that the selection process should be initiated only after these trials and should be based on mean progeny performance at the various locations. The heritability obtained by progeny genetic covariance in July 1988 was similar to that observed for the progenies in February 1989. The same was observed for gain expected by selection in relation to observed gain, emphasizing the importance of obtaining these estimates.

### INTRODUCTION

One of the major problems faced by plant breeders is genotype x environment interaction which is due to differential behavior of genetic materials in different

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environments. The term environment is used broadly to indicate factors such as location, planting time, fertilizers, and pathogens.

The alternatives available to overcome the problem vary according to the crop and environmental effect involved. Thus, in certain limited situations it is possible to identify a specific cultivar for each environmental condition. In this case, breeders will capitalize on the favorable effect of interaction. Unfortunately, this strategy cannot be used for most crops and environmental effects involved, as is the case for the common bean which is a plant with a short cycle and utilized by farmers under many different conditions and using various types of agricultural technology.

The presence of interaction not only impairs the selection process but also affects the estimates of genetic parameters (Allard, 1971; Moll and Stuber, 1974). This obviously hampers the inferences to be made, especially in terms of the response expected with selection and specifically when a material is tested in a given situation and recommendations must be extrapolated to other conditions. The occurrence of interaction and its quantification have been studied in several trials conducted on common beans, involving both cultivar testing (Santos, 1980; Monteiro *et al.*, 1982; Santos *et al.*, 1982; Pacova *et al.*, 1987; Righetto *et al.*, 1990) and progeny testing (Abreu, 1989; Resende, 1989; Abreu *et al.*, 1990b). Although information is available on the occurrence of interaction, very little is known about its effect on the efficiency of the selective process.

Thus, the present study was undertaken with the objective not only of quantifying progeny interaction with locations and planting times, but also of determining the effect of these interaction on the result of selection performed on progenies obtained from the "ESAL 501" x "A354" common bean hybrid.

## MATERIAL AND METHODS

In a partial diallel cross performed by Ramalho *et al.* (1988) with nine common bean cultivars, particularly outstanding was the segregant population originating from "ESAL 501" x "A354". The ESAL 501 cultivar was obtained at "Escola Superior de Agricultura de Lavras" from the "Carioca" x "Cornell 49-242" hybrid, has cream-colored seeds with light brown stripes and yellow halo - "Carioca"-type seed - and its growth habit is type III (Ramalho and Santos, 1986). Cultivar A354 was obtained at "Centro Internacional de Agricultura Tropical" (International Center of Tropical Agriculture - CIAT), has light brown seeds and also type III growth. Cultivar 501 was crossed with A354 in 1984 according to the methodology proposed by Vieira (1967). The population obtained was taken to the F<sub>5</sub> generation by the mass method, and 144 plants with seeds of the "Carioca" type were chosen from this generation.

Each of these plants represented a progeny whose seeds were multiplied in the F<sub>6</sub> generation.

In generations F<sub>7</sub> and F<sub>8</sub>, the plants were tested in experiments with replications and planted in July 1988 and February 1989, respectively, at Lavras and Patos de Minas. The experimental design used in all cases was a 12 x 12 triple lattice with plots consisting of one 3-meter row, spaced 0.50 m apart, and with 15 seeds sown per meter.

Grain yield (kg/ha) data were first analyzed by analysis of variance per trial and then submitted to several joint analyses of variance involving locations, planting times and locations plus planting times. In all of these analyses, variance components were estimated by mean squares expectations, considering progeny effects to be random and environmental effects (locations and planting times) as fixed, according to the methodology of Steel and Torrie (1980). Since the genetic variance for the F<sub>7</sub> and F<sub>8</sub> progenies was practically identical (Ramalho and Vencovsky, 1978), because most loci are in homozygosis in these two generations, the generation effect was not considered, whereas planting time effect was. Progeny x environment interactions were partitioned into two components, one (A) due to the difference in variability in the two environments, and the other (B) due to the lack of correlation between progeny means in the two environments (see Vencovsky, 1987). The genetic parameters were estimated following Takeda (1990).

## RESULTS AND DISCUSSION

Mean productivity varied between trials (Tables I and II). It can be seen that productivity and the amplitude of variation between progenies were higher for the winter crop (7,88). Also experimental precision, evaluated by the coefficient of variation, was similar and of a magnitude comparable to that normally obtained in bean trials in the region (Ramalho *et al.*, 1979a,b, 1988; Santos and Ramalho, 1990).

Table I - Mean grain yield, amplitude of progeny variation, mean square error (MS error) and coefficient of variation (CV%) for each trial.

Trial	Mean (kg/ha)	Amplitude (kg/ha)	MSerror x 10 <sup>4</sup>	CV%
Lavras07/88	2,669	2,747	35.926	22.46
Lavras02/89	1,881	1,579	24.466	26.29
Patos07/88	1,646	2,356	23.916	29.72
Patos02/89	1,185	1,309	7.668	23.36

Table II - Summary of joint analyses of variance of grain yield (kg/ha) obtained from progeny testing in four environments at the plot level.

Source of variation	d.f.	Mean square $\times 10^5$
Progenies (P)	143	4.488*
Trials (T)	(3)	1663.791*
Planting times (S)	1	1682.088*
Locations (L)	1	3193.581*
S x L	1	115.706*
P x T	(429)	3.553*
P x S	143	3.884*
P x L	143	3.040*
P x S x L	143	3.734*
Mean error	1012	2.299
Mean(kg/ha)		1845.41
C.V. (%)		19.12

\* Significant at the 1% level (F test).

There was a highly significant difference between progenies (Table II). Mean yield, regardless of location and year, was 1845 kg/ha, ranging from 1351 to 2366 kg/ha, demonstrating the good performance of the progenies. This was expected on the basis of the results obtained when the diallel cross performed by Ramalho *et al.* (1988) was evaluated. Also, the data showed the existence of variation between the materials tested, indicating that selection would be successful.

Progeny x location and progeny x planting time interactions were also highly significant, a fact commonly observed in bean progeny trials (Abreu, 1989; Resende, 1989; Abreu *et al.*, 1990b). The estimates of the different interactions and their partitioning into components A and B in the analyses involving environments compared two by two, are presented in Table III. It can be seen that the genetic correlations were low, especially with respect to mean progeny performance at the two planting times x location or even with respect to mean performance at the two locations. These results, as expected, reflected on the predominance of interaction component B. As pointed out by Vencovsky (1987), this is the most difficult factor to be handled by breeders because it is due to a lack of coincidence in progeny behavior in the environments tested. Thus, it is unlikely that a material with good performance under all of the various conditions will be obtained.

Table III - Estimates of progeny x environment interactions with the respective proportions (%) of components A and B and of the genetic correlations involved (r).

Interactions	Estimates	Components		r
		A%	B%	
Progeny x trial	31334.85	17	83	-
Progeny x location	6169.81	4	96	0.50
Progeny x location, July 1988	21462.78	40	60	0.43
Progeny x location, February 1989	14793.48	7	93	0.20
Progeny x planting time	13206.72	6	94	0.17
Progeny x planting time, Lavras	35819.80	20	80	-0.13
Progeny x planting time, Patos de Minas	14510.80	11	89	0.16
Progeny x location x time	11958.32	-	-	-

Genetic and phenotypic variance estimates are presented in Table IV. There was wide variation among progenies and progeny genetic variances were higher than genetic covariances. This was due to the fact that genetic variance estimates contain progeny x environment interactions (locations and planting times), whereas the covariances are free from these interactions.

The estimates of progeny x environment interaction presented in Table III in general were higher than the genetic progeny covariances, showing that the divergence in progeny behavior from one environment to the other was greater than the genetic variation between progenies. For example, 48% of the genetic variance for progenies from the July 1988 planting was due to genetic differences, whereas 52% was due to the divergence in progeny behavior between locations. An extreme case was observed in Lavras, where the discordance in behavior between planting times corresponded to the total variance observed between progenies at this location, showing the importance of also testing at different planting times and not only at different locations, as pointed out by Abreu *et al.* (1990b) and Righetto *et al.* (1990).

Heritability at the mean progeny level was estimated from genetic covariance of mean F7 progeny performance at the two locations (Table V). Since in generation F7 genetic variance is almost fully additive (Ramalho and Vencovsky, 1978), this estimate corresponds to narrow-sense heritability. In the present case it was also possible to estimate realized heritability from the simulation of expected and observed gain for generation F8, considering the selection of the 15 best F7 progenies. The result

was practically identical to the estimated one, reinforcing the importance of obtaining the heritability estimate. The estimate of observed gain (5.59%) was of a magnitude similar to that reported in the literature for bean progeny trials (Ramalho *et al.*, 1979; Nienhuis and Singh, 1988; Abreu, 1989).

Table IV - Estimates of genetic and phenotypic variance components in relation to grain yield (kg/ha).

Components	Estimates
Mean progeny variance	18,238.97
Mean progeny covariance	7,794.02
Progeny covariance between times	5,032.25
Progeny covariance between locations	12,069.16
Mean phenotypic variance	37,400.80
Mean progeny variance in Lavras	29,290.54
Progeny covariance between times in Lavras	-6,528.73
Mean phenotypic variance in Lavras	79,617.41
Mean progeny variance in Patos de Minas	19,527.03
Progeny covariance between times in Patos de Minas	5,016.23
Mean phenotypic variance in Patos de Minas	45,847.45
Mean progeny variance in July 1988	41,346.11
Progeny covariance between locations in July 1988	19,883.32
Mean phenotypic variance in July 1988	91,215.16
Mean progeny variance in February 1989	21,545.28
Progeny covariance between locations, in February 1989	6,751.80
Mean phenotypic variance in February 1989	48,323.52

Table V - Heritability estimates and gains expected and realized with selection.

Parameters	Estimates
Expected heritability	21.80%
Gain expected with selection	113.24 kg/ha (5.25%)
Observed heritability	23.23%
Gain observed with selection	85.79 kg/ha (5.59%)

The most important feature of the present study resides in the implications of the interactions in terms of the result of selection. Table VI presents the number of progenies that would coincide by the selection of 15 progenies (10% selection intensity) in the various environments. For example, in Patos de Minas there was coincidence of only one progeny between testing times, and in Lavras there was no coincidence at all. When locations are considered, regardless of planting times, four progenies coincided, whereas only two progenies coincided between times, regardless of locations. These results are coherent with the interaction estimates obtained. Since progeny x time interaction was more marked than progeny x location interaction (Table III), the coincidence of the result with selection was lower.

Table VI - Number of progenies coinciding in two environments, considering the 15 most productive progenies in each environment.

	L8	P7	P8	L	P	7	8	G
L7	0	2	-	7	4	9	0	6
L8		-	2	8	1	2	8	6
P7			1	4	7	7	1	6
P8				2	7	2	8	5
L					4	-	-	9
P						-	-	10
7							2	11
8								6

L7 and L8, plantings in July 1988 and February 1989, respectively, in Lavras.

P7 and P8, plantings in July 1988 and February 1989, respectively, in Patos de Minas.

L and P, Lavras and Patos de Minas, respectively.

7 and 8, plantings in July 1988 and February 1989, respectively.

G, Mean of four trials.

When location mean was considered, coincidence was always higher than 33% of the progenies. These results confirm observations by Rosielle and Hamblim (1981) who suggested that, to minimize genotype x environment interaction, selection should be performed as a function of mean performance in the various environments. With this procedure, gain, although lower for a given environment, will be much higher on average.

From these results we conclude that selection should be performed only after testing progenies in different environments, at different locations and planting times. The procedure usually adopted, i.e., progeny testing in large numbers during the initial generations and at few locations and drastic reduction of progenies to be tested in later stages, may contribute to low selection efficiency, as demonstrated by the present results. Selection intensity can, and should, be strong to obtain expressive gains with selection, but this only applies when the material has been extensively tested, which is not the case for some bean progeny selection studies (Abreu *et al.*, 1990a,b).

## RESUMO

As progênies de feijoeiro da população "ESAL 501" x "A 354" foram avaliadas, quanto a produtividade de grãos, nas gerações F<sub>7</sub> e F<sub>8</sub> (com semeaduras em julho de 1988 e fevereiro de 1989, respectivamente), em Lavras e Patos de Minas. O delineamento experimental utilizado foi um látice triplo 12 x 12, e a parcela foi constituída de uma linha de 3 metros, sendo semeado 15 sementes por metro. Os resultados mostraram que as progênies apresentaram ampla variabilidade e potencial para produção de grãos, confirmando a boa capacidade de combinação dos progenitores. O comportamento das progênies não foi concordante entre os ambientes, realçando a necessidade de suas avaliações serem efetuadas em locais e épocas representativos da região para onde se pretende obter o cultivar melhorado. As interações evidenciaram também que somente após essas avaliações é que deve ser iniciado o processo de seleção, o qual deve ser realizado em função do desempenho médio das progênies nos vários ambientes. A herdabilidade obtida através da covariância genética das progênies em julho/88 foi semelhante a herdabilidade observada nas progênies em fevereiro/89, e o mesmo foi verificado com o ganho esperado com a seleção em relação ao ganho observado, salientando a importância de obter essas estimativas.

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