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EFFECT OF GENOTYPE x ENVIRONMENT INTERACTION ON ESTIMATIONS OF GENETIC AND PHENOTYPIC PARAMETERS OF COMMON BEANS *

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ABSTRACT

Genotype x environment interaction effects on estimations of genotypic and phenotypic parameters were studied, based on seed yield of 97 progenies and three test cultivars of common beans at two different locations in Minas Gerais, Brazil. At one location, Patos de Minas, F_7 progenies and test cultivars were evaluated using a simple 10 x 10 lattice design, whereas F_8 progenies and test cultivars planted at Sete Lagoas at two density rates comprised two independent experiments with the same statistical design as the former. Results indicated the need to evaluate bean progenies at several environments. This was supported by the fact that the narrow sense heritability value, estimated through covariance analysis, was similar to the realized heritability value, and the genetic expected gain estimate was practically equal to the realized gain estimate. Also, selection effectiveness based on the mean over environments, was three times greater than when based on each individual environment.

INTRODUCTION

In Brazil, common beans are grown under quite diverse conditions both in terms of soil and planting systems. On this basis, genotype x environment interaction becomes a very important factor in breeding programs since the existence of interac-

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tion implies the recommendation of cultivars for certain environments or the search for genetic materials that are less affected by environmental variation (Santos, 1980).

Interaction also affects the estimation of genetic parameters and consequently the gain expected through selection. In the specific case of common beans, the information available in the literature about the major gene actions involved in the control of seed yield is still scarce and often discordant, probably owing to the fact that interaction is not taken into consideration when estimates are calculated. It has been shown that when cultivars are tested under conditions of greater plant competition at density rates similar to those used for crop planting, additive variance is the main component of genetic variance (Quiñones, 1969; Hamblin and Evans, 1976; Hamblin and Morton, 1977; Santos *et al.*, 1985). In contrast, when cultivars are planted at lower density rates with lower plant competition, manifestation of dominance has been observed for seed yield (Chung and Stevenson, 1973; Albuquerque and Vieira, 1974; Hamblin and Morton, 1977; Sarafi, 1978; Foolad and Bassiri, 1983).

For common beans, major emphasis has been placed only on the identification of more stable material obtained in trials involving different cultivars (Santos, 1980; Beaver *et al.*, 1985; Pacova *et al.*, 1987; Park, 1987), with few studies on the effect of interaction on the response to selection. Thus, the objective of the present investigation was to test bean progenies at different locations, times and density rates to quantify progeny x environment interaction and to determine its effect on the estimations of genetic and phenotypic parameters to be used in breeding programs.

MATERIAL AND METHODS

The progenies used in the present study were obtained from crosses between Rio Tibagi and Carioca 80. The Rio Tibagi cultivar, of type II growth habit, is a straight-standing plant with small black seeds and is susceptible to anthracnose, while Carioca 80 is of type III growth habit, is prostrate, has cream-colored seeds with brown stripes and is resistant to anthracnose.

Carioca 80 and Rio Tibagi were crossed in 1984 according to the method proposed by Vieira (1967) and the population obtained was taken to the F_5 generation by the mass method. Two thousand seeds of this generation (F_6) were planted, all of them having seeds of the Carioca 80 type. Of the progenies obtained, 97 showing straighter stand were selected and tested for seed production together with three test cultivars (Carioca 80, Rio Tibagi and Carioca 1030) in the F_7 and F_8 generations. The F_7 generation was tested in Patos de Minas in February 1987 using a simple 10 x 10 lattice design. Each plot consisted of a 2-meter line planted with 15 seeds per linear meter. Plots were spaced 0.5 m apart. The F_8 generation was planted at two density rates, 8 and 16 plants per meter, at Sete Lagoas, MG, in two independent experiments, also using a simple 10 x 10 lattice design. Plots consisted of a 4-meter line and were spaced 0.5 m apart.

Data were analyzed by separate and joint analysis of variance considering the two densities and the two generations. Estimations of genetic and phenotypic variance components were obtained according to the scheme proposed by Vencovsky (1987). Selection efficiency (SE) was estimated by the following expression, proposed by Hamblin and Zimmermann (1986):

$$SE = [(A-C)/(B-C)] . 100$$

where:

A: number of selected progenies common to the two selection generations;
B: total number of progenie selected;
C: number of progenies common to the two generations expected to occur strictly at random, and considered to be 10% of B in this specific case.

Realized heritability and realized gain through selection were also obtained as suggested by Fehr (1987).

RESULTS AND DISCUSSION

It should be pointed out that, in the present paper, the generation effect refers to environmental factors such as planting time and location since generations were grown at different times and locations. The generation effect itself should be nonsignificant because in generations F_7 and F_8 the material is already practically pure. Even in populations in the initial stages of segregation such as F_2 and F_3, no interaction occurs with generation (Ramalho *et al.*, 1988) as long as generations are tested at the same planting time and location.

Progeny performance was good in generation F_7, with mean yields of 1812 kg/ha and a range of variation of 816 to 2687 kg/ha, thus indicating the productive potential of some progeny and the possibility of successful selection. In generation F_8, mean yield was 1708 kg/ha at both density rates, with 16% of the progenies performing better than the test cultivars.

Joint analysis of variance for the F_8 progenies at both density rates showed significant progeny, density and within-progeny density effects (Table I). Progeny x density rate interaction was not significant, showing that the material behaved similarly at both density rates. This absence of significant interaction was probably due to the fact that the progenies tested had been previously selected for type of stand. Indeed, Nienhuis and Singh (1985) and Westermann and Crothers (1977) reported that the effect of plant density depends on the type of growth of the cultivar used, *i.e.*, cultivars of determinate growth suffer less competition at higher densities than plants of indeterminate growth.

Table I - Joint analysis of variance for seed yield data (kg/ha) obtained in trials of the F_8 progenies of the Carioca 80 x Rio Tibagi cross. Sete Lagoas, MG, 1987.

FV	d.f.	MS
Progenies and test cultivars (P and T)	(99)	94081.5350**
Progenies (P)	96	93660.9075**
Test cultivars (T)	2	6177.6650
P vs T	1	310269.5750*
(P and T) x D	(99)	61953.8000
D/P	1	391180.2250**
D/T	1	67963.2175
P x D	96	63262.3500
T x D	2	19105.0725
Effective mean error	162	56810.9550
P mean (kg/ha)		1709.50
T mean (kg/ha)		1938.71
CV (%)		13.89

* and **, F test significant at the 5 and 1% level, respectively.

Joint analysis of variance for F_7 and F_8 progenies showed significant progeny, environment and progeny x environment interaction effects (Table II). The variance component of progeny x environment interaction was also found to be approximately double the genetic covariance between progenies at the two locations (Table III), reflecting the true genetic variance between progenies regardless of the environments where they were tested. The main implication of an interaction of this magnitude is that it reflects directly on the response to selection. Thus, when the 20 best progenies were selected from the average for the two sites there was coincidence of 12 progenies at Patos and of an equal number at Sete Lagoas, whereas if selection had been applied at Patos, only five progenies would have also been among the best ones tested at Sete Lagoas (Table IV). By applying Hamblin and Zimmermann's expression (1986), this corresponds to a mean selection efficiency of 55.6%, *i.e.,* approximately three times that obtained if selection had been applied in one environment and gain had been observed in another (only 16.7%). Thus, in this situation the best criterion for progeny selection is mean progeny performance under different environmental conditions, as proposed by Rosielle and Hamblin (1981).

Table II - Joint analysis of variance for seed yield data (kg/ha) obtained in trials of the F_7 and F_8 progenies of the Carioca 80 x Rio Tibagi cross. Patos de Minas and Sete Lagoas, MG, 1987.

FV	d.f.	MS
Progenies (P)	96	97007.5332**
Generations = environments (E)	1	513590.0600**
P x E	96	70301.7177**
Effective mean error	324	43567.6288
Mean (kg/ha)		1760.90
CV (%)		11.85

**, F test significant at the 1% level.

Table III - Estimates of genetic and phenotypic parameters for mean seed yield (kg/ha) obtained in progeny test trials for the Carioca 80 x Rio Tibagi cross.

Genetic and Phenotypic Parameters	Estimates
Genetic variance among F_7 progenies	61601.3200
Genetic variance among F_8 progenies	18424.9763
Genetic covariance among F_8 progenies at planting densities of 8 and 16 plants per meter	15199.2738
Genetic variance among progenies	26719.9522
Genetic variance among progenies at the two locations	13352.9077
Variance of progeny x environment interaction	26734.0889
Mean phenotypic variance of F_7 progenies	120331.0950
Heritability (%)	11.10
Realized heritability (%)	17.39
Expected gain with selection (%)	3.15
Realized gain with selection (%)	4.94

Table IV - Mean seed yield (kg/ha) of the twenty best progenies at each location and within the location mean.

Patos de Minas		Sete Lagoas		Mean	
Progeny	Yield	Progeny	Yield	Progeny	Yield
6	2333	31	2031	6[1]	2094
11	2333	68	1962	11[1]	2037
17	2143	70	1964	31[2]	2078
69	2163	84	1903	60	1951
70	2687	93	1961	70[1,2]	2326
84	2154	125	2033	84[1,2]	2029
87	2295	148	2113	93[2]	1948
118	2207	204	1982	118[1]	2036
123	2233	208	2039	148[2]	1901
128	2244	221	1963	193[1]	2068
193	2335	227	1969	208[2]	1885
221	2532	240	1955	221[1,2]	2248
227	2367	286	2142	227[1,2]	2168
239	2158	303	1946	239[1]	2005
299	2178	323	2148	286[2]	1993
303	2171	358	1967	303[1,2]	2059
309	2214	446	1910	323[2]	1986
338	2442	458	1911	338[1]	2075
476	2146	484	2048	458[2]	1774
481	2194	485	1938	481[1]	2040

[1] and [2], Progeny selected at Patos de Minas and Sete Lagoas, respectively.

Progeny x planting density interaction, although not significant played a considerable role in the estimate of genetic variance components. This was confirmed by comparing the estimation of genetic variance among F_8 progenies obtained via variance components, in which the F_8 progeny x planting density interaction is contained, with the same estimate obtained by the covariance between F_8 progenies at the densities of 8 and 16 plants per meter (Table III), which directly reflects genetic variance, because no covariance exists between errors. It can be seen that the interaction overestimated genetic variance, and consequently the gain obtained by selection would also be overestimated if the effect of this interaction were not eliminated.

Heritability estimates (h^2) were obtained from genetic covariance between progenies in the two environments since, as commented above, the latter directly reflects genetic variance without the presence of genotype x environment interaction. Narrow-sense heritability was similar to realized heritability (Table III) which was obtained by the gain realized with selection by simulating a selection at Patos and estimating gain at Sete Lagoas. Similarly, the gain expected through selection was practically identical to realized gain, further supporting the fact that estimation of genetic parameters through variance components, with care taken to reduce the effects of genotype x environment interaction, is a powerful tool in the development of breeding programs.

RESUMO

Com o objetivo de verificar a influência da interação genótipo por ambiente na estimativa de parâmetros genéticos e fenotípicos no feijoeiro foram avaliadas 97 progênies provenientes do cruzamento entre as cultivares Carioca 80 e Rio Tibagi, juntamente com três testemunhas ("Carioca 80", "Rio Tibagi" e "Carioca 1030"), quanto a produtividade de grãos, nas gerações F_7 e F_8. Na geração F_7 a avaliação foi realizada em Patos de Minas no delineamento látice simples 10 x 10. Na geraçäo F_8 o plantio foi efetuado em Sete Lagoas, empregando-se duas densidades de semeadura, 8 e 16 plantas por metro. Cada densidade constituiu um experimento para o qual adotou-se o delineamento látice simples 10 x 10. Os resultados obtidos permitiram verificar a necessidade das avaliações de progênies serem efetuadas em vários ambientes. Tanto foi assim que a herdabilidade no sentido restrito, obtida via covariância entre as progênies nos dois ambientes foi semelhante a herdabilidade realizada, assim como o ganho esperado com a seleção foi praticamente igual ao ganho realizado. Também a eficiência da seleção baseada na média dos ambientes foi cerca de três vezes maior do que quando se considerou cada ambiente particular.

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