Adaptability and phenotypic stability in early common bean cultivars and lines

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ABSTRACT

This study aimed at estimating the genetic variability for earliness in five common bean cultivars and nine lines. The adaptability and phenotypic stability for grain yield was also assessed using the methodology proposed by Eberhart and Russell (1966). An experiment in randomized complete blocks was carried out in three locations in the wet 2001/2002 growing season and in two locations in the 2002 dry growing season. The estimates of the coefficients of genetic variation (CVg) and environmental variation (CVe), the B index and the coefficient of genetic determination (h^2) showed the presence of genetic variability among the cultivars and lines assessed for the traits number of days from emergence to the appearance of the first flower (DPF) and number of days from emergence to the date of physiological maturity (DMF). The adaptability and phenotypic stability estimates showed that there was generally wide adaptability and stable performance of the cultivars and lines in the different environments. The Alúbia, Baronesa and Carnaval Pitoco cultivars and the LP-20-89 and LP20-90 lines were promising, with high yield, wide adaptablity (β_{1i}=1) and good stability (σ^2_{di}=0).

KEY WORDS: *Phaseolus vulgaris*, earliness, phenotypic stability.

INTRODUCTION

Brazil annually crops around 4.184.800 hectares of common bean (Phaseolus vulgaris L.) with a yield of about 3.010.400 tons (Conab, 2002) and occupies an outstanding position on the international scene as one of the greatest world producers of common bean. Brazil is also one of the largest world consumers of beans with a per capita consumption of around 15.6 kg per person per year, and bean grains are an important source of protein in the Brazilian diet.

Common bean cultivation probably has the shortest cycle among other crops used for basic food consumption. Nevertheless, the search for early cultivars has been the objective of many breeding programs. The search for cultivars that complete the cycle in about 65 to 70 days is important because of its advantages, such as escape from climatic stress and disease occurrence, a harvest that coincides with the less rainy season, reduced harvest losses, lower water consumption and soil use time when in irrigated and intensive cultivation. It also favors crop rotation and permits the product to be marketed early, with higher prices because of lower competition offer. In the traditional cultivation system, the early cultivars enabled wet season bean sowing in the period indicated for the region, for harvesting within 70 days and allowed the cultivation of another summer crop. Crop exposure to the risk of frost is also avoided with early bean plant sowing.

Control of the type of genetic action involved and the coefficient of genetic determination of the earliness trait help the breeder to conduct the breeding programs to obtain early cultivars. Although it presents a high coefficient of genotypic determination, the trait is heavily influenced by environmental factors such as photoperiod and temperature. Photoperiod and temperature interactions with plant development have been widely reported (Wallace et al., 1991, 1993,1995; Yan and Wallace, 1995, 1998).

The number of days from emergence to flowering has been the most used by researchers of the characteristics associated with earliness (Coyne, 1978; Padda and Munger, 1969; Wallace and Enriquez, 1980). Another characteristic related to earliness is the period between emergence and the physiological maturity of the seeds. Bora et al. (1998); Mohanty and Baisakh (1999) reported the influence of the genotype x environment interaction on these earliness-related characteristics.

Bean plant cultivation can be carried out in almost all the Brazilian territory, at different periods and growing seasons and under quite varied edafoclimatic conditions. This makes the genotypes perform differently under various environmental conditions that reflect directly on their agronomic performance. Therefore, in early materials, besides high grain yield and good consumer acceptance of the grains, cultivars are sought with predictable performance and that respond to the stimulus from the environment, as they are sensitive to environmental influences. The influence of the genotype x environment interaction in the phenotypic performance has been reported by Omar et al. (1999); Redden et al. (2000); Truberg and Hühn (2000). According to Omar et al. (1999) plant breeding is not carried out only to obtain high yield capacity in the genotypes, but also requires productive performance stability over many environmental conditions.

Allard and Bradshaw (1964) considered that two conditions contribute to the interaction of the genotype and the environment to which it is submitted. The first, predictable, is included the variation in the environment that occurs from location to location, within a crop distribution area. Included in this environmental condition are characteristics such as climate, soil and agricultural techniques, etc. The second condition is the unpredictable variance that includes rain frequency and distribution, air and soil temperatures and frost occurrence.

Thus the knowledge of stability and adaptability estimates becomes useful, as according to the concept adopted by Eberhart and Russell (1966), adaptability refers to the capacity of genotypes to make use of the stimulus or environment and stability refers to the capacity of the genotypes for highly predictable performance in function of the environmental stimulus.

The objective of the present study was to estimate the genetic variability for the characteristics associated with the crop cycle in early common bean cultivars and lines, and assess the adaptability and phenotypic stability of these materials to orient breeding programs to develop superior early cultivars.

MATERIAL AND METHODS

Genetic material

The characteristics related to the crop cycle were assessed and the adaptability and phenotypic stability were studied in five common bean cultivars and nine lines, developed by the IAPAR plant breeding program or introduced from other Brazilian and international research institutions or collected from farmers (Table 1). The IAPAR 81 cultivar (Moda-Cirino et al., 2001) was used as the grain yield control and the Goiano Precoce cultivar as the cycle control.

Experiment Conduction

In the 2001/2002 growing season, the experiment was set up in the Experimental Area at the IAPAR headquarters in Londrina, PR, at the Forest

Table 1. The seven cultivars and nine lines used in the present study with the respective characteristics for the seeds and origin.

Genotype	Origin	Color	Seed Shape	Degree of flattening
IAPAR 81	IAPAR	Beige with Brown stripes	Oblong/short reniforme	Half full
Goiano Precoce	EMGOPA	Cream	Eliptic	Half full
LP99–2	IAPAR	Cream with red stripes	Oblong/ short reniforme	Semi-cheia
LP99–3	IAPAR	Cream with red stripes	Oblong/medium reniforme	Full
LP99–4	IAPAR	Cream with red stripes	Oblong/medium reniforme	Full
LP20-87	IAPAR	Beige with brown stripes	Eliptic	Half full
LP20-88	IAPAR	Beige with Brown stripes	Elíptica	Half full
LP20-89	IAPAR	Beige with Brown stripes	Elíptica	Full
LP20-90	IAPAR	Beige with Brown stripes	Elíptica	Full
LP20-91	IAPAR	Beige with Brown stripes	Elíptica	Full
Carioca Precoce	Crioulo	Beige with Brown stripes	Elíptica	Half full
Carioca 1070	CENA/USP	Beige with Brown stripes	Elíptica	Half full
Carnaval Pitoco	Crioulo	Cream with red stripes	Elíptica	Full
Alúbia	CIAT	Cream with red stripes	Elíptica	Half full
Baronesa	Crioulo	Cream with red stripes	Oblong/medium reniforme	Full
G – 122	CIAT	Cream with red stripes	Oblong/medium reniforme	Half full

Experimental Station located in Irati country, PR and on a farm located in the county of Capitão Leônidas Marquês –PR. In the 2002 dry growing season, the experiment was carried out at the Irati Experimental Station, PR and at the Ponta Grossa Regional Research Station, Ponta Grossa, PR. A completely randomized block design was used with three replications and plots consisting of two 5m rows, spaced at 0.50m. The sowing density was 20 seeds per linear meter. Thinning was performed after emergence leaving 15 plants per linear meter. They were fertilized with the equivalent of 200 kg/ha NPK (4-14-8) and mulched with 200 kg/ha ammonia sulfate.

Traits assessed

In the experiment carried out in Londrina in the wet 2001/2002 growing season, twenty plants per plot were randomly labeled during the R5 development stage (CIAT, 1987) and the number of days from emergence to the appearance of the first flower (DPF) and number of days from emergence to the date of physiological maturity (DMF) were assessed following the methodology proposed by Cerna and Beaver (1990).

The assessments were made at the suitable developmental stages, in the experiments carried out in the five locations, for reaction to diseases, growth habit and plant height, using the methodology proposed by CIAT (1987). At the R9 physiological maturity stage (CIAT, 1987) the traits weight of 1000 seeds (P1000) and total grain yield per plot were assessed. The grain yield data were transformed in kg/ha corrected to 13% moisture.

Data Analysis

The assessed trait data were analyzed using the Genes program (Cruz, 1997), taking the genotype and environmental effects as fixed effects. The number of days to the start of flowering (DPF) and the number of days to physiological maturity (DMF) data were transformed to square root for statistical analyses, according to Steel and Torrie (1960).

Individual analyses of variance were carried out for each location and the homogeneity of the variances was checked by the Hartley test, which uses the ratio between the largest and smallest variance, according to Ramalho (2000). Later, joint analysis of the experiments was performed and the means of the treatments were grouped by the Scott and Knott method at 5% and 1% probability (Scott and Knott, 1974).

The genetic variation coefficient (CVg), environmental variation coefficient (CVe) and the B index were estimated for all the traits assessed, according to Vencovsky (1969). The coefficient of genotypic determination (h^2) was estimated by the ratio between the genetic and phenotypic variance, according to Cruz (1997). The phenotypic (r_F) and genotypic (r_G) correlations among the traits assessed were estimated using the Genes program (Cruz, 1997).

The adaptability and phenotypic stability were estimated by the method proposed by Eberhart and

Table 2. Means, result of the analysis of variance, estimates of the coefficient of genetic variation (CVg), coefficient of environmental variation (CVe), B indexes (CVg/CVe) and coefficient of genotypic determination (h^2), of the characteristics number of days to the first flower (DPF) and number of days to physiological maturity (DMF) assessed in seven common bean cultivars and nine lines in the experiment carried out in Londrina, wet 2001/2002 growing season.

Genotypes	DPF [1/]	DMF [2/]
IAPAR 81	35.6 a [3/]	69.6 a [3/]
Goiano Precoce	24.0 c	57.4 d
LP99–2	24.8 c	58.7 c
LP99–3	24.6 c	59.9 c
LP99–4	24.2 c	58.7 c
LP20-87	36.6 a	69.2 a
LP20-88	34.8 a	68.9 a
LP20-89	35.3 a	69.0 a
LP20-90	35.0 a	68.6 a
LP20-91	35.4 a	69.4 a
Carioca Precoce	28.8 b	62.8 b
Carioca 1070	28.9 b	63.5 b
Carnaval Pitoco	24.0 c	59.1 c
Alúbia	23.3 c	57.1 d
Baronesa	23.7 c	57.8 d
G – 122	23.7 c	57.0 d
FV		
Genotype	**	**
Residue		
CVe (%)	1.10	0.81
CVg (%)	9.39	4.16
B	8.50	5.14
h^2 (%)	99.54	98.75

[1/] number of days from emergence to the appearance of the first flower; [2/] number of days from emergence tot he date when only one or two pods remained unripe on each plant; [3/] Values followed by the same letter belong to the same group. Scott and Knott at 1%; ** significant at 1% level of probability.

Russell (1966). The significance of the regression coefficient (β_{1i} = 1) was assessed by the t test and the significance of the deviation from the regression (σ^2_{di}=0) by the F test at 5% and 1% probability, according to Cruz and Regazzi (1994).

RESULTS AND DISCUSSION

Table 2 shows that the cultivars and lines differed for crop cycle and there was a significant genotype effect for DPF and DMF at 1% probability. According to the Scott and Knott test, the treatments were clustered in three classes for DPF and the Alúbia, Baronesa and Carnaval Pitoco cultivars and the LP99-2, LP99-3, LP99-4 and G-122 lines were grouped in the same class as the control for earliness, the Goiano Precoce cultivar. The test grouped the materials in four classes for DMF and the Alúbia and Baronesa cultivars and the G-122 line were similar to the 'Goiano Precoce' control, showing, therefore, that they were early cycle. Table 2 also shows that the LP20-87, LP20-88, LP20-89, LP20-90, LP20-91 lines and the control for grain yield, IAPAR 81, presented a greater DPF and DMF than the 'Goiano Precoce' control. These later cycle lines presented an undetermined growth habit (Table 3). According to Beaver et al. (1985) the common Bean genotypes with undetermined growth habit tend to mature later. The Carioca Precoce and Carioca 1070 cultivars had DPF and DMF approximately five days after DPF and DMF of the 'Goiano Precoce' control, respectively, and around six days after those of the LP20-87, LP20-88, LP20-89, LP20-90, LP20-91 lines. Both cultivars can be considered of intermediate cycle.

The estimates of the coefficients of genetic and environmental variation and the B index (Table 2) revealed the presence of genetic variability among the cultivars and lines assessed for the DPF and DMF traits. The coefficient of genotypic determination for the DPF and DMF traits was high, 99.54% and 98.75%, respectively. These results indicate that the traits are little influenced by the environment effect. Yan and Wallace (1995, 1998) reported that these characteristics related to earliness are sensitive to photoperiod and temperature. The high values found for the estimates of the coefficient of genotypic determination and the B index suggest a favorable situation for selection.

The genotypic and phenotypic correlations obtained for the DPF and DMF traits were positive and significant, indicating a possibility of simultaneous selection for both traits.

Genotype performance

Table 3 shows that most of the cultivars and lines assessed, 62.5% of the total, presented determined growth habit. The LP20-87, LP20-88, LP20-89, LP20-90 and LP20-91 lines and the IAPAR 81 control, representing 37.5% of the total, presented type II undetermined growth habit. Regarding plant stand, 56.25% presented erect stand and 43.75% presented semi-erect stand, according the CIAT classification scale (1987). These genotype characteristics did not vary with the locations.

Table 4 shows the reaction of the materials assessed to the main diseases that occurred during the experiment. Favorable climatic conditions resulted in a high incidence of anthracnose in Irati-PR in the wet and dry growing seasons and of common bacterial cresting in Capitão Leônidas Marquês and Ponta Grossa in the dry growing season. Most of the cultivars and lines assessed performed as resistant or moderately resistant to anthracnose, angular leaf spot, rust and oídio, except for the Carioca Precoce and Carioca 1070 cultivars that were susceptible to anthracnose. The earlier cycle cultivars, Alúbia and Baronesa, and the G-122 line and the intermediate cycle cultivars, Carioca Precoce and Carioca 1070, presented susceptibility reaction to common bacterial cresting, showing the need for resistance gene introgression because this disease is

Table 3. Growth habit and plant stand of seven common bean cultivars and nine lines cultivated in Capitão Leônidas Marquês, Londrina and Irati, in the wet 2001/2002 growing season and in Irati and Ponta Grossa in the dry 2002 season.

Genotype	Growth habit[1/]	Plant stand[2/]
IAPAR 81	II	E
Goiano Precoce	I	E
LP99–2	I	E
LP99–3	I	E
LP99–4	I	E
LP20-87	II	SE
LP20-88	II	SE
LP20-89	II	SE
LP20-90	II	SE
LP20-91	II	SE
Carioca Precoce	I	SE
Carioca 1070	I	SE
Carnaval Pitoco	I	E
Alúbia	I	E
Baronesa	I	E
G – 122	I	E

[1/] Growth habit - I: determined and II and III: undetermined; [2/] Plant stand - E: erect and SE: semi-erect.

transmitted by seeds and there is still no efficient chemical control.

Grain yield, weight of 1000 seeds, adaptability and phenotypic stability

Table 5 shows the results of the assessment of the grain yield and weight of 1000 seeds characteristics performed in the five locations and Table 6 shows the joint analysis of variance of the five locations. When the means obtained in the five locations are analyzed, the LP20-87, LP20-88, LP20-89, LP20-90, LP20-91 lines and the Alúbia cultivar presented total grain yield superior to that of the control for grain yield, IAPAR 81, although this difference was not detected by the Scott and Knott test at 1% and 5% probability.

The individual analyses of variance for these characteristics, as well as the joint analysis, revealed significant genotype effects at the level of 1% probability, showing the existence of variability among the materials for the characteristics assessed. The genotype x environment interaction was also significant. This differentiated response of the common bean genotypes to different environments is in line with results obtained by several authors (Omar et al., 1999; Truberg and Hühn, 2000).

The significance of the genotype x environment interaction indicated that the cultivars and lines varied in their adaptations to the environments where they were tested. Some cultivars and lines can present high grain yield only under favorable conditions, while others may have good grain yield under unfavorable conditions. The existence of this genotype x environment interaction makes it difficult to identify superior cultivars and lines for the different environments and highlights the importance of assessing the genotypes for their adaptability and phenotypic stability.

Eberthart and Russell (1966) reported that linear regression (β_{1i}) can be used to measure the response of a particular genotype and the regression deviation

Table 4. Reaction to diseases of seven common bean cultivars and nine lines cultivated in Capitão Leônidas Marquês (A_1), Londrina (A_2) e Irati (A_3), in the wet 2001/2002 growing season and in Irati (A_4) e Ponta Grossa (A_5), in the dry 2002 growing season [1/, 2/].

Genotype	ANT					ALS					CBC					RUS					OID				
	A_1	A_2	A_3	A_4	A_5	A_1	A_2	A_3	A_4	A_5	A_1	A_2	A_3	A_4	A_5	A_1	A_2	A_3	A_4	A_5	A_1	A_2	A_3	A_4	A_5
IAPAR 81	1	1	1	1	1	1	1	1	3	2	6	4	3	3	1	1	3	1	2	2	1	1	1	1	1
Goiano Precoce	1	1	2	2	1	1	1	1	3	5	6	6	4	3	3	2	2	1	3	2	1	4	1	2	1
LP99–2	1	1	1	1	1	1	1	1	4	4	6	6	4	6	3	1	2	1	2	2	1	2	1	1	1
LP99–3	1	1	1	1	1	1	1	1	4	4	6	6	4	4	2	1	1	1	2	1	1	2	1	1	1
LP99–4	1	2	1	1	1	1	1	1	3	4	6	5	3	1	3	1	1	1	2	2	1	2	1	1	1
LP20-87	1	1	1	1	1	1	1	1	1	3	4	3	2	1	3	2	2	1	2	3	1	1	1	1	1
LP20-88	1	1	1	1	1	1	1	1	3	2	2	3	2	2	2	2	3	1	4	2	1	1	1	1	1
LP20-89	1	1	1	1	1	1	1	1	1	2	3	3	2	1	1	2	2	1	1	2	1	2	1	1	1
LP20-90	1	1	1	1	1	1	1	1	1	2	3	3	2	1	1	2	4	1	2	3	1	1	1	1	1
LP20-91	1	1	1	1	1	1	1	1	2	2	3	3	2	2	1	2	2	4	4	2	1	1	1	1	1
Carioca Precoce	1	1	8	5	1	1	1	1	6	4	6	5	6	4	3	1	3	3	6	4	1	1	1	1	1
Carioca 1070	1	1	8	6	1	1	1	1	4	5	8	6	5	2	2	1	3	2	6	2	1	1	1	1	1
Carnaval Pitoco	1	1	1	1	1	1	1	1	3	4	8	6	4	2	2	1	2	3	2	2	1	2	1	1	1
Alúbia	1	1	1	1	1	1	1	1	3	5	7	6	4	4	2	1	1	2	6	5	1	3	1	1	1
Baronesa	1	1	3	1	1	1	1	1	2	5	8	6	5	2	3	3	2	1	2	2	1	3	1	1	1
G – 122	1	1	1	2	1	1	5	1	3	5	8	6	4	2	3	2	3	1	2	2	1	3	1	1	1

[1/] ANT: anthracnose; ALS: angular leaf spot; CBC: common bacterial crest; RUS: rust and OID: oidio; [2/] Assessment scale according to CIAT (1987), where values of 1 – 3: resistant; 4 – 6: moderately resistant and 7 – 9: susceptible.

Table 5. Weight of 1000 seeds (g), total grain yield (kg/ha) and result of the analysis of variance, assessed in seven common bean cultivars and nine lines cultivated in Capitão Leônidas Marquês, Londrina and Irati, in the wet 2001/ 2002 growing season and in Irati and Ponta Grossa, in the dry 2002 growing season.

Genotype	Capitão L. Marquês		Londrina		Irati / wet		Irati / dry		Ponta Grossa		Mean	
	P1000[1/]	YIELD[2/]	P1000[1/]	YIELD[2/]	P1000[1/]	YIELD[2/]	P1000[1/]	YIELD[2/]	P1000[1/]	YIELD[2/]	P1000[1/]	YIELD[2/]
IAPAR 81	229.68	1936.47	280.17	856.19	249.45	2471.38	238.92	2274.95	219.65	1839.06	243.57 c [3/]	1875.61 a [3/]
Goiano Precoce	324.39	1544.74	326.67	1611.97	372.23	907.79	354.86	2250.30	344.48	1319.87	344.53 b	1526.93 a
LP99–2	265.98	1263.58	256.74	1034.96	294.04	1543.63	274.60	2076.00	264.58	1798.69	271.19 c	1543.37 a
LP99–3	275.83	1499.68	251.87	906.08	317.07	1650.04	283.73	2107.25	275.21	1710.85	280.74 c	1574.78 a
LP99–4	285.15	1434.82	257.87	890.89	316.37	1790.47	284.59	1986.76	285.46	1318.18	285.89 c	1484.22 a
LP20-87	201.02	1828.04	247.85	796.03	249.47	2288.80	209.90	2405.23	215.76	2234.47	224.80 d	1910.51 a
LP20-88	184.68	2015.04	225.01	1034.51	219.17	2523.90	185.47	2359.52	188.60	1779.58	200.59 d	1942.51 a
LP20-89	189.12	1940.12	219.99	1416.29	221.26	2276.99	194.41	2417.70	192.12	1958.47	203.38 d	2001.92 a
LP20-90	192.53	2118.78	214.25	1245.68	209.77	1878.48	201.50	2267.11	195.95	1890.16	202.80 d	1880.04 a
LP20-91	190.92	1867.82	223.26	1126.17	217.66	1568.39	202.83	2634.99	198.75	1989.57	206.68 d	1837.39 a
Carioca Precoce	216.94	2007.05	240.97	1842.45	238.11	939.21	214.84	2275.85	218.90	1689.49	225.95 d	1750.81 a
Carioca 1070	181.28	1695.45	207.01	1490.30	215.42	1584.27	186.38	1660.88	189.70	1572.74	195.96 d	1600.73 a
Carnaval Pitoco	337.67	1735.15	334.74	1623.26	407.88	1596.08	366.21	2149.05	351.60	1984.23	359.62 b	1817.56 a
Alúbia	446.08	2043.77	456.27	1821.85	481.91	1666.31	508.36	2296.90	493.47	2109.05	477.22 a	1987.57 a
Baronesa	338.69	1962.38	324.66	1579.59	406.77	1520.39	373.71	2017.14	366.53	1963.46	362.07 b	1808.59 a
G – 122	372.76	1907.44	325.15	1590.51	412.54	1117.05	351.90	2089.00	341.19	1884.46	360.71 b	1717.69 a
FV												
Genotype	**	**	**	**	**	**	**	**	**	**		
Residue												

[1/] weight of 1000 seeds; [2/] total grain yield. [3/] Values followed by the same letter belong to the same cluster. Scott and Knott at 1%.
** significant at the level of 1% probability.

Table 6. Result of the joint analysis of variance of the characteristics weight of 1000 seeds and total grain yield (kg/ha) of seven common bean cultivars and nine lines for the experiments in Capitão Leônidas Marquês, Londrina and Irati, wet 2001/2002 growing season and in Irati and Ponta Grossa, dry 2002 growing season.

SV	DF	YIELD	P1000
Environment	4	**	**
Genotype	15	**	**
Interaction Genotype x Environment	60	**	**
Residue	150		
Mean		1766.26	277.86
CV (%)		16.64	8.34

** significant at the level of 1% de probability.

(σ^2_{di}) can be considered the best parameter for stability. Genotypes with high grain yield and regression coefficient close to one (β_{1i}=1) were considered widely adaptable genotypes, adapted both to favorable and unfavorable environments, whereas genotypes with regression coefficient greater than one (β_{1i}>1) indicated genotypes especially adapted to favorable environments, but with poor performance in stressful environments, when compared with their genetic potential. Genotypes with regression coefficient less than one (β_{1i}<1) maintain their performance in unfavorable environments. Regression deviations equal to zero (σ^2_{di}=0) indicate stable genotypes, with predictable performance for environmental conditions.

Table 7 shows the estimates of the phenotypic adaptability and stability parameters of the cultivars and lines assessed. The results showed the regression coefficients (β_{1i}) estimated for the cultivars and lines tested were mostly (81.25% of the total) statistically equal to one, indicating that the materials possess wide adaptability to the different environments. The LP20-87 and LP20-91 lines presented regression coefficient greater than one and the Carioca 1070 cultivar presented coefficient regression less than one, indicating that this cultivar adapts to environments unfavorable to grain yield.

Regarding regression deviation (σ^2_{di}), the results showed that the performance of most of the cultivars and lines (62.5%) was stable in the different environments. The Carioca 1070, Carnaval Pitoco, Alúbia and Baronesa cultivars and the LP99-2, LP9903, LP99-4, LP20-87, LP20-89, LP20-90 and LP20-91 lines presented regression deviation not

Table 7. Estimates of the parameters of phenotypic adaptability and stability, by the regression coefficient (β_{1i}), regression deviation (σ^2_{di}), determination coefficient (R^2_i) and mean grain yield in kg/ha, of seven common bean cultivars and nine lines for the experiments in Capitão Leônidas Marquês, Londrina and Irati, wet 2001/2002 growing season and in Irati and Ponta Grossa, dry 2002 growing season.

Genotype	Mean	β_{1i} [1/]	σ^2_{di} [2/]	R^2_i (%)
IAPAR 81	1875.61	1.83 [ns]	188611.81 [2/]	58.15
Goiano Precoce	1526.93	-0.99 [ns]	215348.37 [2/]	23.46
LP99-2	1543.37	0.54 [ns]	20217.00 [ns]	78.55
LP99-3	1574.78	1.19 [ns]	-12726.68 [ns]	93.66
LP99-4	1484.22	0.50 [ns]	38008.87 [ns]	72.48
LP20-87	1910.51	2.85 [1/]	129674.23 [2/]	72.70
LP20-88	1942.51	1.38 [ns]	171320.93 [2/]	56.12
LP20-89	2001.92	0.18 [ns]	19110.06 [ns]	75.93
LP20-90	1880.04	0.54 [ns]	-5270.20 [ns]	88.41
LP20-91	1837.39	2.66 [1/]	-14628.11 [ns]	96.56
Carioca Precoce	1750.81	-1.57 [ns]	261706.92 [2/]	13.89
Carioca 1070	1600.73	-3.05 [1/]	-25389.08 [ns]	60.32
Carnaval Pitoco	1817.56	-1.46 [ns]	-3594.18 [ns]	67.29
Alúbia	1987.57	-1.59 [ns]	6550.05 [ns]	56.58
Baronesa	1808.59	-1.70 [ns]	5152.16 [ns]	55.05
G-122	1717.69	-1.30 [ns]	104640.17 [2/]	30.81
Mean	1766.26			

[1/] significantly different from one, by the t test, at the level of 1% probability and [ns] not significantly different from one, by the t test, at the level of 1% probability; [2/] significantly different from zero, by the F test, at the level of 1% probability and [ns] not significantly different from zero, by the F test, at the level of 1% probability.

significantly different from zero, indicating that they are cultivars and lines with predictable performance in the environments tested. These stable cultivars and lines presented variation for adaptability and grain yield. The determination coefficients (R^2_i) estimated revealed a linearity in the response of most of the materials to the different environments, and most of the cultivars and lines had a determination coefficient between 50% and 80% that indicates the fit of the data to the model used.

According to the results obtained, the Alúbia, Baronesa and Carnaval Pitoco cultivars and the LP20-89 and LP20-90 lines were promising, with high grain yield, regression coefficients equal to one, were adaptable to different climatic conditions, and were stable, showing that these cultivars and lines performed consistently both in favorable and unfavorable environments for grain yield that is very desirable for common bean breeding.

The IAPAR 81 cultivar and the LP20-88 line were also promising because they presented high yield, wide adaptability and regression coefficients not different statistically from one. However, they presented low performance predictability in the environments and the regression deviations were statistically different from zero. In spite of this, these materials should not be discarded as their determination coefficient reached levels of around 58%.

The LP20-87 and LP20-90 lines presented high mean grain yield and adaptability to favorable environments (β_{1i}>1) that suggested that the grain yield would increase as the environmental conditions improved. The Carioca 1070 cultivar showed wide adaptability to unfavorable environmental conditions (β_{1i}<1) and high environmental stability (σ^2_{di}=0).

The development of early cycle cultivars, with high grain yield and wide production adaptability and stability in different environments is important for a breeding program. The Alúbia, Baronesa and Carnaval Pitoco cultivars and the LP20-89 and LP20-90 lines could be considered promising for this purpose.

CONCLUSIONS

The Alúbia, Baronesa and Carnaval Pitoco cultivars and the LP20-89 and LP20-90 lines can be considered as promising cultivars and lines from the point of view of plant breeding because they present high grain yield, wide adaptability and high stability in the different locations;

Based on the estimates of the adaptability and phenotypic stability parameters it can be concluded that the cultivars and lines varied in their adaptation in the tested environments;

The coefficients of determination indicated generally a linearity of response of the cultivars and lines in the environments;

The LP20-87 and LP20-91 lines presented high mean grain yield and adaptability to favorable environments, suggesting increased yield as the environmental conditions improve;

The Carioca 1070 cultivar presented wide adaptability to unfavorable environments and high environmental stability;

The Alúbia and Baronesa cultivars and the G-122 line had a mean number of days to physiological maturity similar to that of the 'Goiano Precoce´ control, and were therefore early cycle;

The Carioca Precoce and Carioca 1070 cultivars had

DPF and DMF approximately five days after the DPF and DMF of the 'Goiano Precoce' control, respectively, and around six days after those of the LP20-87, LP20-88, LP20-89, LP20-90, LP20-91 lines. Both cultivars can be considered of intermediate cycle;

The LP20-87, LP20-88, LP20-89, LP20-90 and LP20-91 lines and the control for grain yield, IAPAR 81, with intermediate growth habit, matured later;

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RESUMO

Adaptabilidade e estabilidade fenotípica de cultivares e linhagens precoces de feijoeiro

O presente trabalho teve por objetivo estimar a variabilidade genética para precocidade e avaliar a adaptabilidade e estabilidade fenotípica para produtividade de grãos de cinco cultivares e nove linhagens de feijoeiro, utilizando-se a metodologia proposta por Eberhart e Russell (1966). Para tanto, um experimento em blocos casualizados foi conduzido na safra das águas 2001/2002 em três locais e na safra da seca/2002 em dois locais. As estimativas dos coeficientes de variação genética (CVg) e ambiental (CVe), índice B e coeficiente de determinação genotípica (h^2) revelaram a presença de variabilidade genética entre as cultivares e linhagens avaliadas, para as características número de dias da emergência ao aparecimento da primeira flor (DPF) e número de dias da emergência a data de maturidade fisiológica (DMF). Baseando-se nas estimativas dos parâmetros de adaptabilidade e estabilidade fenotípica observou-se, de maneira geral, ampla adaptabilidade e um comportamento estável das cultivares e linhagens nos diferentes ambientes. As cultivares Alúbia, Baronesa e Carnaval Pitoco e as linhagens LP20-89 e LP20-90 apresentaram-se como promissoras, com alta produtividade, ampla adaptabilidade (β_{1i}=1) e boa estabilidade (σ^2_{di}=0).

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