Rev. Brasil. Genet. 16, 1, 115-127 (1993)
(Brazil. J. Genetics)

PERFORMANCE IN BRAZIL AND COLOMBIA OF COMMON BEAN LINES FROM THE SECOND SELECTION CYCLE

M. Thung[1], R.M. Ferreira[1], P. Miranda[2], V. Moda-Cirino[3], M.A. Gava Ferrão[4], L.O. da Silva[5], V.V. Dourado[6], S. Hemp[7], B. Souza[8], E. Serpa S.[9], M.J.O. Zimmermann[10] and S.P. Singh[11]

ABSTRACT

Seventy-nine lines of the small-seeded common bean (*Phaseolus vulgaris* L.) from the second cycle of selection (SCS) were evaluated for seed yield, days to maturity, and reaction to diseases at ten locations in Brazil. All lines were also tested at CIAT-Quilichao, Colombia. Additionally, 20 of these lines were tested with two cultivars from the first cycle of selection (FCS) and three other checks at three locations for three years in Colombia. Significant differences for seed yield were found among lines in Brazil and Colombia. Of 79 lines from the SCS, 15 lines outyielded the check EMGOPA-Ouro (A 295) from the FCS. Eleven lines also outyielded the best check cultivar Carioca across environments in Brazil and Colombia. Positive associations were found for mean seed yield over five growing seasons at CNPAF-Goiânia, Brazil, with yield at EMGOPA-Goiânia, IAPAR-Londrina, EMCAPA-Linhares, EMPASC-Chapecó, CNPCO-Poço Verde, and IPA-Arcoverde, Brazil. Mean yield across all sites in Brazil correlated positively with mean yield in Colombia.

Correlation coefficients between scores in Brazil and Colombia for common bacterial blight and angular leaf spot were positive and significant ($P < 0.01$). Improved lines had higher resistance to these two diseases and to anthracnose, bean golden mosaic virus, and rust.

[1]CNPAF, Caixa Postal 179, 74001-970 Goiânia, GO, Brasil. Send correspondence to M.T.
[2]IPA, Recife, Pernambuco, Brasil. [3]IAPAR, Londrina, Paraná, Brasil. [4]EMCAPA, Vitória, Espírito Santo, Brasil. [5]EMGOPA, Anápolis, Goiás, Brasil. [6]EPABA, Irecé, Bahia, Brasil. [7]EMPASC, Chapecó, Santa Catarina, Brasil. [8]PESAGRO, Campos, Rio de Janeiro, Brasil. [9]CNPCO, Aracaju, Sergipe, Brasil. [10]CNPAF, Goiânia, Goiás, Brasil. [11]CIAT, A.A. 6713, Cali, Colombia.

INTRODUCTION

Of approximately 13 million hectares of common bean (*Phaseolus vulgaris* L.) grown annually in the world for dry seed production, over 5 million ha are found in Brazil. The most extensively grown cultivars (> 80%) in Brazil are small-seeded (< 25 g/100-seed weight) indeterminates of upright growth habit II and of prostrate semiclimbing growth habit III of cream-striped ('carioca'), cream ('mulatinho'), black ('preto'), pink and purple ('rosinha' and 'roxo'), and beige ('jalinho') colors. Most of these cultivars belong to the Middle American center of domestication and their characteristics conform to the Mesoamerica race (Singh *et al.*, 1991a). As a group, they usually yield significantly higher and are more stable than their large-seeded (> 40 g/100-seed weight) counterparts of Andean South American origin (Ghaderi *et al.*, 1982; Santos *et al.*, 1982; Beaver *et al.*, 1985; Kelly *et al.*, 1987; White and González, 1990; White *et al.*, 1992).

Low soil fertility (acid soils), moisture stress, and diseases such as anthracnose caused by *Colletotrichum lindemuthianum* (Sacc. & Magn.) Scrib., angular leaf spot caused by *Phaeoisariopsis griseola* (Sacc.) Ferr., common bacterial blight caused by *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye, bean golden mosaic virus (BGMV), and rust caused by *Uromyces appendiculatus* pv. *appendiculatus* Unger are among the principal production constraints on common bean in Brazil and many other parts of the world (Vieira, 1983; Zimmermann *et al.*, 1988; Schoonhoven and Voysest, 1989). Most traditional cultivars are susceptible to one or more of these factors, and hence suffer severe losses. Consequently, average yields are usually low (approximately 600 kg ha^{-1}) and unstable (Thung, 1990). Breeding for these groups of small-seeded germplasm at the International Center for Tropical Agriculture (CIAT), Cali, Colombia, was initiated in 1978. Two selection cycles were completed in 1988. In the first cycle of selection (FCS), mostly single crosses were made with the objective of combining resistances to bean common mosaic virus (BCMV), anthracnose, and angular leaf spot. In the second cycle of selection (SCS), in addition to these diseases, resistance to common bacterial blight was selected and mostly multiple crosses were made in 1982-1984. In both cycles, most parents were small-seeded and possessed characteristics of the race Mesoamerica. Moreover, a few crosses of the second cycle included parents of known general combining ability for seed yield, possessing characteristics of the race Durango. As a part of ongoing collaboration, CIAT periodically supplies parental germplasm, segregating populations, and/or improved lines to Brazil and other countries. From the SCS, 79 lines developed at CIAT were introduced by the Centro Nacional de Pesquisa de Arroz e Feijão (CNPAF), Goiânia, Brazil, in the beginning of 1989. These were subsequently distributed to other state institutions engaged in bean research. We report on the comparative performance of these lines in Brazil and Colombia and the significance for improvement of these beans in the future.

MATERIALS AND METHODS

The 79 lines (mostly F_9 and advanced) from the SCS were small-seeded indeterminates of growth habits II and III and were resistant to BCMV. They were evaluated in an adaptation nursery at ten locations, namely, CNPAF-Goiânia (16°28'S, 49°17'W) for five cropping seasons, EMGOPA-Goiânia (16°14'12"S, 49°14'56"W), EMPASC-Chapecó (27°00'S, 52°36'W), PESAGRO-Campos (21°45'S, 41°20'W), CNPCO-Poço Verde (10°43'S, 38°12'W), EPABA-Irecé (11°18'S, 41°52'W), EMCAPA-Linhares (19°23'S, 40°4'W), IAPAR-Londrina (23°12'S, 51°5'W), and IPA stations at Arcoverde (8°26'S, 37°4'W) and Belém do São Francisco (8°46'S, 38°58'W) Brazil, between 1989 and 1991. Except at CNPAF-Goiânia, the nursery was grown only once at each location. The lines were also grown at CIAT-Quilichao (3°6'N, 76°31'W), Colombia, in 1988. Each plot consisted of four rows, 5 m long, without replication. Data were recorded on seed yield (kg ha^{-1}), days to maturity, and reaction to prevalent diseases at each site. In Colombia, this included angular leaf spot and common bacterial blight. In Brazil, materials were scored for BGMV, rust, and angular leaf spot (CNPAF-Goiânia); common bacterial blight (IAPAR-Londrina); and anthracnose (CNPCO-Poço Verde). All disease data were recorded on a 1 to 9 scale, where 1 = immune and 9 = very susceptible. For combined analysis of yield data from an adaptation nursery, locations were used as replications. Additionally, 20 lines (25%) along with two check cultivars from the FCS and three additional checks were grown on CIAT farms at Quilichao, Popayán (2°27'N, 76°34'W), and Palmira (3°30'N, 76°19'W), Colombia, for three years. A 5 x 5 lattice design with four replications was used. In 1988, plots were four rows, 5 m long. In 1989 and 1990, row lengths were 7 m. Data were recorded on days to maturity, seed yield (kg ha^{-1}), 100-seed weight (g), and reaction to common bacterial blight and angular leaf spot at Quilichao and anthracnose at Popayán. Data were subjected to standard statistical analysis using the GENSTAT statistical package (Numerical Algorithms Group, Oxford, U.K.). Simple correlation coefficients were computed for reaction to diseases and seed yield among locations.

RESULTS AND DISCUSSION

Differences among 79 lines tested in Brazil and Colombia were highly significant ($P < 0.01$) for seed yield. In Brazil, yields were higher at EMGOPA-Goiânia, followed by those of EMCAPA-Linhares and CNPAF-Goiânia (Table I). IAPAR-Londrina had the lowest mean yield due to frequent moisture stresses during the growing season. Seed yields at CIAT-Quilichao in 1988 were similar to those of EMGOPA-Goiânia. The crop took about a week longer at CNPAF-Goiânia and a month longer at IAPAR-Londrina compared with CIAT-Quilichao (data not shown). This could very likely be caused by longer photoperiod and relatively lower temperatures in the southern part of Brazil that extended crop duration there. The pressure of angular leaf spot at CNPAF-Goiânia was comparatively higher than that at CIAT-Quilichao (Table II). However, common bacterial blight incidence at IAPAR-Londrina was milder than that at CIAT-Quilichao. Simple correlation coefficients for the two diseases, 0.38** and 0.31**, respectively, between scores from Brazil and Colombia were positive and highly significant ($P < 0.01$). This suggested that genes for resistance which were effective in Colombia were, in general, also effective in Brazil. Moreover, selection for resistance to these diseases in Colombia could be useful for Brazilian bean-growing environments. On the other hand, there were indications that pathogen populations of the causal agent of anthracnose at CIAT-Popayán were different from those at CNPCO-Poço Verde, Brazil (e.g., lines A 767 and A 777 were resistant at Popayán but susceptible at CNPCO-Poço Verde). Thus, reliable selections for resistance to anthracnose would not be feasible in Colombia alone. Anthracnose and angular leaf spot pathogens are known to be variable in Latin American and other bean-growing environments (Alvarez-Ayala and Schwartz, 1979; Menezes and Dianese, 1988). Identification of stable resistance effective against a broad spectrum of pathogen populations of any of these diseases would usually require glasshouse and field testing across locations and growing seasons for variable pathogen populations. Although no screenings and selections were performed in Colombia during the breeding phase of these lines for BGMV and rust, considerable variation for reaction to these diseases was found in Brazil (Table II). Thus, the strategy of using different resistant parents for hybridization and development of lines under stress-free conditions for eventual evaluation and selection in stress environments may be useful to some extent, especially when selection cannot be performed from early on for one reason or another.

Simple correlation coefficients for seed yield among individual sites within Brazil and CIAT-Quilichao, Colombia, were generally nonsignificant (Table III). This indicated that 11 sites used for testing varied to some extent in soil fertility, moisture availability, composition and pressure of pathogen populations, temperature, photoperiod, agronomic management, and other factors affecting growth and development such that yield data from any single site and cropping season was not reliable to determine the performance of common bean lines. Only CNPAF-Goiânia (mean of five trials) and EMPASC-Chapecó, Brazil, showed positive correlation with CIAT-Quilichao. Thus, these sites are, in spite of their long distances from each other,

Table I - Range and mean for seed yield for 79 lines of common bean from the second selection cycle grown in Brazil and Colombia.

Parameters	Seed yield (kg ha^{-1})											
	CNPAF Goiânia*	CNPCO Poço Verde	EMCAPA Linhares	EMGOPA Goiânia	EMPASC Chapecó	EPABA Irecé	IAPAR Londrina	IPA Arcoverde	IPA B.S. Francisco	PESAGRO Campos	CIAT Quilichao	Mean
Minimum	790	420	1334	1102	28	443	147	250	629	275	721	1103
Maximum	2213	1472	2958	3814	2669	2168	1861	2178	2814	2387	3351	2007
Mean	1648	927	2091	2271	1408	1235	880	1215	1355	1144	2284	1551
L.S.D. (0.05)**	163	82	120	131	208	126	129	124	144	143	143	56
L.S.D. (0.05)***	127	127	127	127	127	127	127	127	127	127	127	127

* Mean of five cropping seasons between 1989 and 1991.

** For comparison of values within locations.

*** For comparison of values among locations.

Table II - Mean seed yield and other characteristics of the ten highest yielding common bean lines from the second selection cycle evaluated at three locations in Colombia for three years and for five seasons over three years at CNPAF-Goiânia, Brazil.

Identification	Seed yield ($kg\ ha^{-1}$)					Maturity (d)	100-seed weight	Disease score**						
	Palmira	Popayán	Quilichao	Goiânia	Mean	C*	C	Common bacterial blight		Angular leaf spot		Anthracnose	BGMV	Rust
								Q	L	Q	G	P	G	G
A 774	2587	1695	2267	2189	2186	76.5	22.6	5.9	4	4.0	5	3.3	5	6.0
A 785	2602	1849	2128	1948	2070	80.8	25.1	6.2	2	5.6	7	5.7	6	4.0
A 775	2472	1480	2248	2009	2038	77.0	21.8	5.9	4	3.8	6	4.7	5	6.0
A 787	2263	1507	2180	2042	2013	77.8	22.9	6.1	5	4.8	6	2.6	4	5.5
FEB 166	2464	1601	1978	1877	1946	80.1	22.9	5.2	5	3.6	6	4.6	5	6.5
A 790	2187	1680	1886	1902	1910	79.5	22.3	6.0	4	4.3	5	1.9	6	5.0
Carioca[a]	2293	1752	2048	1689	1860	78.7	23.8	6.2	-	4.6	-	1.7	-	-
A 786	1881	1413	1806	1957	1829	80.1	26.2	5.9	5	4.6	6	1.8	5	5.0
FEB 170	2017	1475	2116	1784	1826	77.2	20.0	5.3	6	4.1	5	4.3	5	7.0
A 769	2142	1318	2069	1775	1809	75.9	18.6	5.9	6	4.8	6	2.1	6	7.0
A 777	2038	1591	2110	1663	1788	79.1	23.8	5.6	8	4.0	7	1.8	5	8.0
A 295[b]	1969	1183	1884	1672	1675	79.6	18.4	7.6	-	5.6	-	4.2	-	-
Mean	2120	1507	1947	1719	1799	79.6	21.1	6.0	4.9	4.6	5.9	3.2	5.8	6.4
LSD (0.05)	160	112	214	165	118	0.7	0.5	0.3	1.5	0.4	0.5	0.9	0.7	0.9

* C = mean across locations and/or years in Colombia.

** Diseases scored on a 1 to 9 scale, where 1 = immune and 9 = very susceptible. Q = CIAT-Quilichao, P = CIAT-Popayán, G = CNPAF-Goiânia, and L = IAPAR-Londrina.

[a] Highest yielding commercial check cultivar.

[b] Highest yielding check from the first selection cycle.

Table III - Simple correlation coefficients for seed yield among locations in Brazil and Colombia obtained from 79 lines of common bean from the second selection cycle.

Locations	CNPAF Goiânia	EMGOPA Goiânia	IAPAR Londrina	EMCAPA Linhares	IPA B.S. Francisco	IPA Arcoverde	PESAGRO Campos	CNPCO Poço Verde	EMPASC Chapecó	EPABA Irecé
CIAT-Quilichao	0.24*	0.09	0.17	-0.08	-0.43**	0.06	0.01	0.02	0.30**	0.02
CNPAF-Goiânia		0.31**	0.31*	0.23*	-0.19	0.28*	-0.03	0.33**	0.26*	0.22
EMGOPA-Goiânia			0.19	0.20	-0.05	0.20	0.10	0.30*	0.07	0.05
IAPAR-Londrina				-0.09	-0.04	0.22*	0.15	0.26*	0.33**	0.13
EMCAPA-Linhares					0.06	0.12	-0.01	0.23	-0.03	0.35**
IPA-B.S. Francisco						-0.16	-0.05	-0.04	-0.17	0.12
IPA-Arcoverde							0.52**	0.20	-0.11	0.14
PESAGRO-Campos								0.00	-0.08	0.15
CNPCO-Poço Verde									-0.14	0.15
EMPASC-Chapecó										0.01

*, ** Significant at P = 0.05 and P = 0.01, respectively.

expected to have some factors affecting bean growth in common, although with the information available it was not possible to know which these were. The correlation coefficient between CIAT-Quilichao and IPA-Belém do São Francisco was negative. The latter site had negative values, although nonsignificant, in relation to most other sites. IPA-Belém do São Francisco is a relatively warm site in the delta of the São Francisco River, with very sandy soils heavily infested with root-rot pathogens. This makes it a unique site, much different even from its nearest site, IPA-Arcoverde, for common bean germplasm evaluation. Among the ten locations in Brazil, mean seed yield over five cropping seasons at CNPAF-Goiânia had significant positive associations with all except IPA-Belém do São Francisco, PESAGRO-Campos, and EPABA-Irecé. Similarly, IAPAR-Londrina showed positive correlation with IPA-Arcoverde, CNPCO-Poço Verde, and EMPASC-Chapecó. Thus, for a national agricultural research center like CNPAF, responsible for developing superior germplasm for such diverse and large common bean growing environments as occur in Brazil, it is imperative to identify a few contrasting, complementary, and key sites representing maximum diversity in biotic and abiotic production constraints and in cropping systems for testing. This is even more important when seed quantity and resources are limiting, access to all sites is not feasible, and/or a relatively large number of materials need to be tested. All newly developed and introduced germplasm for sites showing positive associations with CNPAF-Goiânia could initially be tested there over seasons, and all poor-yielding and susceptible entries discarded on the basis of mean performance. This should be followed by testing of a reduced number of entries at other member-sites within the group showing positive associations. However, sites showing negative or no association with CNPAF-Goiânia (e.g., IPA-Belém do São Francisco, PESAGRO-Campos, and EPABA-Irecé) are probably different from each other and should be used from the beginning for germplasm testing. Thus, a reduced number of test sites would be required at national, regional, and state levels within Brazil. Nonetheless, at every step of testing, the mean yield across sites (and also across seasons) should be used among principal selection criteria, along with reaction to diseases and pests, to identify stable and high-yielding genotypes with broad adaptation.

When yield data from all 79 lines from a single season at each site were used, CIAT-Quilichao showed positive association with only EMPASC-Chapecó, whereas CNPAF-Goiânia showed positive associations with four of the nine other sites in Brazil. However, mean yield over five seasons at CNPAF-Goiânia for 79 lines correlated positively with CIAT-Quilichao and six locations within Brazil (Table III). Similarly, when mean yield across seasons for a reduced number of lines (20) was used, then CIAT sites at Palmira and Quilichao, but not Popayán, correlated positively with CNPAF-Goiânia (Table IV). In addition, mean values across all sites in Brazil correlated positively with mean yield across locations in Colombia. This indicates that reliable yield

Table IV - Simple correlation coefficients for seed yield* among CIAT sites in Colombia and CNPAF-Goiânia, Brazil, obtained from 20 lines of common bean from a second selection cycle.

Locations	CIAT sites in Colombia			
	Palmira	Quilichao	Popayán	Mean
CNPAF-Goiânia	0.62**	0.63**	0.15	0.59**
Palmira		0.54**	0.26	0.79**
Quilichao			0.40	0.81**
Popayán				0.68**

* Mean values for three years at each site in Colombia and for five cropping seasons over three years at CNPAF-Goiânia in Brazil were used to calculate correlation coefficients.

** Significant at P - 0.01.

estimates could be obtained by testing across contrasting sites and seasons within either Colombia or Brazil.

A direct and more objective comparison could not be made because the majority of lines from the FCS and SCS were tested in different trials and years, and different checks (including some improved lines from the FSC) were used in the SCS. However, from mean yield of the ten best lines from FCS and SCS, along with checks from across locations in Brazil (Table V), and yield data on individual lines shown in Table II, it is

Table V - Mean seed yield (kg ha^{-1}) of common bean lines from the first and second selection cycles evaluated in Brazil.

	Selection cycle*	
	First	Second
10 best lines	1628	2133
All lines	1164	1440
Checks**	1156	1503

* Bred lines from the first cycle were tested in 44 trials between 1983 and 1985, and those from the second cycle were tested in 14 trials between 1989 and 1991.

** Some checks in the second cycle were improved lines (e.g., A 247, A 285, A 295) from the first selection cycle and other sources (e.g., IPA 6) and were different from the checks used in the first selection cycle.

obvious that considerable yield gains have been achieved in the SCS. Of 79 lines from the SCS, 15 significantly ($P < 0.05$) outyielded the highest yielding check, A 295 (EMGOPA-Ouro), across environments in Brazil and Colombia. Eleven of these lines also yielded higher than the best check cultivar Carioca (data not shown). Similarly, when 20 of 79 lines (25%) from the SCS were compared for three years at three locations in Colombia and for five cropping seasons at CNPAF-Goiânia with two checks (A 247 and A 295) from the FCS, nine lines significantly outyielded the best check (A 295) from the FCS, and five also outyielded the highest yielding cultivar Carioca. Table II provides data on ten high-yielding lines, the best check (A 295) from the FCS, and the highest yielding commercial cultivar (Carioca). Line A 295 is in commercial production in Brazil and is known as 'EMGOPA-Ouro'. Bred lines from the SCS usually had higher levels of resistance to most diseases.

Why few lines from the SCS outyielded Carioca is worth examination. Breeders have traditionally exploited genetic variability available within a seed class (Voysest and Dessert, 1991), gene pool (Singh, 1989), or races (Singh *et al.*, 1991a). This is because of problems of adaptation of introduced germplasm from other races, difficulty in recovering desirable seed and plant characteristics from interracial populations, and insufficient knowledge about combining ability among and within different races and gene pools (Singh, 1991, 1992). Also, sometimes there are problems of incompatibility or genetic recombination among different groups of germplasm (Singh and Gutiérrez, 1984; Vieira *et al.*, 1989). Moreover, bean breeders have often emphasized breeding for resistance to diseases, and selection for seed yield has been based on visual observations, at least in the early segregating generations. Only fixed lines in advanced generations are subjected to yield tests. Visual selection for seed yield in F_2 and F_3 was found to be ineffective in common bean (Patiño and Singh, 1989).

Some recent work suggests that most of the high-yielding, small-seeded cultivars extensively grown in Latin America such as 'Carioca', 'ICA Pijao', 'Rio Tibagi', 'Jamapa', 'Porrillo Sintético', and others possess negative general combining ability (GCA) for seed yield (Nienhuis and Singh, 1988a). Thus, crosses among parents within this group would result in little or no additive genetic variance for selection to be effective. Positive GCA for seed yield could be found in medium-seeded germplasm belonging to races Durango and Jalisco and in some large-seeded germplasm belonging to race Nueva Granada (Nienhuis and Singh, 1988a; Singh *et al.*, 1992). Moreover, seed yield is a dependable selection criterion in early generations of common bean populations, when both bulk populations (Nienhuis and Singh, 1988b; Singh *et al.*, 1990, 1991b) and pedigree selections (Singh and Gutiérrez, 1990) are used. No yield gains could be made from populations within small-seeded common beans irrespective of selection environments (Singh and Gutiérrez, 1990; Singh *et al.*, 1989b). On the contrary, significant progess could be made from interracial populations involving diverse and high-yielding parents possessing positive GCA for seed yield (Singh *et al.*, 1989a; Singh and Gutiérrez, 1990). Evidence supporting this claim could also be seen by examining the pedigree of the three highest yielding lines, A 774, A 775, and A 785, from the SCS (Table II). A 774 and A 775 are sister lines selected from an interracial multiple-parent population BZ 5687 = BAT 85 x [(A 375 x G 17702) x (A 445 x XAN 112)]. A 785 also originated from a similar population BZ 5838 = [(A 373 x XAN 93) x (BAT 477 x A 213)] x [(A 375 x G 17702) x (A 445 x XAN 112)]. Parents A 375 and A 445 involved in both populations possess positive GCA for seed yield (Nienhuis and Singh, 1986, 1988a; Singh *et al.*, 1992), have medium-sized seed (25 to 40 g/100-seed weight), and have other characteristics of the race Durango. Thus, we suggest avoiding the use of intraracial populations. Instead, bean breeders should rely on interracial populations involving high-yielding parents possessing positive GCA for seed yield for improving potential productivity of common bean.

CONCLUSIONS

More than ten common bean lines from the second selection cycle outyielded check cultivars Carioca and EMGOPA-Ouro (A 295) in both Brazil and Colombia. Improved lines possessed relatively higher levels of resistance to common bacterial blight, angular leaf spot, anthracnose, rust, and BGMV. The highest yielding lines (e.g., A 774, A 775, and A 785) were derived from interracial populations.

Mean seed yield over five growing seasons at CNPAF-Goiânia correlated positively with yields at EMGOPA-Goiânia, IAPAR-Londrina, EMCAPA-Linhares, IPA-Arcoverde, CNPCO-Poço Verde, and EMPASC-Chapecó in Brazil and CIAT-Palmira and CIAT-Quilichao, Colombia. IPA-Belém do São Francisco, PESAGRO-Campos, EPABA-Irecé in Brazil and CIAT-Popayán in Colombia did not show associations with CNPAF-Goiânia. These last sites need to be used for germplasm development and testing from the beginning for identification and improvement of superior common bean germplasm for specific adaptation to its respective areas. They should also be used for multilocation testing when broadly adapted cultivars are required.

ACKNOWLEDGMENTS

We are grateful to Henry Terán for statistical analysis, Aracelly Fernández for secretarial help, and Bill Hardy for editorial assistance.

RESUMO

No Brasil e na Colombia, mais de dez linhagens do feijoeiro comum, obtidas do segundo ciclo de seleção, foram mais produtivas que as testemunhas cvs. Carioca e EMGOPA-Ouro (A 295). As linhagens

melhoradas mostraram, comparado as testemunhas, maiores níveis de resistência a bacteriose comum, antracnose, ferrugem e virose do mosaico dourado. As de maior rendimento (A 774, A 775, e A 785) foram obtidas de cruzamentos entre raças.

A produção média de grãos avaliada em cinco plantios realizados no CNPAF-Goiânia mostrou-se positivamente correlacionada com os rendimentos obtidos na EMGOPA-Goiânia, IAPAR-Londrina, EMCAPA-Linhares, IPA-Arcoverde, CNPCO-Poço Verde e EMPASC-Chapecó, no Brasil, e CIAT-Palmira e CIAT-Quilichao na Colombia. Todavia, não se detectou associação com as produções observadas no IPA-Belém do São Francisco, PESAGRO-Campos e EPABA-Irecé no Brasil e CIAT-Popayán na Colombia. Essas quatro últimas localidades devem ser usadas desde o início do desenvolvimento e da avaliação de linhagens superiores que sejam específicas para essas áreas e também podem ser usadas para avaliações multilocais, buscando identificar variedades de ampla adaptabilidade.

REFERENCES

Alvarez-Ayala, G. and Schwartz, H.F. (1979). Preliminary investigations of pathogenic variability expressed by *Isariopsis griseola. Annu. Rep. Bean Improv. Coop.* 22: 86-88.

Beaver, J.S., Paniagua, C.V., Coyne, D.P. and Freytag, G.F. (1985). Yield stability of dry bean genotypes in the Dominican Republic. *Crop Sci.* 25: 923-926.

Ghaderi, A., Adams, M.W. and Saettler, A.W. (1982). Environmental response patterns in commercial classes of common bean (*Phaseolus vulgaris* L.). *Theor. Appl. Genet.* 63: 17-22.

Kelly, J.D., Adams, M.W. and Varner, G.V. (1987). Yield stability of determinate and indeterminate dry bean cultivars. *Theor. Appl. Genet.* 74: 516-521.

Menezes, J.R. and Dianese, V.C. (1988). Race characterization of Brazilian isolates of *Colletotrichum lindemuthianum* and detection of resistance to anthracnose in *Phaseolus vulgaris. Phytopathology* 78: 650-655.

Nienhuis, J. and Singh, S.P. (1986). Combining ability analyses and relationships among yield, yield components, and architectural traits in dry bean. *Crop Sci.* 26: 21-27.

Nienhuis, J. and Singh, S.P. (1988a). Genetics of seed yield and its components in common bean (*Phaseolus vulgaris* L.) of Middle-American origin. I. General combining ability. *Plant Breed.* 101: 143-154.

Nienhuis, J. and Singh, S.P. (1988b). Genetics of seed yield and its components in common bean (*Phaseolus vulgaris* L.) of Middle-American origin. II. Genetic variance, heritability and expected response from selection. *Plant Breed.* 101: 155-163.

Patiño, H. and Singh, S.P. (1989). Visual selection for seed yield in the F_2 and F_3 generations of nine common bean crosses. *Annu. Rep. Bean Improv. Coop.* 32: 79-80.

Santos, J.B., Bello, N.A. and Ramalho, M.A.P. (1982). Stability of grain yield and of its components in beans (*Phaseolus vulgaris* L.). *Rev. Bras. Genet.* 4: 761-772.

Schoonhoven, A. van and Voysest, O. (1989). Common beans in Latin America and their constraints. In: *Bean production problems in the tropics* (Schwartz, H.F. and Pastor-Corrales, M.A., eds.). CIAT, Cali, Colombia, pp. 33-57.

Singh, S.P. (1989). Patterns of variation in cultivated common bean (*Phaseolus vulgaris*, Fabaceae). *Econ. Bot. 43*: 39-57.

Singh, S.P. (1991). Breeding for seed yield. In: *Common beans: research for crop improvement* (Schoonhoven, A. van and Voysest, O., eds.). C.A.B. Intl., Wallingford, U.K., and CIAT, Cali, Colombia, pp. 383-443.

Singh, S.P. (1992). Common bean improvement in the tropics. *Plant Breed. Rev. 10*: 199-269.

Singh, S.P., Cajiao, C., Gutiérrez, J.A., García, J., Pastor-Corrales, M.A. and Morales, F.J. (1989a). Selection for seed yield in inter-gene pool crosses of common bean. *Crop Sci. 29*: 1126-1131.

Singh, S.P., Gepts, P. and Debouck, D. (1991a). Races of common bean (*Phaseolus vulgaris*, Fabaceae). *Econ. Bot. 45*: 379-396.

Singh, S.P. and Gutiérrez, J.A. (1984). Geographical distribution of the *Dl1* and *Dl2* genes causing hybrid dwarfism in *Phaseolus vulgaris* L., their association with seed size, and their significance to breeding. *Euphytica 33*: 337-345.

Singh, S.P. and Gutiérrez, J.A. (1990). Selection for seed yield in three plant densities of two population types of common bean, *Phaseolus vulgaris* L. *Euphytica 51*: 173-178.

Singh, S.P., Lépiz, R., Gutiérrez, J.A., Urrea, C., Molina, A. and Terán, H. (1990). Yield testing of early generation populations of common bean. *Crop Sci. 30*: 874-878.

Singh, S.P., Urrea, C., Gutiérrez, J.A. and García, J. (1989b). Selection for yield at two fertilizer levels in small-seeded common bean. *Can. J. Plant Sci. 69*: 1011-1017.

Singh, S.P., Terán, H., Molina, A. and Gutiérrez, J.A. (1991b). Genetics of seed yield and its components in common beans (*Phaseolus vulgaris* L.) of Andean origin. *Plant Breed. 107*: 254-257.

Singh, S.P., Terán, H., Molina, A. and Gutiérrez, J.A. (1992). Combining ability for seed yield and its components in common bean of Andean origin. *Crop Sci. 32*: 81-84.

Thung, M. (1990). Phosphorus: A limiting nutrient in bean (*Phaseolus vulgaris* L.) production in Latin America and field screening for efficiency and response. In: *Genetic aspects of plant mineral nutrition* (El Bassam, N., Dambroth, M. and Loughman, B.C., eds.). Kluwer, Dordrecht, Netherlands, pp. 501-521.

Vieira, A.L., Ramalho, M.A.P. and dos Santos, J.B. (1989). Crossing incompatibility in some bean cultivars utilized in Brazil. *Rev. Bras. Genet. 12*: 169-171.

Vieira, C. (1983). *Doenças e pragas do feijoeiro*. Universidade Federal, Viçosa, Brazil.

Voysest, O. and Dessert, M.J. (1991). Bean cultivars: classes and commercial seed types. In: *Common beans: research for crop improvement* (Schoonhoven, A. van and Voysest, O., eds.). C.A.B. Intl., Wallingford, U.K. and CIAT, Cali, Colombia, pp. 119-162.

White, J.W. and González, A. (1990). Characterization of the negative association between seed yield and seed size among genotypes of common bean. *Field Crops Res. 23*: 159-175.

White, J.W., Singh, S.P., Pino, C., Rios, M.J.B. and Buddenhagen, I. (1992). Effects of seed size and photoperiod response on crop growth and yield of common bean. *Field Crops Res. 28*: 295-307.

Zimmermann, M.J.O., Rocha, M. and Yamada, T. (eds.). (1988). *Cultura do feijoeiro: factores que afetam a produtividade*. Associação Brasileira para Pesquisa da Potassa e do Fosfato, Piracicaba, São Paulo, Brazil.

(Received February 4, 1992)