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# Breeding methods and history of bean cultivars released in CBAB - Crop Breeding and Applied Biotechnology

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**ABSTRACT** - *Common bean is a staple food of great economic and social importance and breeding programs are being carried out in different institutions in Brazil and abroad. Aiming to determine how many new cultivars were presented in the journal CBAB - Crop Breeding and Applied Biotechnology and which breeding methods were used to develop the new genotypes, a historical survey of CBAB from 2001 to 2008 was carried out. During this period, 23 new common bean cultivars were described in CBAB, of which all but two that were bred at universities had been developed by public research institutes. The most commonly used breeding method was the pedigree, followed by bulk and the single pod descent (SPD) method. Since the preference of Brazilian consumers for carioca and black grain beans is noticeable, most bean breeders in the country have focused their research on these two bean types.*

***Key words****: Phaseolus vulgaris* L., breeding, development of new genotypes.

## INTRODUCTION

Common beans are consumed in Brazil by all social classes. Particularly for the portion of the low-income population common bean is the main source of protein, minerals and vitamins (Carbonell et al. 2008a). Around the world, an average of 27 million hectares is planted every year and approximately 20 million tons of beans are harvested in more than 100 countries, of which Brazil is the largest producer (Chiorato et al. 2008).

The establishment of bean cultivars that satisfy farmers as well as consumers involves dedication of the breeders in research work in genetics and plant breeding. Aside from yield, the main target traits in the improvement of the crop are grain type and size besides pathogen resistance.

For the grain type, breeding should take the consumers' preference into account. It is known that carioca grain is the most consumed in all the country, accounting for 79% of the total consumption, followed by black beans with 17%, and other types representing 4% of the national consumption (Faria et al. 2008). For this reason more effort is spent on breeding programs to obtain cultivars with carioca grain. Other traits related to the grain type, such as little browning during storage and ease of cooking should also be observed (Faria et al. 2004).

For growth habit, the improvement targets are more upright plants (with determinate or type I growth habit), of which cultivation is easier and crop losses and pathogen incidence are lower. The yields of such plants is however lower than of plants with indeterminate growth habit (type II, III and IV) (Silva et al. 2006).

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In terms of disease resistance, the use of resistant cultivars has been the most effective control method (Abreu et al. 2007). Among the most important diseases of common bean are anthracnose (caused by *Colletotrichum lindemuthianum*) and angular leaf spot (caused by *Phaeoisariopsis griseola*) (Costa et al. 2006).

Common bean is an autogamous and also cleistogamous plant. Due to this pollination system, bean cultivars are normally a pure line or a mixture of several pure lines. Since the genetic constitution of the plants will remain unchanged over successive generations, farmers can produce seeds from their own crops.

The following breeding methods are mostly used for autogamous plants: population or bulk, genealogical or pedigree and the single seed descent (SSD) method. A variation of the SSD is used for common bean, called Single Pod Descent (SPD) method, where the generations are advanced using a pod rather than a seed of each plant (Peloso et al. 2004).

The common bean improvement programs in Brazil are restricted to and predominantly concentrated in the public sector. First programs were initiated around 1930, but most activities began after 1970 (Voysest 2000). According to Matos et al. (2007), the contributions of any breeding program, especially when resources are limited, should periodically be critically analyzed and new methodologies sought for that could improve the efficiency.

The purpose of this study was a diagnosis of the release and announcement of bean cultivars in the journal Crop Breeding Applied Biotechnology, the main scientific journal in the field of plant breeding in Brazil between 2001 and 2008, identifying the main improved characteristics and most commonly used breeding methods.

## MATERIAL AND METHODS

All published volumes of the journal CBAB - Crop Breeding Applied Biotechnology from January 2001 to December 2008 were consulted for a literature review of the announcement of the release of new bean cultivars. These articles in the CBAB report the main characteristics of each new cultivar and describe the breeding methods used and the research institutions involved.

## RESULTS AND DISCUSSION

In the studied period, 23 new bean cultivars were released CBAB (Table 1). Ten of these were obtained by Empresa Brasileira de Pesquisa Agropecuária (Embrapa), in Goiania, where the institution does most of its research on rice and beans. Two of these cultivars were obtained by Embrapa Rice and Beans in partnership with federal universities in the state of Minas Gerais (Universidade Federal de Viçosa - UFV and Universidade Federal de Lavras - UFLA) and a research company of the same state (Empresa de Pesquisa Agropecuária de Minas Gerais - EPAMIG). Cultivar BRS Horizonte was obtained in a partnership of Embrapa Rice and Beans and the International Center for Tropical Agriculture (CIAT).

It is noteworthy that only in two cases public universities were involved in the release of cultivars announced in the CBAB journal, whereas federal or state research institutions were involved in the development of 100% of the cultivars reported in CBAB. In general, the main objective of universities is to training researchers, aside from the operational and financial difficulties of maintaining relatively large experiments over several years, which is an essential factor for the development of a cultivar. There are few common bean breeding programs in Brazil, and in view of the nation-wide importance of the crop, the number of breeders is still low. The interest of private seed companies in maintaining their own breeding program is also small. Thus, the responsibility to obtain new lines that can advantageously replace the existing will rest with programs of the public sector, namely of universities, the Embrapa and other state companies (Matos et al. 2007).

To obtain common bean cultivars the pedigree or also called genealogical method was most commonly used. It was used in 48 % of the cultivars announced in CBAB, alone or in combination with other methods. In the pedigree method, plants of the segregating population are individually evaluated and selected. Thus, each generation should be grown in the representative region and planting time of the environment where the cultivar will be used (Borém and Miranda 2005). Perhaps for this reason, this method was only used in the later generations, as in the cases of the cultivars IAPAR 81, IPR Graúna and IPR Juriti (Moda-Cirino et al. 2001b Moda-Cirino et al. 2003a, Moda-Cirino et al. 2003b).

It should be emphasized that when the population is advanced by the pedigree method, the progeny is derived from a plant. Thus, in most cases the available seed quantity limits the use of a larger number of plots, replications and/or locations for evaluation. Therefore, the experimental conditions in the field trials with a view to uniform plant stands must be planned very carefully. Also, the

**Table 1**. Grain type, breeding methods used and developing institutions of common bean cultivars whose release was announced in the journal CBAB - Crop Breeding and Applied Biotechnology between 2001 and 2008

| Cultivars | Grain | Method* | Institution | Reference |
|---|---|---|---|---|
| IAPAR 80 | Carioca | Pedigree | IAPAR | Moda-Cirino et al. (2001a) |
| IAPAR 81 | Carioca | SPD/Pedigree | IAPAR | Moda-Cirino et al. (2001b) |
| IPR88 Uirapuru | black | Pedigree | IAPAR | Moda-Cirino et al. (2001c) |
| Carnaval | brown with purple spots | Introduction Germplasm | EPAMIG | Vieira et al. (2002) |
| IPR Graúna | black | SPD/Pedigree | IAPAR | Moda-Cirino et al. (2003a) |
| IPR Juriti | Carioca | SPD/Pedigree | IAPAR | Moda-Cirino et al. (2003b) |
| BRS Radiante | striped | Bulk/SPD | Embrapa[1] | Faria et al. (2003) |
| BRS Valente | black | Bulk/SPD* | Embrapa[1] | Peloso et al. (2003) |
| BRSMG Talismã | Carioca | Recurrent selection | Partnership[2] | Abreu et al. (2004) |
| BRS Pontal | Carioca | Bulk/SPD | Embrapa[1] | Peloso et al. (2004) |
| BRS Requinte | Carioca | Bulk | Embrapa[1] | Faria et al. (2004) |
| Jalo MG-65 | yellow | Germplasm Introduction | EPAMIG | Vieira et al. (2004) |
| BRS Pitanga | purple | Bulk | Embrapa[1] | Rava et al. (2005) |
| BRS Horizonte | Carioca | Pure/inbred lines | Partnership[3] | Melo et al. (2005) |
| BRS 7762 Supremo | black | Bulk/SPD | Embrapa[1] | Costa el al. (2006) |
| BRSMG Majestoso | Carioca | Bulk | Partnership[2] | Abreu et al. (2007) |
| IAC-Alvorada | Carioca | Pedigree | IAC | Carbonell et al. (2008b) |
| IAC-Boreal | striped | Pedigree | IAC | Chiorato et al. (2008) |
| IAC-Centauro | light brown | Pedigree | IAC | Carbonell et al. (2008a) |
| IAC-Diplomata | black | Pedigree | IAC | Carbonell et al. (2008b) |
| IAC-Galante | pink | Pedigree | IAC | Carbonell et al. (2008a) |
| IAC-Harmonia | striped and speckled | Pedigree | IAC | Chiorato et al. (2008) |
| BRS Cometa | Carioca | Bulk | Embrapa[1] | Faria et al. (2008) |

* SPD: Descent from a single pod.
[1] Embrapa Arroz e Feijão; [2] Embrapa Arroz e Feijão/UFLA/UFV/EPAMIG; [3] Embrapa Arroz e Feijão/CIAT.

importance of an adequate plant management should be observed due to its influence on the experimental accuracy and selection success (Moreto et al. 2007). The institutions that used this method most were the Instituto Agronômico do Paraná (IAPAR) and the Instituto Agronômico de Campinas (IAC).

The bulk method was used alone or combined with other breeding methods in the development of 35% of the cultivars reported by CBAB during the considered period. In four cases it was used alone and in four other cases it was associated with the Single Pod Descent (SPD) method. In the latter case, for the early generations of the populations the bulk method was used, with *Colletotrichum lindemuthianum* inoculation, to eliminate susceptible plants. The remaining population was conducted by the SPD method (Costa et al. 2006). The bulk method was most used for improvement by Embrapa Rice and Beans.

The bulk method was proposed in the early 20th century; in this method the plants from $F_2$ onwards are harvested in bulk, from which a seed sample is taken to obtain the $F_3$ generation. The process is repeated for a few generations. Then the plants are harvested individually (opening of the bulk) and give rise to families that are evaluated in an experiment with replication, until identifying superior lines (Allard 1971). An important question regarding this method is about the correct moment for the bulk opening which usually happens in the $F_5$ generation, when 93.75% of homozygosis is expected. From this point onwards, there is no advantage in the maintenance of the bulk, since the increase in the proportion of homozygotes is small. However, the method is known for its flexibility, enabling a delay, in case of lack of resources, of the opening of the bulk until a more appropriate moment. Besides, over the generations, the population is exposed to natural selection, subjecting the plants to competition (Vieira et al. 1999).

The Single Pod Descendant (SPD) method was adopted to obtain seven cultivars from different populations. As already mentioned, for four of these cultivars this method was used in combination with the

bulk and for three other cultivars, together with the pedigree method. In the association of SPD with pedigree, the early segregating populations ($F_2$, $F_3$ and $F_4$) were obtained by SPD and then the progeny was selected and conducted by the pedigree method to more advanced generations ($F_7$, $F_8$) (Moda-Cirino et al. 2003a). This association was only used at the Instituto Agronômico do Paraná (IAPAR).

According to Vieira et al. (1999), the SPD method is widely used to obtain common bean cultivars, taking advantage of the fact that sampling losses can be reduced and segregating generations advanced requiring less labor and space. In most Brazilian states, where up to three growing seasons per year are possible, time savings in advancing generations are rather significant.

To obtain the cultivars Carnaval and Jalo MG-65, both developed by EPAMIG, germplasm was introduced. According to Vieira et al. (1999) this method is rather widespread, particularly in the case of germplasm from CIAT. The development of some common bean cultivars that were widely used in Brazil such as 'Rico 23' and 'Capixaba Precoce' was based on the introduction of germplasm from abroad. In this method the accessions are released as cultivar after assessments in experiments in representative regions; the great advantage is the almost immediate availability of superior genotypes, similar to those developed in breeding programs (Borém and Miranda 2005).

The selection of inbred lines was the method used to obtain a plant variety obtained by the partnership of Embrapa Rice and Beans with CIAT. The selection method of inbred lines is based on the selection of individual plants in the original population, followed by the evaluation of the progenies (Allard 1971). In the bean cultivars obtained by this method, the inbred lines were selected in a segregating population originating from controlled crosses rather than from heterogeneous populations, based on mutations, mechanical seed mixing or natural crosses, as originally proposed by the method.

Finally, recurrent selection, a method originally developed based on an alogamous plant, was used to obtain the cultivar BRSMG Talisman, resulting from a partnership project of Embrapa Rice and Beans, UFLA, UFV and EPAMIG (Abreu et al. 2004). According to Ramalho et al. (2005), this method consists of performing re-selection generation after generation, intercrossing the selected genotypes to achieve genetic recombination. Recurrent selection is therefore a cyclical and continuous process, which involves the development of individuals or families, the assessment, selection and intercrossing of superior genotypes, aiming at a higher frequency of favorable alleles and, consequently, a better expression of the trait under selection (Cargnin 2007). The advantage of this method is that the yield a cultivar can achieve is not determined by an original plant only, but by the most favorable combination of existing genes in a group of original plants.

With regard to the grain type (Table 1), 43.5 % of the new cultivars have carioca grain, in other words, striped, cream colored grains. According to Faria et al. (2008), carioca grain is the most consumed throughout the country, accounting for about 80% of the total consumption. The cultivars with carioca grain probably have cultivar Carioca as common ancestor, which according to Ramalho (personal communication) is the most productive in the absence of diseases, even compared to newer cultivars with this grain type. Cultivars with black grain represent 21.75% of the cultivars released in the studied period. According to Carbonell et al. (2008b), the consumer demand is highest for cultivars with carioca and black grain, which are therefore of greatest interest for researchers.

According to Singh (2001), remarkable efforts to collect, characterize, and evaluate the genetic diversity in common bean have been made in the second half of the 20$^{th}$ century. Likewise, the main yield limits and deficient traits in bean cultivars were determined. The main achievements of several decades of bean breeding include early cultivars adapted to higher latitudes and with high yields and new cultivars with increased production of better quality pods and seeds, erect growth habit and disease, pest and drought resistance. However, the genetic base of commercial cultivars within specific market classes is narrow. The overall average yield of bean is still low (below 900 kg ha$^{-1}$), and production is affected by a wide range of restrictions of biotic and abiotic stresses causing some loss in total production. This makes the importance of breeding for this species evident and the need to ensure the continuity of such programs, targeting high-quality cultivars that are suitable for sustainable production systems.

# Métodos de melhoramento e histórico de cultivares de feijoeiro lançadas na CBAB - Crop Breeding and Applied Biotechnology

**RESUMO -** *O feijoeiro comum é um alimento de grande importância econômica e social, sendo objeto de estudo de programas de melhoramento de diferentes instituições no Brasil e no exterior. O objetivo deste trabalho foi fazer um diagnóstico das cultivares de feijoeiro que tiveram seu lançamento divulgado na revista CBAB - Crop Breeding and Applied Biotechnology, entre 2001 e 2008, identificando os métodos de melhoramento utilizados para a sua obtenção. Neste período, foram lançadas 23 cultivares de feijoeiro e todas foram obtidas por institutos públicos de pesquisas e em apenas duas delas houve participação de universidades. O método de melhoramento mais utilizado foi o Pedigree, seguido pelo Bulk e pelo Descendente de uma Única Vagem (SPD). Os grãos do tipo carioca e do tipo preto são os que têm maior aceitação dos consumidores, sendo os de maior interesse dos melhoristas.*

***Palavras-chave:*** Phaseolus vulgaris *L., melhoramento, obtenção de novas cultivares.*

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