CROP BREEDING AND APPLIED BIOTECHNOLOGY

CULTIVAR RELEASE

BRS FS311: common bean cultivar with striped seed coat, high yield, and commercial quality

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Abstract: *BRS FS311 is a cultivar of common bean in the striped seed coat group, with high yield, larger bean grain, and visual appearance suitable for the striped seed coat standard. It also has a cycle of semi-early, upright architecture and moderate resistance to fusarium wilt and anthracnose.*

Keywords: *Plant breeding, grain size, fusarium wilt*

INTRODUCTION

In Brazil, the planted area with common bean is 1.6 million hectares, with production of 2.5 million metric tons and mean yield of 1,536 kg ha^{-1} (CONAB 2021). Currently, Brazil has been the main consumer and producer of common bean (*Phaseolus vulgaris*). Common bean is of great social and economic importance, constituting an important source of protein for the Brazilian population.

Among the types of common bean grain, the carioca (cream colored background with brown streaks) and black seed coat beans are preferred by the majority of consumers and represent approximately 85% of the consumer market (Pereira et al. 2019). However, beans with other types of seed coats are consumed to a lower degree, which have grown as an alternative source for placing a differentiated product with higher commercial value on the domestic market, and have awakened interest in export. These types of beans are denominated special bean grains and include beans of varied size and different colors such as white, red, cream-colored, and yellow seed coats, with and without stripes/streaks (Gonçalves et al. 2010).

Andean beans have received less attention within common beans breeding programs, mainly to those with grain types preferred on international markets, compared to the Mesomaerican carioca and black grain beans. Consequently, a small number of Andean beans are available, resulting in a low production and high imports of these grain (Pereira et al. 2020).

In this respect, the third most important group of common bean in Brazil is the striped/pinto (*rajado*) group, which has seed coats with beige coloring and reddish stripes/streaks and larger bean size in relation to carioca bean, ranging from 35 to 40 g 100 seeds^{-1}. In addition, the grain of this commercial group has

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export potential. Some cultivars of this group have already been developed, although; BRSMG Realce is currently the most used (Melo et al. 2014, Pereira et al. 2020).

BREEDING METHODS

The cross between the lines PR 93201472 and 200105594 originated the BRS FS311, in 2001. In 2002, the F_1 generation was sown in screened enclosures. In the same year, was sown in the field in Ponta Grossa, PR (rainy crop season) the F_2 generation, in bulk population, and selection was made for reaction to rust (*Uromyces phaseoli*), anthracnose (*Colletotrichum lindemutianum*) and common bacterial blight (*Xanthomonas axonopodis* pv. *phaseoli*), and. In May 2003, the segregating population in the F_3 generation was sown and the selection was carried out for yield and plant architecture.

In January 2004, dry crop season, was advanced in Ponta Grossa, Paraná the F_4 generation, in bulk population, with selection of individual plants based on resistance to common bacterial blight, rust and anthracnose. In the winter crop season, also in 2004, the progenies in the $F_{4:5}$ generation were sown in Santo Antônio de Goiás in individual rows, and the best plants were selected based on yield and plant architecture. In the winter crop season of 2005, the progenies in the $F_{4:6}$ generation were sown in Santo Antônio de Goiás, where progenies were selected based on plant architecture and yield.

In the dry season of 2006, the progenies in the $F_{4:7}$ generation were sown in individual rows in Ponta Grossa. based on resistance to rust, anthracnose, and common bacterial blight, individual plants (lines) were selected among the progenies. In 2006, rainy season, the F4:7:8 generation were selected in Ponta Grossa based on resistance to anthracnose, rust, common bacterial blight, and yield. In 2007, winter crop season, the remaining lines, in the $F_{4:7:9}$ generation, were evaluated once more, and the line LMC207208933 was selected, based on plant architecture and yield. From this step on, this line received the pre-commercial name CNFRJ 15411.

In 2008, the line CNFRJ 15411 was evaluated in a striped/pinto progeny trial, composed of 24 treatments, consisting of 22 new lines and 2 check cultivars (BRS Radiante and Iraí). The experimental model used was that of randomized block with three replications, and plots consisted of two rows of 4 meters with the spacing between lines of 0.50 meters. The trials were set up in Ponta Grossa, PR, in the dry and rainy seasons, and in the winter crop season in Santo Antônio de Goiás, GO. In these trials, we evaluated plant architecture, reaction to common bacterial blight, resistance to lodging and grain yield. Combined analysis of these data led to selection of the line CNFRJ 15411 for participation in the preliminary striped/pinto bean trial.

In 2009, the line CNFRJ 15411 was evaluated in the preliminary striped/pinto bean trial, composed of 16 treatments, consisting of 14 lines and 2 check cultivars (BRS Radiante and Iraí). The experimental model used was that of randomized block with three replications, and plots consisted of two rows of 4 meters with the spacing between lines of 0.50 meters. The trials were conducted, in the winter crop season, in Santo Antônio de Goiás, GO, and in the rainy season, in Ponta Grossa, PR. These trials allowed evaluation of cycle, plant architecture, grain yield, resistance to lodging and reaction to diseases rust, common bacterial blight, angular leaf spot anthracnose and fusarium wilt. Based in the combined analysis of these data, line CNFRJ 15411 was selected to participate in the preliminar striped/pinto bean trial.

The line CNFRJ 15411 was evaluated in an intermediate striped/pinto bean trial composed of 14 treatments, consisting of 11 new lines and 3 check cultivars (BRS Radiante, Iraí, and BRSMG Realce). In 2011, the experimental model used was that of randomized block with three replications, and plots consisted of two rows of 4 meters with the spacing between lines of 0.50 meters. The trials were evaluated in Santo Antônio de Goiás, GO, in the dry and winter seasons, and in Ponta Grossa, PR, in the rainy and dry seasons. These trials allowed evaluation of cycle, reaction to diseases angular leaf spot, powdery mildew (*Erysiphe polygoni*) and anthracnose, resistance to lodging and plant architecture. Combined analysis of the data from the preliminary and intermediate trials led to selection of the line CNFRJ 15411 for the Value for Cultivation and Use (VCU) trail, based on evaluation in six environments. In the winter season of 2010, lines were multiplied to prepare the VCU trials.

The line CNFRJ 15411 was evaluated in 31 VCU experiments composed of 10 genotypes with striped/pinto seed types: 8 lines and the check cultivars BRS Radiante and BRSMG Realce from 2013 to 2015. This same line was also evaluated

in a new VCU trial in 2016 and 2017 in 40 experimental trials composed of 10 treatments – 8 new lines and the same 2 check cultivars. The random block design was used with three replications, and plots consisted of four rows of 4 meters with the spacing between lines of 0.50 m.

These trials allowed evaluation of the following aspects related to the bean grain: 100-seed weight, yield, visual evaluation, and cooking time. The following aspects were also evaluated, through a scoring scale ranging from 1 (totally favorable phenotype) to 9 (totally unfavorable phenotype) (Melo 2009): plant architecture, resistance to lodging, and reaction to anthracnose, common bacterial blight, angular leaf spot, bacterial wilt, fusarium wilt, white mold and powdery mildew.

The yield was corrected to 13% grain moisture and, later, was estimated in kg ha^{-1}. For 100-seed weight, a random 100-bean sample was removed from each plot and weighed. In the best trials (higher mean yields and lower coefficients of variation), samples were removed to analyze cooking time and protein content. For the evaluation of cooking time, the grains were soaked in distilled water at ambient temperature at the proportion of 1:4 (w/v). After 16 hours, the water was discarded. The beans were placed in a Mattson cooker and the cooking time was determined from the time the water boiled to the time at which the rods of the Mattson cooker penetrated 50% + 1 bean. Using bean grain meal (beans ground in a ball mill) was analyzed the protein content. The nitrogen content was determined by the micro-Kjeldahl method (Proctor and Watts 1987).

Yield potential and grain yield

Of the 71 trials set up, 52 were harvested and achieved the standards of experimental quality necessary to be considered in the cultivar registration process in relation to yield data. From 2013 to 2017, these 52 VCU trials were conducted in Region I (São Paulo, Paraná and Santa Catarina) in the rainy and dry seasons, and in Region II (Goiás, Mato Grosso, Espírito Santo, Minas Gerais and Distrito Federal) in the winter, dry and rainy seasons. In the region I, the mean yield of BRS FS311 was similar to those of the check cultivars, according to the Scott-Knott test (Table 1). In Region II, BRS FS311 had higher yield than BRSMG Realce and BRS Radiante, representing 5% and 4.8% superiority, respectively. The cultivar BRS FS311 (CNFRJ 15411) also had overall mean yield superior to that of the check cultivars, with 4.6% superiority in relation to the best check cultivar, BRSMG Realce (Table 1).

Table 1. Mean yield of BRS FS311 compared to those of the check cultivars in the Value for Cultivation and Use trials conducted in three seasons and two regions from 2013 to 2017

Region	Season	BRS FS311	BRS Radiante	BRSMG Realce	Number of evaluated environments
		(kg ha^{-1})			
I	Rainy	2,037a	1,824a	1,953a	12
	Dry	1,301a	1,397a	1,284a	03
	Overall	1,890a	1,738a	1,819a	15
II	Rainy	1,872a	1,865a	1,745a	11
	Dry	1,607a	1,491a	1,217a	02
	Winter	2,395a	2,254a	2,315a	24
	Overall	2,197a	2,097b	2,086b	37
Overall	-	2,108a	1,993b	2,009b	52

Region I – PR, RS, MS, SP and SC; Region II – ES, MG, MT, GO, BA, DF, TO, RJ and MA. Mean scores followed by the same letter in the rows do not differ statistically from each other according to the Scott-Knott method at 5% probability.

With the average of the five trials with the highest yields, was obtained the yield potential of BRS FS311 (3,493 kg ha^{-1}). This estimate shows high genetic potential and that if the environment is favorable, high yields can be achieved.

OTHER TRAITS

In relation to traits of grain industrial and technological quality, the cultivar BRS FS311 has a mean 100-seed weight of 40 grams, superior to that of the check cultivars. The bean grain is striped/pinto type (cream-colored background

Table 2. The common bean cultivar BRS FS311 compared to those of the check cultivars for grain traits

Cultivar	**GCT** (min.)	**GPC** (%)	**100 Seed Weight** (g)
BRS FS311	39.2	20.2	40
BRS Radiante	45.8	19.5	39
BRSMG Realce	44.9	20.7	37

GCT - Grain Cooking Time; GPC - Grain Protein Content.

Table 3. Reaction to diseases and agronomic traits of the cultivar BRS FS311 compared to the check cultivars

Cultivar	CBB	AN	ALS	CM	FW	GM	BW	RR	ARQ	Cycle
BRS FS311	MS	R	MS	R	MR	S	MS	MS	Upright	SE
BRS Radiante	S	R	MS	R	MR	S	MR	MS	Semi-upright	E
BRSMG Realce	MS	R	MS	NA	MR	S	MR	MS	Upright	SE

CBB – common bacterial blight; AN – anthracnose; ALS – angular leaf spot; CM – common mosaic; FW – fusarium wilt; GM – golden mosaic; BW – bacterial wilt; RR – root rots; S – susceptible; MS – moderately susceptible; MR – moderately resistant; R – resistant; NA – information not available; ARQ – plant architecture; SE – semi-early; E – early.

with reddish stripes) of medium oblong reniform shape, intermediate brightness, and visual appearance similar to that of the check cultivars. The average cooking time of BRS FS311 was 42 minutes, a little lower than that of the check cultivars BRSMG Realce and BRS Radiante. The grain protein percentage of BRS FS311 (20%) was similar to the check cultivars (Table 2).

The BRS FS311 is resistant to pathotypes 65, 73, 89, 91, and 453 of anthracnose and to common mosaic virus, under artificial inoculation. It was resistant to anthracnose, moderately resistant to fusarium wilt, and moderately susceptible to powdery mildew, common bacterial blight, angular leaf spot, root rots and bacterial wilt, in field trials. However, that cultivar was susceptible to the golden mosaic virus (Table 3).

BRS FS311 has a semi-early cycle (from 75 to 84 days), similar to that of the cultivar BRSMG Realce. The plants are shrub type, with determinate growth habit. The BRS FS311 has good resistance to lodging, upright and is adapted to mechanized harvest, including direct harvest (Table 3). The flowers are white and when the plant matures, the pods are yellow with red streaks.

SEED PRODUCTION

BRS FS311 was registered on 3 July 2019 under number 41035 and protected in 2020 under number 20210028 with the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA). Embrapa will be responsible for the production of basic seeds

CONCLUSIONS

The BRS FS311 cultivar with striped/pinto beans, stands out for its high yield, semi-early cycle, upright plant architecture, with larger beans and visual appearance suitable for the striped/pinto bean grain standard, along with good yield potential. In addition, it has moderate resistance to fusarium wilt and resistance to anthracnose.

The cultivar BRS FS311 is recommended for sowing in the states of Goiás, Bahia, Mato Grosso, Distrito Federal, Tocantins, Espírito Santo and Maranhão (Region II) in the rainy and winter crop seasons and in the states of São Paulo, Mato Grosso do Sul, Santa Catarina, Paraná and Rio Grande do Sul (Region I) in the dry and rainy crop seasons.

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