

## Agronomic and qualitative performance of some special grain bean cultivars

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### Abstract

In Brazil, bean consumption is predominated by grains like carioca, but special grains are gaining space on Brazilian tables and can be a source of income for producers. The objective of this study was to evaluate the agronomic and qualitative performance of common bean cultivars with special grains, aiming to identify those with productive potential and superior technological characteristics. The treatments consisted of nine bean cultivars with special grains: BRS Radiante, BRS Realce, BRS Pitanga, BRSMG Tesouro, BRS Marfim, BRSMG União, IAC Tigre, EPAMIG Ouro Vermelho, and EPAMIG Ouro da Mata. The agronomic (number of pods per plant, number of grains per pod, mass of 100 grains, and grain yield) and qualitative (sieve yield, crude protein, cooking time, percentage of imbibition before and after cooking, percentage of whole grains after cooking, and grain hydration capacity) attributes were evaluated. There were statistical differences between cultivars for the number of grains per pod and mass of 100 grains. The cultivars EPAMIG Ouro Vermelho, BRS Marfim, and BRS Pitanga presented the highest yields, with values of 2,907, 2,871, and 2,608 kg ha<sup>-1</sup>, respectively. There was variability between cultivars for all qualitative attributes. The cultivars BRS Radiante, BRSMG Realce, BRSMG Tesouro, IAC Tigre, and EPAMIG Ouro Vermelho stood out with superior quality grains.

**Keywords:** *Phaseolus vulgaris* L., production component, productivity, technological characteristics of grains.

**Abbreviations:** NS\_ no\_till system, SY\_ sieve yield, PC\_ protein content, CT\_ cooking time, IBEC\_soaking before cooking, IBAC\_soaking after cooking, PGW\_ percentage of whole grains after cooking, HT\_ time for grain hydration, HR\_ hydration ratio.

### Introduction

Bean grains (*Phaseolus vulgaris* L.) represent an important protein source in the diet and are the main product of the diet of more than 400 million people in the tropics. This importance is due especially to the quality and the lower cost of its protein in relation to products of animal origin (Buratto et al., 2009; Perina et al., 2010). Bean beans are also rich in carbohydrates, minerals, unsaturated fatty acids, dietary fiber and B vitamins (Silva et al., 2013).

In Brazil, beans are a traditional and important product in the population's diet where consumption is around 17,4 kg inhabitant<sup>-1</sup> year<sup>-1</sup>, and it is still the largest producer country in the world with 3.0 million tons of grains grown in an area of 2.9 million hectares. It is noteworthy that bean in Brazil, is a relatively cheap source of protein and it has high biological value when associated with cereals rich in sulfur amino acids (Bressani, 1993). In addition, it has importance in food security, being able to reduce malnutrition in developing countries (Reichert et al., 2015).

Despite the large availability of bean cultivars from various commercial groups, the main group of beans grown in Brazil is the carioca type (cream tegument with streaks or brown streaks) and because of this, receives greater attention from research and breeding programs. Special beans are all those that differ from the carioca and black types, and may be

destined for export or not, with colored grains or not (Ferrari and Ramos Junior, 2015). This group is defined by having white, red, cream, yellow integument grains, among others, with absence or presence of streaks or streaks of other colors, and with grains of medium to large size (Blair et al., 2010).

Therefore, an alternative for the diversification of the cultivation and increase of income for the producers would be the adoption of the cultivation of beans of special grains, making available, in the internal and external market, a differentiated product and with greater added value, that is, a gourmet product. However, there is a lack of research and technical information on the performance of these cultivars in this commercial group, especially in relation to adaptation to cultivation sites and productive potential.

The importance of research on the adaptation and production stability of bean cultivars in different regions and environments is known (Pereira et al., 2012; Pereira et al., 2017). For cultivars from less widespread commercial groups, such as the special group, these studies are even more important, given the scarcity of information for these cultivars. Once launched, cultivars with wide adaptation and production stability lead to high economic benefits and income generation, reaching values close to US \$ 106 million (Silva and Wander, 2015).

In addition to productivity and adaptation to the place of cultivation, attributes or technological / qualitative characteristics of the grains are desirable in bean cultivars to satisfy consumer requirements (Carbonell et al. 2010). According to Lemos et al. (2015), the commercial group to which a bean cultivar belongs brings together attributes related to the quality of grains, encompassing the technological characteristics represented by three properties: commercial, culinary and nutritional. Commercial quality means the type of grain formed by the characteristics of color, brightness, shape and size. Culinary quality is formed by the characteristics of hydration capacity, cooking time, color of the broth, flavor and texture. Nutritional quality is made up of crude protein, amino acids, carbohydrates, minerals, among others.

In view of the above, the objective was to evaluate the agronomic and qualitative performance of common bean cultivars with special grains, aiming to identify those with productive potential and with superior technological characteristics.

## Results and discussion

### *Agronomic attributes of the grains*

The precision of the results through the verification of the variation coefficient (VC), was 20.4%, 9.9%, 5.3% and 19.1%, for the number of pods per plant, number of grains per pod, mass of 100 grains and grain yield, respectively (Table 1). These values demonstrated the proper conduct of the experiment, and the CVs found are below the limits considered acceptable for beans, where the number of pods per plant is 26.30%, the number of grains per pod is 18.35%, mass of 100 grains is 11.30% and grain yield is 24.86% (Oliveira et al., 2009).

It was verified for the components of production, number of grains per pod and mass of 100 grains, as well as for the grain yield that showed significant differences between bean cultivars. However, there was no difference between bean cultivars for the number of pods per plant that ranged from 9.5 to 14.7 obtained by cultivars BRSMG Realce and BRS Pitanga. For the number of grains per pod, EPAMIG Ouro Vermelho and BRSMG Tesouro obtained the highest values, compared to the others (Table 1).

As for the mass of 100 grains, IAC Tigre (38.5 g) and BRSMG União (37.7 g) cultivars had the highest values, differing significantly from the others (Table 1). It should be noted that the mass of 100 grains of the cultivars varied from 38.5 to 20.2 g, obtained by IAC Tigre and BRS Pitanga, respectively. The size of the grains, expressed by the mass of 100 grains, varies according to the cultivar, being an attribute very influenced by the environment and of great importance for the consumer market (Carbonell et al., 2010; Perina et al., 2010). It is noteworthy that for special grain cultivars, no reference or citation was found in the literature that indicated the ideal value for this response variable.

According to Pereira et al. (2012) the mass of 100 grains, for the carioca type, preferred by the consumer must be above 25 g 100<sup>-1</sup> grains. Thus, using this reference as a basis for discussion, it can be inferred that all the cultivars studied showed extremely satisfactory performance regarding this attribute, except for BRSMG Tesouro and BRS Pitanga with 20.2 and 23 g, respectively. However, these values are in accordance with that recommended by Embrapa for the two cultivars, which are 21.9 and 20.2 g, respectively.

The bean cultivars differed for grain yield, which ranged from

1,798 to 2,907 kg ha<sup>-1</sup>, being obtained by BRSMG Realce and EPAMIG Ouro Vermelho, respectively, that is, variation of 1,109 kg of grains which is equivalent to more of 18 bags of beans (Table 1). The cultivars BRS Ouro Vermelho, BRS Marfim and BRS Pitanga with 2,907, 2,871 and 2,608 kg ha<sup>-1</sup> stood out with the highest grain yield, showing the color of the red, mulatinho / light brown and purple tegument, respectively (Table 5 and 1). These values are close to the average for the State of São Paulo, which was 2,741 kg ha<sup>-1</sup> for beans of the Carioca type in the winter harvest with the use of irrigation (IEA, 2018), which shows the productive potential of these aforementioned cultivars.

Bean grain yield is the result of a combination of its components, such as the number of pods per plant or per unit area, the number of grains per pod and the mass of grains, being influenced by genetic and environmental factors (Fageria et al., 2015). Depending on the conditions, some production components may increase and others may decrease, facilitating the maintenance of grain productivity stability (Costa et al., 1983). As shown in Figure 1, during the conduction of the experiment, the climatic conditions remained in the ideal range for the vegetative and reproductive development of the bean (Portugal et al., 2015), a fact that is proven by the satisfactory grain yields obtained by the cultivars. The air temperature should not exceed 29 °C day<sup>-1</sup> to achieve high potential yields. Temperatures about 35 °C may cause losses in grain yield due to the abortion of flowers and pods, reduction of the number of grains per pod, grains with less dry mass and uneven distribution of pods in the plant. In addition, there is a reduction in the plant cycle, with less time for filling the grains (Silva et al., 2014).

Thus, the cultivar EPAMIG Ouro Vermelho obtained the highest grain yield due to the high number of grains per pod. The cultivar BRS Pitanga stood out in terms of grain productivity due to the higher number of pods per plant. The cultivar BRS Marfim also stood out in relation to grain productivity due to obtaining values for production components close to the experimental average.

### *Qualitative attributes of the grains*

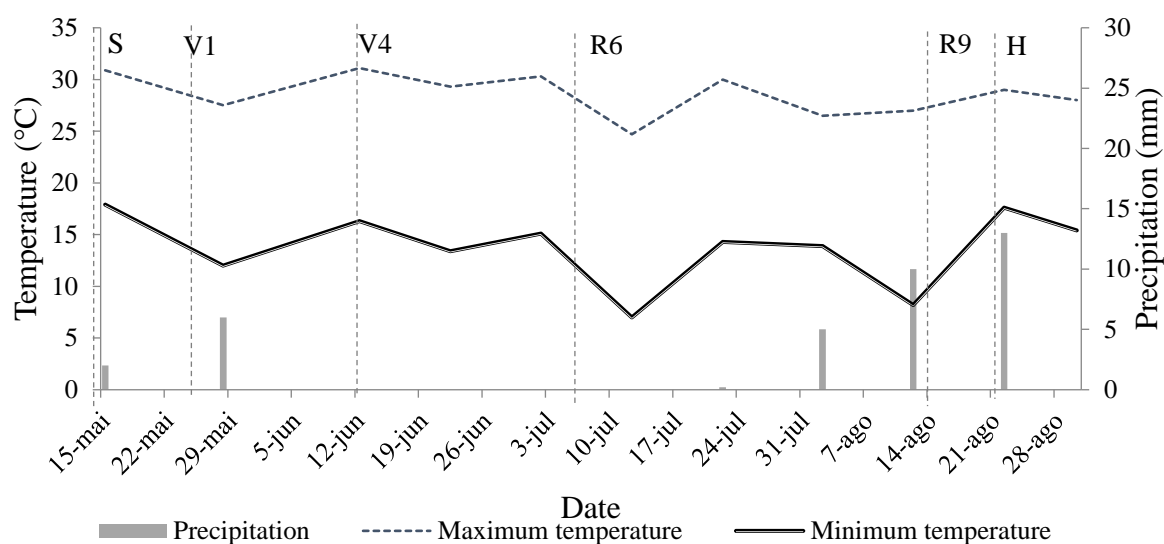
Regarding the qualitative attributes, in the study referring to the grain size of the cultivars, there was a significant difference in all classification screens (Table 2). For Carbonell et al. (2010) a bean cultivar must have SY<sub>≥12</sub> above 70%, which represents coarse grains and with greater financial return to the producer. Thus, within this context, the cultivars BRS Radiante, EPAMIG Ouro da Mata, IAC Tigre, BRSMG Realce, BRSMG União and BRSMG Tesouro were highlighted. These cultivars also stood out in the percentage of grains retained in the sieve 13 (SY<sub>13</sub>), differing statistically from the others. It should also be noted that the cultivar BRS Radiante obtained the highest value of SY<sub>≥12</sub> (89.5%), with 45.7% and 35.3%, that is, 81.0% of grains retained in the sieves of sieves 14 (SY<sub>14</sub>) and 13 (SY<sub>13</sub>), respectively.

It was found that the bean cultivars showed significant differences regarding the crude protein content in the grains (Table 3). The cultivars EPAMIG Ouro Vermelho, BRS Radiante and BRSMG Tesouro stood out for this variable, obtaining values of 22.7%, 22.0% and 21.8%, respectively, differing statistically from the others. This qualitative attribute can vary depending on the place of cultivation, the effect of genotype interaction by environment and the genetic variability between cultivars (Buratto et al., 2009; Ribeiro et al. 2008; Ribeiro et al., 2014). However, the average protein content was 21.1%, corroborating the results obtained by

**Table 1.** Number of pods per plant, number of grains per pod, mass of 100 grains and grain yield, of common bean cultivars with special type grains. Jaboticabal, SP - 2018 <sup>(1)</sup>.

Cultivars	Plant pods	Grains per pod	Mass of 100 grains	Grain productivity
	-----n <sup>o</sup> -----		g	kg ha <sup>-1</sup>
BRS Radiante	10.7	4.5 c	35.7 b	2.019 b
BRSMG Realce	9.5	4.7 c	31.7 c	1.798 b
BRS Pitanga	14.7	5.7 b	20.2 g	2.608 a
BRSMG Tesouro	14.2	6.5 a	23.0 f	2.447 b
BRS Marfim	12.7	5.7 b	29.2 d	2.871 a
BRSMG União	12.0	5.7 b	37.7 a	2.140 b
IAC Tigre	12.5	4.7 c	38.5 a	2.309 b
EPAMIG Ouro Vermelho	11.2	6.7 a	26.0 e	2.907 a
EPAMIG Ouro da Mata	12.7	5.5 b	26.7 e	2.112 b
Average	12.2	5.5	29.8	2.357
Test F	1.72 <sup>ns</sup>	7.9*	66.5*	2.13*
CV (%)	20.4	9.9	5.3	19.1

<sup>1</sup>Means followed by the same letter belong to the same group by the Scott-Knott test (p-value < 0.05). CV (%) = coefficient of variation; ns = not significant; \* = significant (p < 0.05).



**Figure 1.** Climatic conditions recorded during the conduct of the experiment of special bean cultivars, in the winter harvest for the region of Jaboticabal, SP in 2018. S = sowing; V1 = emergency; V4 = third trefoil completely expanded; R6 = full flowering; R9 = physiological maturity; C = harvest. Source: Agroclimatological station, Department of Exact Sciences UNESP, Jaboticabal, SP.

**Table 2.** Sieve yield (SY) of sieve 11, 12, 13, 14 and greater than and equal to 12, of common bean cultivars with special type grains. Jaboticabal, SP - 2018 <sup>(1)</sup>.

Cultivars	SY11	SY12	SY13	SY14	SY≥12
	-----%-----				
BRS Radiante	1.5 c	8.6 c	35.3 a	45.7 a	89.5 a
BRSMG Realce	9.5 b	27.2 b	34.5 a	19.6 c	81.2 a
BRS Pitanga	21.0 a	50.9 a	18.3 b	0.0 f	69.2 b
BRSMG Tesouro	16.8 a	32.9 a	33.1 a	7.5 e	73.7 b
BRS Marfim	27.6 a	45.0 a	5.9 b	0.54 f	67.0 b
BRSMG União	4.1 c	19.9 b	33.1 a	26.7 b	79.7 a
IAC Tigre	9.1 b	27.8 b	38.6 a	15.6 d	82.5 a
EPAMIG Ouro Vermelho	22.2 a	38.6 a	22.9 b	2.0 f	66.0 b
EPAMIG Ouro da Mata	11.9 b	40.7 a	45.4 a	2.0 f	84.2 a
Average	13.6	32.2	29.7	13.3	77.0
Test F	11.0*	6.77*	4.0*	62.0*	4.4*
CV (%)	38.0	31.1	39.7	29.3	10.2

(1) Means followed by the same letter belong to the same group by the Scott-Knott test (p-value < 0.05). CV (%) = coefficient of variation; ns = not significant; \* = significant (p < 0.05).

**Table 3.** Crude protein content (PC), cooking time (CT), soaking before cooking (IBEC), soaking after cooking (IBAC), and percentage of whole grains after cooking (PGW), of bean cultivars common with special type grains. Jaboticabal, SP - 2018 <sup>(1)</sup>.

Cultivars	PC	CT	IBEC	IBAC	PGW
	%	min:seg	-----%	-----%	-----%
BRS Radiante	22.0 a	26:03 b	103.48 b	143.68 c	88.65 a
BRS Realce	21.1 b	25:03 b	105.36 a	143.48 c	88.36 a
BRS Pitanga	20.2 c	23:37 c	98.21 d	152.23 b	90.23 a
BRS Tesouro	21.8 a	20:03 d	98.39 d	158.62 a	80.38 b
BRS Marfim	21.2 b	23:33 c	94.39 e	142.93 c	74.31 b
BRSMG União	20.6 c	28:05 a	103.84 b	149.54 b	69.49 c
IAC Tigre	20.8 b	19:04 d	100.66 c	141.63 c	88.88 a
EPAMIG Ouro Vermelho	22.7 a	20:12 d	104.37 b	146.61 c	68.93 c
EPAMIG Ouro da Mata	20.2 c	19:37 d	101.07 c	140.31 c	78.02 b
Average	21.1	22:48	101.17	146.56	80.80
Test F	8.17*	13.82*	78.17**	5.73**	21.88**
CV (%)	3.2	7.44	0.69	2.92	3.94

<sup>(1)</sup> Means followed by the same letter belong to the same group by the Scott-Knott test (p-value < 0.05). CV (%) = coefficient of variation; \* = significant (p < 0.05); \*\* = significant (p < 0.01).

**Table 4.** Regression equation between the time for grains hydration, amount of water absorbed by the grains, time for grain hydration (HT) and the hydration ratio (HR) of common bean cultivars with special type grains. Jaboticabal, SP – 2018<sup>(1)</sup>.

Cultivars	Regression equation <sup>(2)</sup>	R <sup>2</sup>	HT <sup>(1)</sup> h:min	HR
BRS Radiante	$y = -0.00006x^2 + 0.11107x - 1.00334$	0.99**	16:03 a	2.0 a
BRSMG Realce	$y = -0.00006x^2 + 0.11778x - 3.38630$	0.98**	15:18 a	2.0 a
BRS Pitanga	$y = -0.00008x^2 + 0.12387x - 0.19114$	0.98**	13:13 b	1.9 b
BRSMG Tesouro	$y = -0.00008x^2 + 0.11937x + 6.83594$	0.92**	13:32 b	1.9 b
BRS Marfim	$y = -0.00006x^2 + 0.10745x + 1.84444$	0.99**	14:55 a	1.9 b
BRSMG União	$y = -0.00007x^2 + 0.12305x + 0.32970$	0.99**	13:55 b	2.0 a
IAC Tigre	$y = -0.00005x^2 + 0.10420x - 2.45236$	0.98**	15:22 a	2.0 a
EPAMIG Ouro Vermelho	$y = -0.00009x^2 + 0.12224x + 11.46168$	0.82**	11:47 c	2.0 a
EPAMIG Ouro da Mata	$y = -0.00004x^2 + 0.08613x + 2.51407$	0.97**	15:46 a	2.0 a
Average	----	---	14:03	2.0
Test F	----	---	14.95**	5.2**
CV (%)	----	---	5.61	0.29

<sup>(1)</sup> Means followed by the same letter belong to the same group by the Scott-Knott test (p value > 0.05). CV: coefficient of variation. \*\* significant at 1% probability. <sup>(2)</sup> x = time for hydration (hours) and y = amount of water absorbed (ml).

**Table 5.** Information regarding common bean cultivars with special grains. Jaboticabal, SP - 2018.

Cultivares	Owned institution <sup>(1)</sup>	Growth habit	Cycle (days)	Integument description
BRS Radiante	EMBRAPA	Type II	80	Brindle - cream tegument with streaks or red stripes
BRSMG Realce	EMBRAPA	Type I	67-75	Brindle - cream tegument with streaks or red stripes
BRS Pitanga	EMBRAPA	Type II	80-85	Purple
BRSMG Tesouro	EMBRAPA	Type II	80-90	Purple
BRS Marfim	EMBRAPA	Type II	85-90	Mulatinho - light brown coat
BRSMG União	EMBRAPA	Type III	77	Jalo - yellow coat
IAC Tigre	IAC	Type II	85	Brindle - cream coat with spots light brown
EPAMIG Ouro Vermelho	EPAMIG	Type II	80-90	Red
EPAMIG Ouro da Mata	EPAMIG	Type II	85-90	Red

<sup>(1)</sup> Brazilian Agricultural Research Corporation (EMBRAPA); Campinas Agronomic Institute (IAC); Minas Gerais Agricultural Research Company (EPAMIG). <sup>(2)</sup> According to the release bulletin by the bodies responsible for the cultivar.

Ramos Junior et al. (2005), Farinelli and Lemos (2010), Perina et al. (2010) and Mingotte et al. (2013). Regarding cooking time, cultivars obtained an average of 22:48 minutes: seconds, ranging from 19:04 to 28:05 minutes: seconds (Table 3). This difference of 09 minutes can be considered expressive or high, within the context of energy consumption in terms of gas and time for food preparation. The cultivars IAC Tigre, EPAMIG Ouro da Mata, BRS Tesouro and EPAMIG Ouro Vermelho showed the lowest values for cooking, between 19:04 and 20:12 minutes: seconds, differing statistically from the others. According to Proctor and Watts (1987), the cooking time between 16 to 20 minutes is classified as having medium resistance to cooking. For these same authors, the other bean cultivars were classified as normal cooking

resistance, that is, they obtained values in the range of 21 to 28 minutes. However, it should be noted that all cultivars were within the cooking time range recommended by Ramalho and Abreu (2006), which is less than 30 minutes. There were statistical differences between bean cultivars for qualitative attributes percentage of soaking before cooking (IBEC), percentage of soaking after cooking (IBAC) and percentage of whole grains after cooking (PGW) (Table 3). The cultivars BRS Realce and BRS Tesouro stood out with the highest values of PIBEC and PIBAC, respectively. The highlights for PGW were the cultivars BRS Pitanga, IAC Tigre, BRS Radiante and BRS Realce. It was also observed that the BRS Realce cultivar that obtained the highest PIBEC was not the one that had the shortest cooking time, contrary to the

results found by Dalla Corte et al. (2003) and Rodrigues et al. (2005), who mentioned that the cooking time depends on the water absorption capacity. However, the cultivar IAC Tigre showed the shortest cooking time and stood out among the materials that obtained high PGW, this aspect being very interesting for both the packaging industry and the consumer. The regression equations between the hydration time and the amount of water absorbed by the beans of the bean cultivars (Table 4), showed that the period necessary for maximum hydration ranged from 11:47 hours (EPAMIG Ouro Vermelho) to 16:03 hours (BRS Radiante). Therefore, there was a difference of 5:06 hours, which can be considered a high value. The cultivars that had the longest periods were BRS Radiante, EPAMIG Ouro da Mata, IAC Tigre, BRSMG Realce and BRS Marfim with values of 16:03, 15:46, 15:22, 15:18 and 14:55 hours, respectively.

The methodology used, described in Normative Instruction No. 25 of 05/23/2006 of the Ministry of Agriculture, Livestock and Supply-MAPA (Brazil, 2006), considers as standard the time of 16 hours of hydration of the grains in distilled water, the cultivars showed satisfactory performance for the grains to obtain complete water absorption. However, as beans are usually left to steep (imbibition) the night before preparation, for a period of approximately 12 hours (Ramos Junior et al., 2005), satisfactory performance was observed only for EPAMIG Ouro Vermelho cultivar.

As for the hydration ratio, it was found that there were statistical differences between the cultivars evaluated (Table 4). However, these values were close to two (2.0), that is, the grains absorbed a water mass similar to its initial mass, which shows satisfactory performance regarding this attribute (Ramos Junior et al., 2005; Farinelli and Lemos 2010; Mingotte et al. 2013).

Thus, regarding the qualitative attributes, it can be inferred that the cultivar BRS Radiante stood out for presenting the highest RP $\geq$ 12, RP 13 and RP14, that is, coarse grains, with a high content of crude protein and PGW. The cultivar BRSMG Realce stood out for obtaining the highest value for PIBEC, as well as high RP $\geq$ 12 and PGI. The BRSMG Tesouro cultivar also stood out, presenting high PIBAC, high crude protein content and short cooking time. The cultivar IAC Tigre stood out due to the shorter cooking time, high RP $\geq$ 12 and PGW. It also stood out for cultivating EPAMIG Ouro Vermelho due to the higher crude protein content, as well as the reduced cooking time and the lower HT.

## Materials and methods

### Experimental site

The experiment was conducted at the Teaching, Research and Extension Farm (FEPE) of the Faculty of Agricultural and Veterinary Sciences of the São Paulo State University (UNESP), located in the municipality of Jaboticabal, São Paulo State, Brazil. According to the Köppen classification, the predominant climate in the region is of the Aw type, humid tropical with rainy season in summer and dry in winter. The soil in the experimental area is classified as a clayey red latosol (Embrapa, 2013). The climatic data during the conduct of the experiment are shown in Figure 1.

The chemical attributes and the granulometry of the soil were determined in the layer 0.00-0.20 m deep, before sowing the bean and the results obtained were: pH (CaCl<sub>2</sub>) = 6.1; MO = 22 g dm<sup>-3</sup>; P (resin) = 87 mg dm<sup>-3</sup>; K = 9.0 mmolc dm<sup>-3</sup>; Ca = 48 mmolc dm<sup>-3</sup>; Mg = 20 mmolc dm<sup>-3</sup>; S = 10 mg dm<sup>-3</sup>; B = 0.25 mg dm<sup>-3</sup>; Cu = 1.0 mg dm<sup>-3</sup>; Fe = 20 mg dm<sup>-3</sup>; Mn = 23 mg dm<sup>-3</sup>;

<sup>3</sup>; Zn = 4.0 mg dm<sup>-3</sup>; H + Al = 25 mmolc dm<sup>-3</sup>; CTC = 102 mmolc dm<sup>-3</sup>; V = 75%; clay = 540 g kg<sup>-1</sup>; silt = 230 g kg<sup>-1</sup> and sand = 230 g kg<sup>-1</sup>.

### Treatments and experimental design

The experimental design was in randomized blocks, with nine treatments and four replications. The treatments consisted of nine bean cultivars with special grains: BRS Radiante, BRS Pitanga, BRS Realce, BRSMG Tesouro, BRS Marfim, BRSMG União, IAC Tigre, EPAMIG Ouro Vermelho and EPAMIG Ouro da Mata (Table 5). Each experimental plot consisted of five lines with five meters in length, spaced at 0.45 meters, being considered useful area to the three central lines, disregarding 0.5 meters from each end.

The experimental area was in the first year of adoption of the no-tillage system, being implanted through soil scarifying on December 06, 2017, followed by the application of lime (dose of 1 t ha<sup>-1</sup>) based on previous soil analysis, with subsequent incorporation by one disk plow and two leveling harrows. The crop prior to bean was millet (*Pennisetum americanum* L.), cultivar ADR - 300, sowed on December 13, 2017, using 14 kg ha<sup>-1</sup> of seeds with a spacing of 0.45 m between rows. The millet culture was desiccated at 60 days after emergence, when it was with the panicles, using glyphosate at a dose of 2 L ha<sup>-1</sup> of the commercial product. Ten days after the herbicide application, millet was managed using a mechanized plant desintegrator.

The bean cultivars were sown on May 18, 2018, distributing 12 seeds per meter of furrow, with a spacing of 0.45 m, standardizing a final population of 245,000 plants ha<sup>-1</sup> for all plots. The cultivation was classified as winter bean due to the sowing time and use of irrigation. A conventional sprinkler irrigation system was used, with the irrigation frequency every 4 days, applying a 10 to 20 mm of water depth according to the crop's need. The total water depth applied was 550 mm (Pavani et al., 2008).

### Cultural management and treatment

The sowing and sidedress fertilizations were carried out according to the technical recommendations of Ambrosano et al. (1997). The fertilization in the sowing furrow was carried out using a dose of 350 kg ha<sup>-1</sup> of the formulated 04-28-10 (0.3% B, 4% Ca, 0.01% Mo, 5% S and 1.2% Zn), corresponding to the doses of 14, 98 and 35 kg ha<sup>-1</sup> of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O, respectively. The cover fertilizations were carried out in two stages: the first at the phenological stage V4-4 (fourth formed and expanded trifoliate leaf) which consisted of 60 kg ha<sup>-1</sup> of N and 20 kg ha<sup>-1</sup> of K<sub>2</sub>O via formulated fertilizer 30-00-10 and the second at stage V4-6 (sixth trifoliate leaf formed and expanded) of 60 kg ha<sup>-1</sup> of N, via urea. The fertilizers were applied to the soil surface in a continuous thread 10 cm from the crop line, followed by irrigation with a 15 mm water depth.

For the control of weeds, applications of the herbicides S-metolachlor were carried out at a dose of 1.2 kg ha<sup>-1</sup> in pre-emergence and in post-emergence Cletodim (108 g ha<sup>-1</sup> of ia) was used in stage V3 (emission of the first trifoliate leaf) and in V4 (emission of the third trifoliate leaf) of Bentazone + Imaxomoxy (600 + 28 g ha<sup>-1</sup> of ia). Phytosanitary management was carried out by monitoring pests and diseases, spraying acetamiprid (300 g ha<sup>-1</sup> a.i.) on July 6; acetamiprid + pyriproxifem (300 + 100 g ha<sup>-1</sup> a.i.) on July 5; thiamethoxam + lambda-cyhalothrin (100 mL ha<sup>-1</sup>) on July 10; piraclostrobin + thiamethoxam + lambda-cyhalothrin (40 g + 100 mL ha<sup>-1</sup> of a.i.) on July 26.

### Variables analyzed

The agronomic attributes were determined from the physiological maturity of the pods (R9). The production components were evaluated: number of pods per plant, number of grains per pod and mass of 100 grains by collecting 10 consecutive plants in the cultivation line in the useful area of each plot. As for grain productivity, it was carried out by plucking the plants in the useful area of the plot, with drying in full sun and subsequent mechanized trail, standardizing the moisture content of the grains to 13% b.u.

The determination of qualitative attributes started with the sieve yield (SY), where grain samples from each experimental plot were submitted to the set of number 11 (11/64 "in.), 12 (12/64) oblong sieves. "In.), 13 (13/64" in.) And 14 (14/64 "in.) Stirring for one minute. The values presented were used to calculate the percentage of grains, through the relationship between the mass of grains retained in each sieve and the mass of the total sample of each repetition. A sieve yield greater than or equal to 12 ( $SY \geq 12$ ) was also performed, with the sum of the sieves with oblong sieves 12, 13 and 14.

The crude protein content (%) was obtained by the content of nitrogen (N) contained in the grains and the calculation was made:  $PC = (\text{total N} \times 6.25)$  where, PC = crude protein content in the grains ( $\text{g kg}^{-1}$ ) and total N = N content in the grains. The cooking time was determined with the aid of the Mattson cooker. For this determination, the grains were previously hydrated in deionized water for 16 hours.

The percentage of imbibition before (IBEC) and after cooking (IBAC) were obtained using the methods described by Garcia-Vela and Stanley (1989) and by Plhak et al. (1989). For this, approximately 30 g of uniform and whole grains were sampled, obtaining the dry mass of the grains (DM) in the initial stage of the analytical procedure. The grains were soaked in 100 ml of deionized water in a 250 ml beaker for 16 hours at room temperature. For IBEC, after this period, the beans were removed and quickly dried with paper towels and then weighed, obtaining the wet grain mass (MU) and the percentage of imbibition, determined by the formula:  $IBEC = [(MU - MS) / MS] \times 100$ .

For IBAC, after 16 hours of soaking, the 30g of grains were heated in an electric hot plate for one hour after the beginning of the boil, with replacement of evaporated water, when necessary. The grains (whole and fragmented) were drained and weighed, obtaining the wet mass after cooking (MUC) and determined by the formula:  $IBAC = [(MUC - MS) / MS] \times 100$ .

From the sample from IBAC, the percentage of whole grains after cooking (PGW) was obtained. The beans, after cooking, were counted in their entirety (T) and separated into two portions: whole (W) and broken (B). From that count, the PGW was then calculated using the formula:  $PGW = [(T - B) / T] \times 100$ .

The hydration capacity was quantified in samples of 50 g placed in deionized water for 16 hours, evaluating the volume of water not absorbed by the grains every two hours, pouring it from the beaker into a beaker. At the end of the expected hydration time, the water was completely drained and the grains were weighed. Then the hydration ratio was determined, determined by the ratio between the mass after hydration and the initial mass of the grains. The study of polynomial regression between time (hours) and hydration capacity (mL) was performed to determine the time required for maximum grain hydration.

The data were submitted to analysis of variance by the F test and the means grouped by the Scott-Knott test. Polynomial

regression analysis was used for time data for maximum grain hydration. The analyzes of variance were performed with the aid of the SISVAR statistical program (Ferreira, 2014).

### Conclusions

There is variability between special grain cultivars in terms of agronomic and qualitative attributes.

The most productive cultivars were EPAMIG Ouro Vermelho, BRS Marfim and BRS Pitanga. The cultivars BRS Radiante, BRSMG Realce, BRSMG Tesouro, IAC Tigre and EPAMIG Ouro Vermelho stood out for the qualitative attributes of the grains.

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