

## Sowing time and physiological potential of bean seeds of different growth types

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**ABSTRACT:** This work was carried out in order to evaluate the physiological quality of common bean seeds of different types of growth, according to the sowing seasons. The treatments were arranged in 2 x 4 factorial scheme, involving two sowing seasons (dry and winter) and four genotypes (Ouro Vermelho, Ouro Negro, BRSMG Madrepérola e Manteigão Vermelho), in randomized blocks design. The seeds were initially evaluated as for water content, thousand seeds weight and physiological potential by the germination and vigor tests (first germination count, plantlets emergence in sand, emergence speed Index and electrical conductivity). The seeds of the prostrate genotypes, with type of growth III (Ouro Negro and BRSMG Madrepérola) or semi-prostrate with type of growth II/III (Ouro Vermelho) present better physiological potential, regardless of the sowing season. In the crop of Summer/autumn, the sowing of bean is more suitable for producing seeds with high physiological quality in the conditions of cultivation of the north of Minas Gerais.

**Key words:** crops; germination; *Phaseolus vulgaris* L.; vigor

## Época de semeadura e potencial fisiológico de sementes de feijoeiros de diferentes tipos de crescimento

**RESUMO:** O objetivo neste trabalho foi avaliar a qualidade fisiológica de sementes de feijão-comum de diferentes tipos de crescimento, em função das épocas de semeadura. Os tratamentos foram dispostos em esquema fatorial 2 x 4, envolvendo duas épocas de semeadura (seca e inverno) e quatro genótipos (Ouro Vermelho, Ouro Negro, BRSMG Madrepérola e Manteigão Vermelho), em delineamento experimental casualizado em blocos. As sementes foram inicialmente avaliadas quanto ao teor de água, massa de mil sementes e potencial fisiológico pelos testes de germinação e vigor (primeira contagem de germinação, emergência de plântulas em areia, índice de velocidade de emergência e condutividade elétrica). As sementes dos genótipos de porte prostrado, com tipo de crescimento III (Ouro Negro e BRSMG Madrepérola) ou semiprostrado com tipo de crescimento II/III (Ouro Vermelho) são de melhor potencial fisiológico, independente da época de semeadura. Na safra da seca, a semeadura do feijoeiro é mais adequada para a produção de sementes com elevada qualidade fisiológica nas condições de cultivo do norte de Minas Gerais.

**Palavras-chave:** safras; germinação; *Phaseolus vulgaris* L.; vigor

## Introduction

The common bean (*Phaseolus vulgaris* L.) is cultivated by small and large producers in diversified production systems and technological levels, being of great socioeconomic importance in all Brazilian regions. Brazil is among the largest consumers and producers of common bean, with a total production of around 3.09 million tons, in an area of approximately 3.130 million hectares, with an average yield of 1.079 kg ha<sup>-1</sup> in 2015 (IBGE, 2017).

The State of Minas Gerais is one of the largest national bean producers, producing around 509 thousand tons and with an average productivity of 1,527 kg ha<sup>-1</sup>, with the northern region of the State responsible for the production of 22,137 thousand tons in an area of 34.429 thousand hectares, with an average yield of 840 kg ha<sup>-1</sup> (IBGE, 2017).

The use of seeds with high physiological potential is related to their ability to perform vital functions, characterized by longevity, germination, and vigor (Cardoso et al., 2012). However, these characteristics may be influenced by the genotype (Mambrin et al., 2015), environmental conditions of its production and season yields (Zucareli et al., 2016).

It is necessary to consider the size, growth habit, type of growth and the plant cycle when choosing the genotype since these characteristics are a fundamental decision for the production of quality seeds. In the prostrate genotypes, with indeterminate growth habit and growth type III, the stems are more developed than type II, because they have a greater number of nodes and the average length of internodes is slightly higher (Santos & Vencovsky, 1986), usually leading to greater contact of the pods with the soil in the period before harvesting and, if there is high humidity, they can cause physiological damages to the seeds.

Beans are usually grown in three planting seasons in Brazil, with the most common cultivation in spring-summer (harvest season), summer-autumn (dry season) and autumn-winter (winter season) (Araújo & Camelo, 2015). However, in regions with a warmer climate, such as the North of Minas Gerais, for cultivation in drought and winter seasons, there is a greater advantage in cultivation in the harvest of the waters due to the higher temperatures that tend to cause greater abortion of flowers (Didonet & Vitoria, 2006), greater competition with weeds (Barrosos et al., 2010), and the risk of harvesting in the rainy season (Araújo & Camelo, 2015), impairing the production of good quality seeds. Zucareli et al. (2016) reported that bean cultivation in the dry season provides seeds with greater germination and vigor compared to the harvest of the waters.

Thus, the objective of this study was to evaluate the physiological quality of common bean seeds of different growth types, as a function of sowing times.

## Material and Methods

The experiment was carried out in the city of Janaúba, state of Minas Gerais, in the summer-autumn (dry season)

crops, with planting in March 2011 and winter-spring (winter season), with planting in August 2011. The experimental area is located at the border of the Gortuba project, with a latitude of 15°47'50''S and a longitude of 43°18'31''W and an altitude of 516 m, in Eutrophic Red Latosol (Embrapa, 2006).

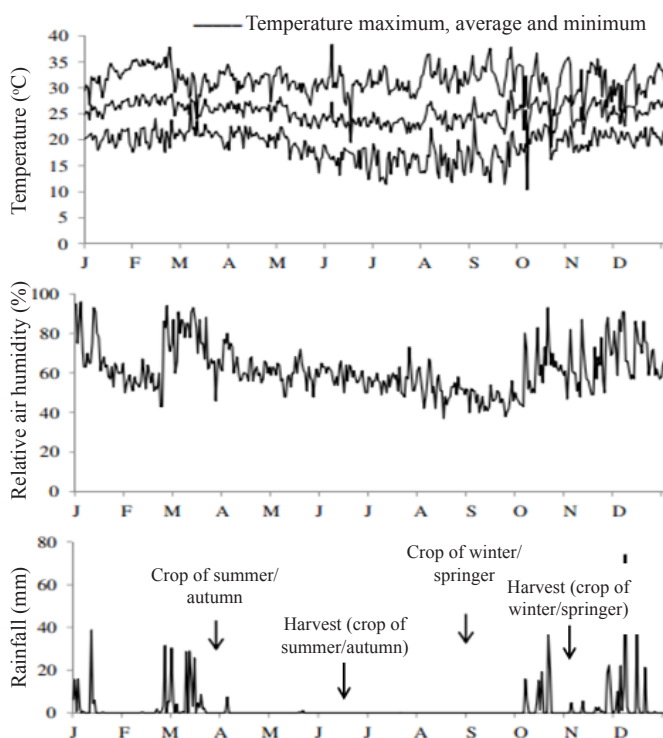
The climate of the region was classified as "AW" by Köppen (tropical with dry winter), whose data of daily occurrences of precipitation, temperature and relative humidity recorded during the period of conduction of the experiments are shown in Figure 1.

The treatments were arranged in a 2 x 4 factorial scheme, involving two sowing seasons (dry and winter) and four genotypes of common bean (Ouro Vermelho, Ouro Negro, BRSMG Madrepérola and Manteigão Vermelho), whose experimental design was the randomized blocks, with four replicates.

The main characteristics of the common bean genotypes studied are described in Table 1.

The experimental area was divided in plots composed of six rows of common bean, 5 m long, spaced 0.5 m apart, making a total area of 15 m<sup>2</sup>.

For the evaluation of the physiological potential of the seeds, only plants located in the four central meters of the fourth and fifth rows of each plot were considered useful area, making a total of 4 m<sup>2</sup>. In the two season cultivations, the soil preparation of the experimental areas was carried out in a conventional manner, with one plowing and two pre-planting.



**Figure 1.** Daily variation of averages of precipitation, temperature (maximum, average and minimum) and relative air humidity during 2011. Data obtained at the Estação Climatológica da Empresa de Pesquisa em Agropecuária de Minas Gerais (EPAMIG), Nova Porteirinha – MG, Brazil.

**Table 1.** Main characteristics of genotypes of common bean (*Phaseolus vulgaris* L.) sown in the 2011 dry and winter season.

Characteristics	Ouro Vermelho	Ouro Negro	BRSMG Madrepérola	Manteigão Vermelho
Commercial group	Vermelho	Preto	Carioca	Manteigão
Color of grains	Red	Red	Frayed	Red
Growth habit	Type II/III	Type III	Type III	Type II
Mass of 100 grains	24-26 g	25-27 g	24-25 g	30-40 g
Postage	Semiprostate	Prostate	Prostate	Semierect
Cycle	Medium	Medium	Medium	Medium

Source: Paula Júnior et al. (2010); Embrapa (2011).

After the soil preparation, a mechanized traction seed drill was used, adjusted for the spacing of 0.5 m between rows for the preparation of the grooves and distribution of the planting fertilizer. The sowing fertilization was performed according to the results of the chemical analysis of the soil, following an official recommendation for the State of Minas Gerais for level 3 of technology (Chagas et al., 1999) and in both seasons had 375 kg ha<sup>-1</sup> of the formulation NPK 04-30-10 in the planting, plus 40 kg ha<sup>-1</sup> of N in cover, applied via soil during the V3-V4 stage of the crop. Also, a 40g ha<sup>-1</sup> application of molybdenum via leaf was used, using sodium molybdate as a source.

Seeds previously treated with the mixture of the fungicides Carboxin and Thiram were used in the dosing of 300 mL 100 kg<sup>-1</sup> of seeds. After the emergence of the seedlings, a thinning was performed to obtain a population equivalent to 300.000 plants per hectare.

In both sowing times, a tank mix of the herbicides Fomesafen and Fluazifop-p-butyl was applied at the dose of 125 g ha<sup>-1</sup>, at 25 days after emergence. The experiment was supplemented by conventional irrigation with a 350 mm blade during the crop cycle and a three-day irrigation shift, also constantly monitored for the adoption of phytosanitary management. The plots were harvested as soon as the pods reached maturity, characterized by the change of green to straw yellow coloration, when the pods began to dry, according to the cultivar. The pods were separated from the plants and the seeds were threshed manually, separated from the inert material and broken seeds. Then, the seeds were taken to the Seed Analysis Laboratory and packed in polyethylene (waterproof) packaging, sealed and kept in a cold room (65% RH and 10 °C) for one week until the beginning of the determinations and tests.

The water level was determined by the greenhouse method at 105 ± 3 °C for 24 hours, according to the Rules for Seed Analysis - RAS (Brazil, 2009).

For the germination test, four replicates of 50 seeds per treatment were used, having the roll of germitest paper moistened with distilled water in the volume of 2.5 times the dry paper weight as substrate. The seeds were placed to germinate in a digital germinator previously regulated at a constant temperature of 25 °C. The germination evaluation was performed in the fifth (first germination count) and ninth day after sowing, with the results expressed as percentage of normal seedlings, according to the RAS (Brasil, 2009).

The seedling emergence test in sand was held in a laboratory, with four replicates of 50 seeds, using sand

washed substrate. The seeds were sown at three centimeters in plastic trays containing the substrate moistened with water equivalent to 60% of the retention capacity (Brasil, 2009). The results expressed as a percentage were obtained by the number of normal seedlings emerged, determined on the ninth day after the test installation.

The emergence speed index (IVE) was held with the seedling emergence test in sand, daily counting the number of emerged seedlings up to nine days after sowing (Maguire, 1962).

The electrical conductivity test was performed using four replicates of 50 seeds per treatment, weighed in a 0.07 g balance and placed in plastic cups (200 mL capacity) containing 75 mL of distilled water for 24 hours in the incubator called Biological Oxygen Demand (B.O.D.) regulated at 25 °C. After that period, the conductivity of the soaking solution was obtained with the help of a Digimed conductivity meter (model DM 31), and the results were expressed in µS cm<sup>-1</sup> g<sup>-1</sup> of seed, according to Marcos Filho et al. (1987).

The data were tested for normality and homogeneity and then, they were submitted to the analysis of joint variance involving the two harvests. When the effects of the genotypes were significant, they were studied by the Tukey test at 5% of significance. To verify the behavior of the variables, according to the sowing times, for each cultivar the F test was conclusive (p < 0.05).

## Results and Discussion

The results of the analysis of variance showed that the variables water content, germination, seedling emergence in sand, emergence velocity index and electrical conductivity were influenced by the interaction between the genotypes (GN) and sowing time (S). There was a significant effect of the isolated factors for the data of the first germination counting. After the unfolding of the interaction GN x S, when studying the effect of the genotypes within each season, the water levels of the seeds of all the genotypes were statistically similar after the harvest in the dry season (Table 2). These levels are within the ideal standards for harvesting and storage of beans, which are at most 13% moisture (Vieira & Yokoyama, 2000).

The climatic conditions, especially the temperature, precipitation and relative humidity of the air (Figure 1) observed in the harvest period of the seeds produced in

**Table 2.** Water levels of seeds of genotypes of common bean (*Phaseolus vulgaris* L.) sown in the dry and winter seasons.

Crops	Water content (%)				CV (%)
	Genotypes				
	Ouro Vermelho	Ouro Negro	BRSMG Madrepérola	Manteigão Vermelho	
Summer	11.3 Ba	11.0 Ba	10.4 Ba	9.1 Ba	8.09
Winter	15.8 Ac	21.3 Aa	18.5 Ab	13.4 Ad	

Means followed by different letters differ significantly by the F test (seasons) or the Tukey test (genotypes), at 5% significance. Capital letters compare seasons, while lower case comparisons of genotypes.

the dry season contributed to the maintenance of the ideal levels of humidity, which agrees with Marcos Filho (2015). In the winter season, the water level of seeds of the genotype Manteigão Vermelho was lower than in the seeds of the other genotypes.

In the winter season, a higher water level of genotype seeds was observed than in the dry season (Table 2). The pre-harvest period of the seeds from the winter season occurred at a time of high rainfall index (Figure 1), possibly reflecting on the water level of the seeds. In the genotypes of prostrate, with growth type III (Ouro Negro and BRSMG Madrepérola) or semi-prostrate with growth type II/III (Red Gold), there are more branches and a large number of pods located in the basilar part of the plant, reflecting in the direct contact of them with the humid soil, with effects on the water level of the seeds.

For the germination test, in the interaction GN x S and studying the effect of genotypes within each season, the highest percentages of germination in the dry season were observed for the seeds of the genotypes Ouro Vermelho, Ouro Negro and BRSMG Madrepérola (Table 3). Only the seeds of the genotypes Ouro Vermelho and Ouro Negro germination were superior to 70% in the winter season being the minimum recommended for the commercialization of

basic bean seeds (Brasil, 2013). The germination percentages of the seeds of the genotype Manteigão Vermelho were lower than 70%, regardless of the sowing season.

These results can be attributed to the genetic constitution of the genotype, with the Red Manteigão little explored in breeding programs. However, some breeding programs have currently focused on this type of grain, seeking to obtain and identify lines with better adaptation to soil conditions of the country (Pereira et al., 2016), with production of seeds of better physiological quality.

Due to the commercial preference and consequent predominance of undetermined growth types (mainly types III and II/III) in farmers in the last decades, it is also worth noting that the research work on genetic improvement, phytotechnical management and, mainly, technology of seed production in this period were mostly focused on cultivars of these groups. Therefore, the seeds of these genotypes may express better responses in than others, possibly by the lower seed germination results of the Manteigão Vermelho genotype.

The exposure of bean seeds to alternating cycles, high and low humidity before harvesting and frequent rainfall (Figure 1), possibly contributed to the deterioration of the seeds and, consequently, damage to germination. According

**Table 3.** Seed germination, emergence of seedlings in sand, emergence speed index and electric conductivity of seeds of common bean (*Phaseolus vulgaris* L.) genotypes seeded in the dry and winter seasons.

Crops	Genotypes				CV (%)
	Ouro Vermelho	Ouro Negro	BRSMG Madrepérola	Manteigão Vermelho	
Germination (%)					
Summer	97 Aa	95 Aa	92 Aa	44 Ab	14.79
Winter	74 Bab	85 Aa	53 Bbc	51 Ac	
Emergence of seedlings in sand (%)					
Summer	90 Aa	99 Aa	95 Aa	52 Bb	11.63
Winter	88 Aa	90 Aa	85 Aa	81 Aa	
Emergence speed index					
Summer	14.6 Aa	13.5 Aa	13.1 Aa	4.4 Bb	13.66
Winter	12.1 Bab	15.2 Aa	11.7 Ab	6.7 Ac	
Electric conductivity ( $\mu\text{S cm}^{-1} \text{g}^{-1}$ )					
Summer	36.59 Aa	30.16 Aa	32.71 Aa	9.1 Bb	22.00
Winter	29.01 Aab	29.34 Aab	38.75 Aa	20.2 Ab	
First germination count (%)					
	80 a	83 a	70 a	21 a	22.00
		Summer 78 A	Winter 49 B		

Within each variable, averages followed by different letters differ significantly by the F test (seasons) or the Tukey test (genotypes), at 5% significance. Capital letters compare seasons, while lower case letters compare genotypes.

to Marcos Filho (2015), besides accelerating the metabolism, the excess pre-harvest rainfall favors the incidence of microorganisms, compromising the physiological potential of the seeds. The deterioration is even more intense if such conditions are associated with high temperatures (França Neto & Henning, 1984).

By the interaction of genotypes (GN) and seasons (S), the highest germinative percentages were observed in the seeds of the genotypes Ouro Vermelho and BRSMG Madrepérola when cultivated in the dry season, while for the seeds of the other genotypes, there was no seasons effect (Table 3). Despite its wide geographic distribution, the common bean is not very tolerant to extreme environmental factors (Paula Junior et al., 2008) and, for this reason, it is evident that the use of adapted genotypes, associated with the choice of regions with favorable climatic characteristics, can safely provide the production of seeds of better physiological quality (Braccini et al., 2003).

For the emergency test, evaluating the effect of genotypes within each season, emergency percentages of seedlings from genotypes Ouro Vermelho, Ouro Negro and BRSMG Madrepérola were the highest when compared to the seeds of genotype Manteigão Vermelho, in the dry season (Table 3). For the winter season, there was no difference in the emergency of seedlings originated from the seeds of the genotypes studied.

Analyzing the effect of seasons within each genotype, the emergency of seedlings from the genotypes Ouro Vermelho, Ouro Negro and BRSMG Madrepérola were not influenced by sowing times (Table 3). Seeds of the genotype Manteigão Vermelho originated higher percentages of seedlings emerged when cultivated in the winter season.

The high quality of the seeds of the genotypes Ouro Vermelho, Ouro Negro and BRSMG Madrepérola can be associated to the characteristics related to them, as previously reported, as well as to the favorable climatic conditions observed in the region in the drought season, highlighting the North Minas Gerais State to produce high quality bean seeds in this period.

It is observed that the values of emergency in sand were higher than the results obtained in the germination test, especially in the seeds from the genotype Manteigão Vermelho, with their germination markedly lower. This result is in agreement with those obtained by França Neto & Henning (1984) when they verified that the germination of seeds in sand or soil is less affected by fungi.

By analyzing the results of vigor by the test of emergency speed index (IVE), studying the effects of the genotypes within each season, it is verified that in the dry season the seeds of genotypes Ouro Vermelho, Ouro Negro and BRSMG Madrepérola provided the highest indexes when compared to the seeds of the genotype Manteigão Vermelho (Table 3). For the winter season, superior indices were obtained with the seeds of the Ouro Negro genotype but did not differ statistically from the seeds of the Ouro Vermelho genotype. According to Ferreira & Borghetti (2004), the emergency

speed index is a quantitative emergency measure that relates the number of emerged seedlings to the number of sowing days, so the higher the IVE, the greater the emergency speed, which allows to quantify the vigor of the seed lots.

Considering the effect of seasons within each genotype, it is noted that the seeds of the Ouro Vermelho genotype provided the highest emergency speed index when cultivated in the dry season, while the emergency speed index of seedlings originated from the seeds of the genotypes Ouro Preto and Madrepérola were not influenced by season yields. However, for the seeds of the genotype Manteigão Vermelho, the crop in the winter season yielded more vigorous seeds when compared to the planting in the dry season (Table 3). Carvalho et al. (1998) reported that sowing of bean genotypes in May (dry period) is more promising because of higher values in the emergency speed index than in the sowing in July, at which time the harvest may coincide with the rainy season.

Regarding the electrical conductivity, when studying the effects of genotypes within each season, the dry season the seeds of the genotype Manteigão Vermelho were the most vigorous because the lowest values occurred in relation to the seeds of the other genotypes (Table 3). The test of electrical conductivity is based on the principle that, with the deterioration process, leaching of the cellular constituents of seeds imbibed in water occurs due to the loss of the integrity of the cellular membranes systems (Gonzales et al., 2009). Thus, the higher the conductivity value, the greater the damage to the seed.

The release of exudates by the seed is directly related to the intensity of water imbibition, and occurring rapidly, it promotes a greater release of exudates. From observations during the course of the work, it was observed that seeds from the genotype Manteigão Vermelho have a hard tegument than the other genotypes, which, according to Marcos Filho (2015), it prevents rapid hydration, leading to a reduction in amount of exudates released by the seed. This fact may have contributed to the low values obtained since the duration of the imbibition period is among the factors that affect the results of the electrical conductivity test, as verified by Araujo et al. (2011) in *Jatropha curcas* seeds.

In the winter season, the values of electrical conductivity of the seeds from the genotype BRSMG Madrepérola were higher, and the intermediate values were observed for the seeds of the genotypes Ouro Vermelho and Ouro Negro and lower for the seeds of the Manteigão Vermelho (Table 3).

Evaluating the effect of harvests on each genotype, it was observed that only for seeds of the genotype Manteigão Vermelho there was a significant difference, with lower values in the dry season (Table 3). The northern region of Minas Gerais has environmental conditions that favor the production of seeds of high physiological quality when the bean is grown in the dry season. The low rainfall, low relative humidity, and mild temperatures highlight the region in the production of high-quality seeds. However, research aimed both at the determination of the sowing season and the

indications of bean genotypes for seed production in the region are still incipient.

The genotypes acted independently on the vigor of the seeds evaluated by the first germination count (Table 3), which is a simple vigor test, carried out simultaneously to the germination test and it is based on the assumption that the most vigorous seeds germinate faster (Abud et al., 2013). In the first count, seed germination of the genotypes Ouro Vermelho, Ouro Negro and BRSMG Madrepérola were higher than the seeds of the genotype Manteigão Vermelho, for which the results were lower, indicating low seed vigor.

The detected differences can be possibly attributed to the genetic constitution of the evaluated materials, since the Manteigão Vermelho is a strain from Value and Cultivation Value Assays (VCU), not coming to be cultivated, as the other materials evaluated.

By analyzing the effect of seasons on the first germination count (Table 3), germination was higher for the seeds produced in the dry season, and the low values obtained in the seeds produced in the winter season indicate unfavorable conditions for obtaining of quality seeds, possibly due to higher deterioration due to the occurrence of high temperatures and excessive rainfall during the physiological maturity of the seeds and pre-harvest.

This result highlights the importance of choosing the best season for sowing seed production fields, looking for the coincidence between favorable climatic conditions and the demands of plants in their different stages of development.

## Conclusions

The seeds of prostrate-sized genotypes with growth type III (Ouro Negro and BRSMG Madrepérola) or semi-prostrate with growth type II/III (Ouro Vermelho) have a better physiological potential, independent of sowing time.

The bean sowing is more adequate for the production of high physiological quality seeds in the northern Minas Gerais in the dry season.

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