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# Dry season bean production at different sowing dates under the South Minas Gerais conditions, Brazil

**Cristiane Fortes Gris[1*], Carlos Henrique Evaristo[1], Lucas Eduardo de Oliveira Aparecido[2], Denis Henrique Silva Nadaleti[1] and Willian César Freiria[1]**

[1]Instituto Federal do Sul de Minas Gerais, Campus Muzambinho, Brazil.
[2]Universidade Estadual Paulista, Departamento de Ciências Exatas, Jaboticabal, São Paulo, Brazil.

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**The agro-climatic zoning classifies the southern region of Minas Gerais, Brazil, as being suitable for bean farming, especially in the dry season, where there are appropriate climatic conditions for growing. In this area, determining the optimum sowing dates is controlled by the climatic conditions and the adaptability of different cultivars. Therefore, the aim of this study was to evaluate the agronomic characteristics of some common bean cultivars submitted to different seeding times in the dry season in the South of Minas Gerais. The beans cultivars were used (Perola, TAA Bola Cheia and IAPAR 81) submitted to four sowing date (January 18, February 26, March 08 and March 20). The experimental was arranged in a randomized complete block design (RBD) with three replications in a factorial 4 × 3, corresponding to the four sowing dates and three bean cultivars and results were submitted to analysis of variance by the F test, and when there was a significant, means were compared by Tukey test at 5% and regression analysis. The water deficit was the weather element most influencing bean yield. There was interaction between cultivars and seeding times only on bean yield. The first sowing (January 18) provides the highest yield (30% more in relation the other) and the best agronomic characteristics, regardless of the cultivar. Cultivars Bola Cheia and Perola are the most productive.**

**Key words:** Phaseolus vulgaris, crop yield, water stress, main components.

## INTRODUCTION

Brazil is the largest producer of common bean (*Phaseolus vulgaris* L.) with a production of 3.34 million tons in 2014 in all country (Companhia Nacional de Abastecimento, 2014/15). The bean is grown almost all Brazilian States, in various environmental conditions and in different seeding times (Carneiro, 2002). The state of Minas Gerais is the second largest bean producing, with 592,200 tones (Companhia Nacional de Abastecimento, 2014/15). The agro-climatic zoning of the state of Minas Gerais showed that state is apt for bean crop, especially during the dry season (BRASIL, 2014).

The determination of sowing periods takes into account the key climate risk factors, seeking a lower probability of loss of crops (Aparecido et al., 2014a). Thus, the producers get better yields in a particular region, without providing increase production costs, especially in the dry season, which concentrates periods of water deficit at end of cycle (Wrege et al., 1999; Dalla Corte, 2003).

*Corresponding author. E-mail: cristiane.gris@muz.ifsuldeminas.edu.br

Producers are seeking periods without rain for planting. Thus, many producers seek to plant in the dry season, occurring in Brazil for the months of February to March, taking advantage of the end of the rainy season. This time, air temperatures are usually more appropriate, the problems with weeds and diseases are reduced (EMBRAPA, 2005).

The weather is the main factor that makes producers anticipates sowing dates of the dry season. However, the response to seeding periods is not connected only with seeding time, but also the cultivar (Wrege et al., 1999). Interaction of genotype with environment is a major problem for selection or appointment of cultivars of bean breeding program, with the alternative identification of cultivars with higher phenotypic stability and wide adaptability (Ribeiro et al., 2008).

Commons bean cultivated in different sowing dates when subjected to adverse weather demonstrated reductions in grain yield (Ramalho et al., 1998; Carbonell and Pompeu, 2000; Carbonell, 2001). Accordingly, preference should be given to cultivars with a wide adaptation to different cropping systems, mainly because of the seeding, defined by agroclimatic zoning of crop, most often early or delayed by farmers due to climate risks (Carbonell, 2001).

Few studies have been conducted to examine the optimum sowing date and cultivar selection for the different cultivated crops (Ribeiro, 2004; Aparecido et al., 2014b). Thus, the aim of this work was to evaluate the agronomic characteristics of some beans cultivars under different sowing dates in the dry season in the South of state of Minas Gerais, Brazil.

## MATERIALS AND METHODS

The experiment was conducted in Muzambinho, Minas Gerais, Brazil (21°22′33″S, 46°31′ 32″W, 1050 m of altitude), an important region of bean production. The classification of the predominant climate of the region is $B_4rB'_2a$ (humid with low water deficit) following Thornthwaite (1948) (Aparecido et al., 2015). The classification soil of the experimental area has rhodic Haplustox soil (EMBRAPA, 2006).

Data for maximum and minimum air temperature (°C) and rainfall (mm) were measured by Davis sensors. The sequential daily water balance was calculated as proposed by Thornthwaite and Mather (1955) using SYSWAB software (Gaspar et al., 2015). The potential evapotranspiration was estimated using the Thornthwaite (1948) method.

Meteorological data were used to calculate water deficiencies (DEF) (Equation 1), from the water balance calculation by the Thornthwaite and Mather (1955) method at monthly scale with available water capacity of 100 mm.

$$DEF = PET - AET \quad (1)$$

where, DEF is water deficiency at the soil-plant system; PET is the potential evapotranspiration and AET is actual or real evapotranspiration

The selected cultivars were Perola, Bola Cheia and IAPAR 81. Perola has indeterminate growth habit, semi-erect, 90-day cycle with a mean duration of 46 days to flowering, white flower, with resistance to rust and mosaic-common (Yokoyama, 1999). The Bola Cheia has an indeterminate growth habit, semi-erect, intermediate cycle, 36 to 45 days to flowering, with white flower (SEPROTEC, 2014). And the cultivar IAPAR 81 has an indeterminate growth habit, erect, 92 days cycle, and mean of 42 days to flowering and white flower (IAPAR, 2014).

The experimental design was a randomized complete block design (RBD) with three replications in a factorial 4 × 3, with four seeding dates and three beans cultivars, totaling 36 installments. The experimental unit consisted of four rows with 5.0 m of width, spaced 0.50 m each one. The full experimental area had 20 m of size and 12 of wide.

Seeding of all cultivars was made on the following dates: January 18, February 26, March 08 and Marrch 20 of 2014. The gap between the first and second sowing dates was due to unusual dry spell that occurred in the region causing a delay for the second sowing day. The fertilization was applyed according to soil analysis, and the interpretations proposed by Barbosa and Gonzaga (2012), taking into account technology level 3. The authors used 300 kg $ha^{-1}$ formulated fertilizer 8-28-16, by applying 30 kg $ha^{-1}$ N, 25 days after emergence, using as N font ureia.

Data on soil analysis can be viewed below: pH – 6.0; P – 2.4 mg $dm^{-3}$; K - 81 mg $dm^{-3}$; Ca – 1.65 cmolc $dm^{-3}$; Mg – 0.84 cmolc $dm^{-3}$; Al – 0.03 cmolc $dm^{-3}$; H + Al – 2.57 cmolc $dm^{-3}$; Zn – 1.0 mg $dm^{-3}$; Fe – 32.3 mg $dm^{-3}$; Mn – 6.3 mg $dm^{-3}$; Cu – 1.2 mg $dm^{-3}$; B – 0.18 mg $dm^{-3}$; SB – 2.7 cmolc $dm^{-3}$; t – 2.7 cmolc $dm^{-3}$; T – 5.3 cmolc $dm^{-3}$, V – 51.2%; m – 1.1%; medium texture. Other agricultural practices were performed as recommended by the literature.

The harvest was performed manually in the developmental stage R9 (Gross and Kigel, 1994), where the following characteristics were evaluated: height: considering ground level until the last top node of the main stem and number of pods per plant, both obtained from 04 plants randomly in the useful portion; number of grains per pod: average score obtained in the pods of 04 plants randomly in the useful portion; grain yield (kg $ha^{-1}$), calculated in kg $ha^{-1}$ and mean weight of 100 seeds: determined from seeds harvested in the useful area of each plot, according to the methodology established by BRASIL (20014).

Yield was corrected to 13% moisture content, according to the equation:

$$PF = PI \times (100 - UI) / (100 - UF)$$

where, PF = corrected final weight of the sample; PI = initial weight of sample; UI = initial moisture content of the sample and UF = final moisture content of the sample (13%).

Results were analyzed using F test and the means were compared by Tukey test (at 5% significance) and regression analysis. "SISVAR" (Ferreira, 2011) program was used to perform all the statistical analysis.

## RESULTS AND DISCUSSION

The average temperature in the region during the study period ranged from 15.4 to 22.4°C (Figure 1). The water deficit (DEF) occurred from January to March with intensity of - 5 mm and May to July, reaching an intensity of - 6 mm (Figure 1). The values of air temperature were similar to the normal climatological conditions of 16 to 23ºC, but the values of DEF were not similar, because it typically does not occur, DEF in the period of January to March (INMET, 2015).

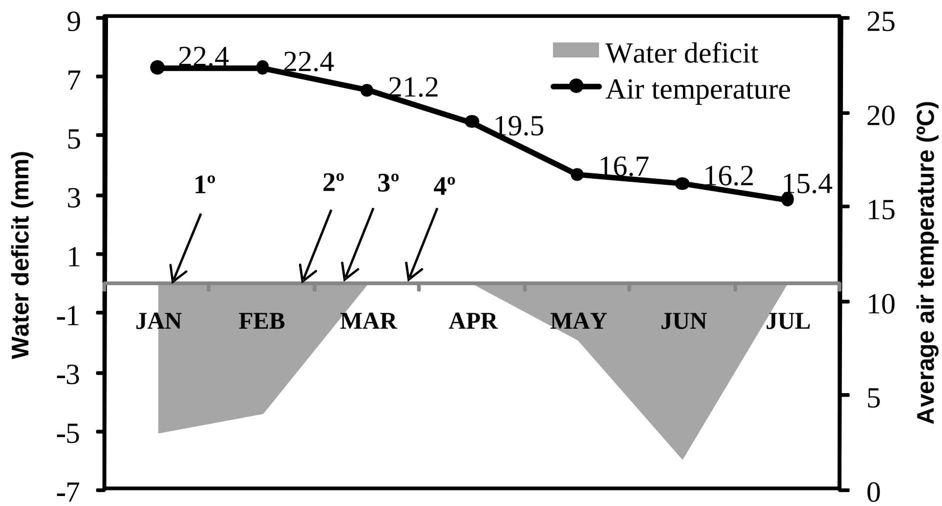


**Figure 1.** Water deficit (mm) and average air temperature (°C) in during the period from January to July of 2014 in the South of Minas Gerais – MG (1º; 2º; 3º and 4º is first, second, third and fourth sowing data, respectively).

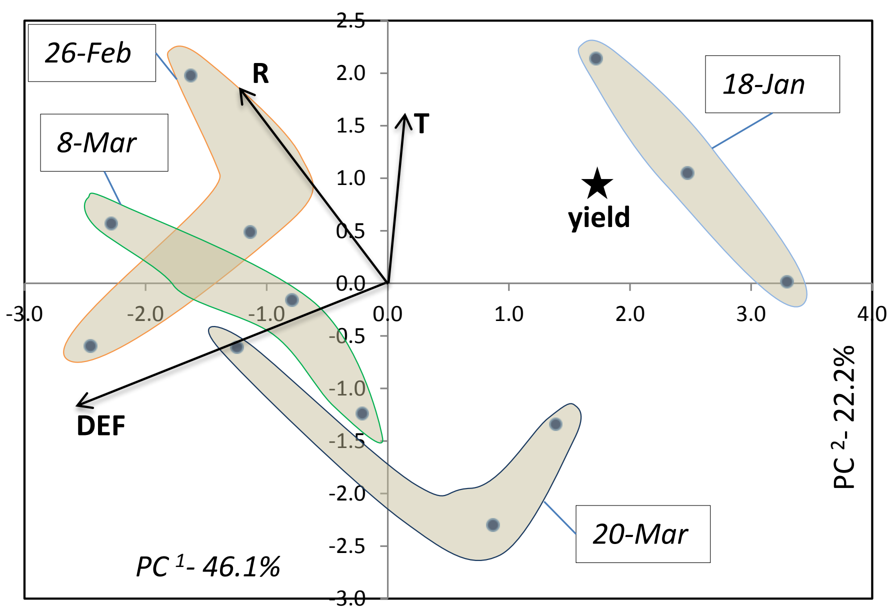


**Figure 2.** Biplot PC1 vs PC2 of dependent and independent variables and sowing dates (DEF = water deficit; T = Air temperature; R = rainfall).

The period of the first to second sowing dates there was a reduction in rainfall in the South of Minas (Figure 1), raining only 28% (68 mm) of normal (245 mm). The authors observed that in March there is a reduction of maximum and minimum temperatures in the region, and thus late bean plantations coincided with periods of minimum temperatures below the optimal range recommended for bean crop, that is between 18 to 24°C (EMBRAPA, 2005).

The development of the bean plants in the various sowing dates was dependent on the climatic conditions. The first two components ($PC_1$ and $PC_2$) of the PCA of all variables of growth and meteorological conditions together explained 68.3% of the total variability of the data. The development of the plants, mainly yield was most influenced by DEF (Figure 2), showing to be the most important variable climate (Aparecido et al., 2015).

There was a significant interaction between cultivars and sowing dates seeding only in the variable yield. The highest values of plant height (1.26 m), number of

**Table 1.** Results of plant height (PLH), number of pods per plant (NPP), number of seeds per pod (NSP), weight of 100 seeds (W100) and crop yield (Y) of bean of dry season in function of the sowing date in the South of Minas, MG.

| Sowing date | PLH (M) | NPP (unit) | NSP (unit) | W100 (g) | Y (kg $ha^{-1}$) |
|---|---|---|---|---|---|
| January 18 | 1.26$^{a}$ | 17.28$^{a}$ | 5.55$^{a}$ | 21.01$^{b}$ | 1.391$^{a}$ |
| February 26 | 0.82$^{b}$ | 8.69$^{b}$ | 4.75$^{b}$ | 25.99$^{a}$ | 963$^{c}$ |
| March 08 | 0.76$^{b}$ | 9.41$^{b}$ | 4.75$^{b}$ | 22.11$^{b}$ | 1.077$^{b}$ |
| March 20 | 0.84$^{b}$ | 10.11$^{b}$ | 5.31$^{ab}$ | 21.69$^{b}$ | 896$^{c}$ |
| CV (%) | 14.99 | 30.27 | 12.03 | 7.14 | 9.99 |

*Means followed by the same letter in the column do not differ by Tukey test at 5% probability. cV: coefficient of variation (%).

**Table 2.** Results of plant height (PLH), number of pods per plant (NPP), number of seeds per pod (NSP), weight of 100 seeds (W100) and crop yield (Y) of bean of dry season in the South of Minas, MG.

| Cultivars | PLH (M) | NPP (unit) | NSP (unit) | W100 (g) | Y (kg $ha^{-1}$) |
|---|---|---|---|---|---|
| Perola | 1.06$^{a}$ | 11.92$^{a}$ | 5.10$^{ab}$ | 24.55$^{a}$ | 1.136$^{a}$ |
| IAPAR 81 | 0.69$^{c}$ | 10.92$^{a}$ | 4.71$^{b}$ | 21.57$^{b}$ | 927$^{b}$ |
| Bolacheia | 0.92$^{b}$ | 11.29$^{a}$ | 5.46$^{a}$ | 21.98$^{b}$ | 1.181$^{a}$ |
| CV% | 14.99 | 30.27 | 12.03 | 7.14 | 9.99 |

*Means followed by the same letter in the column do not differ by Tukey test at 5% probability. cV: coefficient of variation (%).

pods per plant (17.28), number of grains per pod (5.55) and grain yield (1,391 kg $ha^{-1}$) were obtained from the seeding at January 18, regardless the used cultivar (Table 1).

The best plant height, number of pods per plant and yield were observed in the first sowing (Table 1). For seeds yield, plants seeded in January 18 produced 42.13% (412 kg $ha^{-1}$) more yield (978 kg $ha^{-1}$), possibly due to the higher response of yield components on this seeding. The highest 100-seed weight value of 25.9 was recorded by seeding in February 26, however, the grain yield was not affected by this increase. The highest yield obtained at study is close to the recorded for the dry season in Minas Gerais, according to data from Companhia Nacional de Abastecimento (2014/15), are around 1,387 kg $ha^{-1}$.

The number of pods per plant is the yield component most affected by water deficit, resulting a reduction in grain yield (Guimarães et al., 1996; Gomes et al., 2000), because the bean productivity is highly correlated with the yield components, number of pods per plant, number of grains per pod and seed weight (Costa and Zimmermann, 1988; Coimbra et al., 1999).

Perola showed the highest height values of plants and weight of 100 seeds. The highest yields were observed by Perola cultivars and Bola Cheia (Table 2). There were not differences among cultivars for the number of pods per plant, which showed mean values of 11.37 (average all cultivars) pods per plant. The Perola and Bola Cheia demonstrated similar responses to the agronomic characters.

The bean cultivars showed a quadratic response for grain yield (Figure 3). Cultivars Bola Cheia and Perola showed better performance when seed in the first sowing dates in mid-January, for the cultivar IAPAR 81 yield at the 3 firsts sowings were similar and higher than the last sowing date (March 20).

## Conclusion

The bean seeded in January 18 demonstrates higher yield, plant height number of pods per plant and number of seeds per pod in the regions of South of Minas Gerais. The authors observed that with the delay of sowing is the reduction of common bean yield.

The water deficit is the variable climate that most influences common bean yields in the South Minas. Cultivars Bola Cheia and Perola are more productive when compared with the cultivar IAPAR 81.

## Conflict of Interest

The author(s) have not declared any conflict interest.

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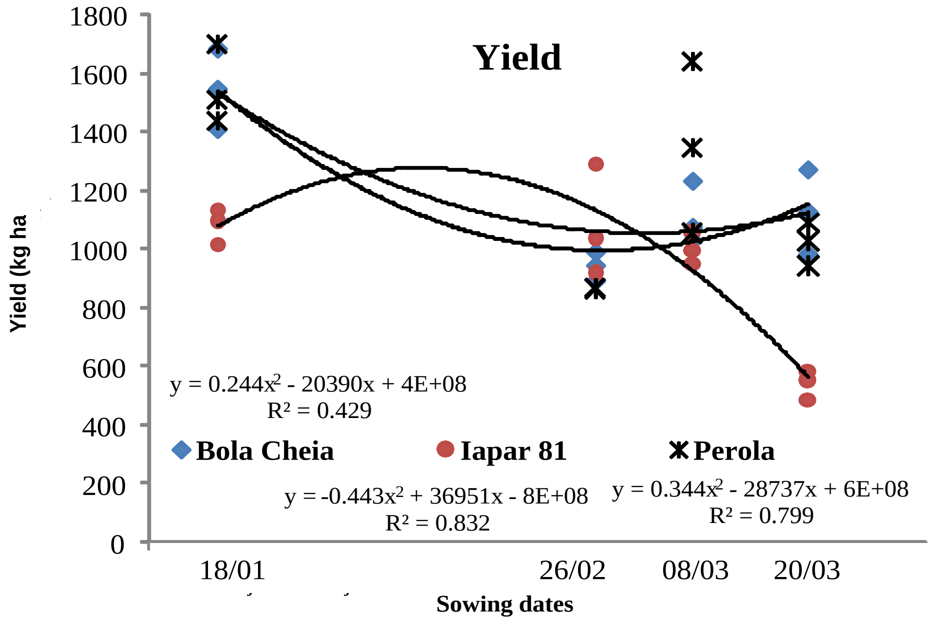


**Figure 3.** Yield (kg ha$^{-1}$) of the Bean in the dry season in function of the sowing dates in the South of Minas - MG.

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