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Irrigation blades and nitrogen doses in bean cultivation

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Abstract

Irrigation makes it possible to increase productivity in bean crops, but if mishandled, it can increase production costs and promote the leaching of nutrients, especially nitrogen, a nutrient that is fundamental for the development of the crop. Given the above, the objective of this study was to evaluate the yield of common beans subjected to different doses of nitrogen and water depths in the region of Uberaba – MG, Brazil. The experiment was conducted at IFTM – Campus Uberaba, in randomized blocks, consisting of four levels of irrigation (deficits of 15 %, 30 %, and 45 % and a factor without water deficit) and four doses of nitrogen (50 kg ha^{-1}, 100 kg ha^{-1}, 150 kg ha^{-1}, and 200 kg ha^{-1}) applied in stage V4 of beans. The cultivar used was BRSMG Majestoso. There was no interaction between irrigation levels and nitrogen doses for the variables studied. Nitrogen doses influenced linearly only leaf nitrogen content. The water deficit of 9.72 % was favorable to achieve maximum grain yields and favors the number of pods per plant. The plant mass in R6, a mass of 100 grains, hydration, and thermal sum declined linearly with increased water deficit.

Keywords: Irrigation management. Water deficit. *Phaseolus vulgaris* L.

Introduction

Brazil concentrates 50 % of the gross domestic product in agribusiness and ranks sixth among the most promising economies in the world. For this reason, more and more sustainable food production has been sought to meet global needs (SABUNDIJIAN *et al*., 2016).

Among the main crops produced in the country, beans (*Phaseolus vulgaris* L.) are grown in all Brazilian regions, in three growing seasons, for presenting a high climate adaptation, being a source of income for large and small producers, besides being, undoubtedly, of great nutritional importance for Brazilians. According to Conab (2019) data, the production of the three harvests was 3.23 million tons distributed over 2.927 million hectares. When grown during a water shortage, beans need irrigation to reach their full productive potential.

Soil and water are components that demand significant management attention for the productive efficiency of irrigated beans (MORAIS *et al*., 2017). Today, we know how valuable the conscious use of water supplies is. Therefore, irrigation must be managed correctly so that high levels of efficiency are achieved in crops. Thus, some aspects of irrigation management strategies should be analyzed: when to apply, the quantity of water to be applied, and the total blade applied during crop development (PACHECO *et al*., 2016).

As for fertilization, the nutrient most absorbed by beans is nitrogen, which is present in several molecules and physiological processes of the plant. Nitrogen fertilization influences the increase in leaf area and, consequently, in the plants' higher absorption of light and photosynthetic activity, providing in higher crop yields (SCHERER *et al*., 2015). However, research on nitrogen in bean cultivation is very controversial and varies significantly according to the agricultural management adopted (BERNARDES *et al*., 2014).

Given the above, the objective of this study was to evaluate the yield of common bean subjected to different doses of nitrogen and water blade irrigation in the region of Uberaba - MG.

Material and methods

The study was conducted at the Uberaba Campus of the Federal Institute of Education, Science and Technology of the Triângulo Mineiro located in the municipality of Uberaba – MG, Brazil, located at 800 m above sea level, latitude 19° 39' 19 "S and longitude 47° 57' 27" W. According to the Köppen classification, the climate is Aw type - hot and rainy summer, cold and dry winter - with a mean annual temperature of 23.2 ºC (VALLE JUNIOR *et al*., 2010) and mean annual rainfall of 1584.2 mm $year^{-1}$ (SILVA; GUIMARÃES; TAVARES *et al*., 2003).

The experiment was conducted in randomized blocks (RBD), using a factorial scheme 4 x 4 consisting of four levels of water availability in soil (deficits of 15 %, 30 %, and 45 %, and a factor without water deficit) and four doses of nitrogen (50 kg ha^{-1}, 100 kg ha^{-1}, 150, and 200 kg ha^{-1}) differentiated in coverage in stage V4 of beans, using urea as a source of this nutrient. Four replications were used in a total of 16 treatments and 64 plots. Each experimental plot consisted of six seeding lines, with three meters in length. Plants located in the center of the area were considered useful for data collection (1 m^2 area).

The soil of the experimental area was classified as dystrophic red latosol, whose chemical characteristics were analyzed by the Laboratório de Análise de Solo/Soil Analysis Laboratory – Labfert Uberaba, MG, and are presented in Table 1. All nutrient contents were corrected following the recommendation of Chagas *et al*. (1999) for the NT4 level. The soil belongs to the texture class sandy clay loam (TABLE 2).

Table 1 – Results of the chemical analysis of the soil used in the experiment. IFTM - Uberaba Campus. Uberaba/MG, 2017.

Characteristics	Contents	Characteristics	Contents
pH in $CaCl_2$	5.8	H + Al (mmolc dm^{-3})	16.0
P (mg dm^{-3})	31.12	SB (mmolc dm^{-3})	44.86
K (mmolc dm^{-3})	2.96	T (mmolc dm^{-3})	60.86
Ca^{2+} (mmolc dm^{-3})	26.2	V (%)	73.21
Mg^{2+} (mmolc dm^{-3})	15.7	MO (g dm^{-3})	17.8
Al^{3+} (mmolc dm^{-3})	0		

SB is the sum of exchangeable bases; T is the CTC at pH equal to 7.0; V is the base saturation; MO is the organic matter in the soil.

Source: Laboratório de Análise de Solo – Labfert Uberaba, MG.

Table 2 – Results of the physical analysis of the soil (texture) of the experimental area. IFTM – Uberaba Campus. Uberaba/MG, 2017.

Layer (cm)	Sand (%)	Silt (%)	Clay (%)	Class
0-20	64	10	26	Sandy clay loam

Source: Laboratório de Análise de Solo – Labfert Uberaba, MG.

Table 3 shows the equations for adjusting the characteristic curves of water retention in the soil for layers 0 cm – 20 cm and 20 cm – 40 cm deep.

From the soil collected through the Uhland cylinder, soil density values of 1.18 g cm^{-1} and 1.22 g cm^{-1} were verified for the respective depths 0 cm – 20 cm and 20 cm – 40 cm. The field capacity was 0.23 cm^3 cm^{-3} for the average water stress in the soil of 10 kPa in the layer 0 cm – 20 cm and permanent wilting point of 0.054 cm^3 cm^{-3}.

Table 3 – Results of the hydric characterization of the soil of the experimental area. IFTM – Uberaba Campus. Uberaba/MG, 2017.

Layer (cm)	Equation	R2
0 – 20	$\theta = \frac{0,46}{\left[1+(1,4 * \Psi_m)^{4,707}\right]^{0,116}} + 0,078$	0.925
20 – 40	$\theta = \frac{0,375}{\left[1+(0,985 * \Psi_m)^{6,917}\right]^{0,127}} + 0,238$	0.958

θ= volumetric moisture (cm^3 cm^{-3}); ψ_m= matrix potential (kPa).
Source: Elaborated by the authors (2017).

The cultivar used in the experiment was BRSMG Majestoso, which presents indeterminate growth habit type III and carioca type beans. The soil preparation system was conventional, with the aid of a grader and the grooves being opened by a cultivator, with stems spaced at 50 cm. The experiment was sown on April 16, 2017, with a density of 16 seeds per meter. Weed control was carried out through manual weeding, and control of insects and diseases in beans was performed as needed, using pesticides registered for the crop. The harvest was on August 7, 2017, 92 days after the seeding.

The meteorological data were obtained through a digital thermohygrometer and a rain gauge *Ville de Paris* model installed at the experiment site and measured with data from the automatic meteorological station located at IFTM – *Campus* Uberaba.

Four micro-sprinklers installed in the plots irrigated the soil, with 50 % overlap installed at 20 cm from the ground, with an application intensity of 7.5 mm h^{-1}. Tensiometer rods were installed in each treatment to evaluate the water stress and soil moisture. Data were read during the morning.

To obtain the reference evapotranspiration, Hargreaves and Samani (1985) equation 1 was used.

$$ETo = 0,0023\ (Tmed + 17,8) \times (Tmax - Tmin)^{0,5} \times Ra \times 0,408 \quad (1)$$

at which: ETo = reference evapotranspiration (mm day^{-1}); Tmin = minimum temperature (°C); Tmax = maximum temperature (°C); Tmean = average temperature (°C) and Ra = radiation at the top of the atmosphere (MJ $m^{-2}day^{-1}$).

Data regarding solar radiation were obtained following Doorenbos and Pruitt's (1975) recommendation. The crop evapotranspiration values in the treatment without water deficit were obtained through equations 2 and 3, and the other irrigation levels obeyed the proportion of each treatment.

$$ETc = ETo \times Kc \times Ks \quad (2)$$

at which: ETc = crop evapotranspiration (mm day^{-1}); Kc = crop coefficient (dimensionless) and Ks = moisture coefficient (dimensionless).

$$LB = LL/Cu \times Ea \quad (3)$$

at which: LB = gross irrigation depth (mm); LL = net irrigation depth, considering the estimated ETc (mm); Ea = system application efficiency (decimal) and Cu = system uniformity coefficient (decimal).

The culture coefficient adopted was proposed by Santana (2007). Throughout the experiment, we accepted 1 (one) as the soil moisture coefficient value; for both parameters of application efficiency and uniformity coefficient of the system, 0.85 was applied to the formula.

The Arnold method (1959) was used for the thermal sum, with a record per plot when at least ten plants had changed phenological phase. The upper and lower base temperatures considered were 35 °C and 10 °C, respectively. The method was calculated according to equation 4.

$$GD = \{[(Tmax + Tmin)/2] - Tbase\} \quad (4)$$

at which: GD = cumulative degree-day (°C); Tmax = maximum average daily air temperature (°C); Tmin = the minimum average daily air temperature (°C) and Tbase = the temperature below which plants do not develop.

Grain hydration was determined by the methodology described by Durigan (1979). In each beaker with a capacity of 250 ml, 50 grams of previously chosen grains and 200 mL of distilled water were added. During 12 hours, we measured the volume of water not absorbed by the grains. At the end of the time predicted for hydration, the water was fully drained and the grains were weighed. The hydration ratio was determined as the ratio between the mass after hydration and the initial mass of the grains.

Other parameters were evaluated as grain yield, the mass of 100 grains, mass of the plant in R6, number of pods per plant, number of grains per plant, number of grains per pod, water use efficiency (EUW), and leaf nitrogen content. Productivity and mass values of 100 grains were corrected for 13 % humidity.

All parameters were submitted to analysis of variance using the statistical program Sisvar version 5.6 (FERREIRA, 2014), and the effects of treatments when significant at 5 % probability were studied by regression analysis.

Results and discussion

Table 4 shows the mean values of water stress in the soil and the total blade applied to each treatment. The analysis of the water stress data in the soil did not show any difference between the water deficits, with values ranging from 12.83 kPa to 16.32 kPa.

Table 4 – Water stress in the soil and blades applied in the experiment. IFTM – Uberaba Campus. Uberaba/MG, 2017.

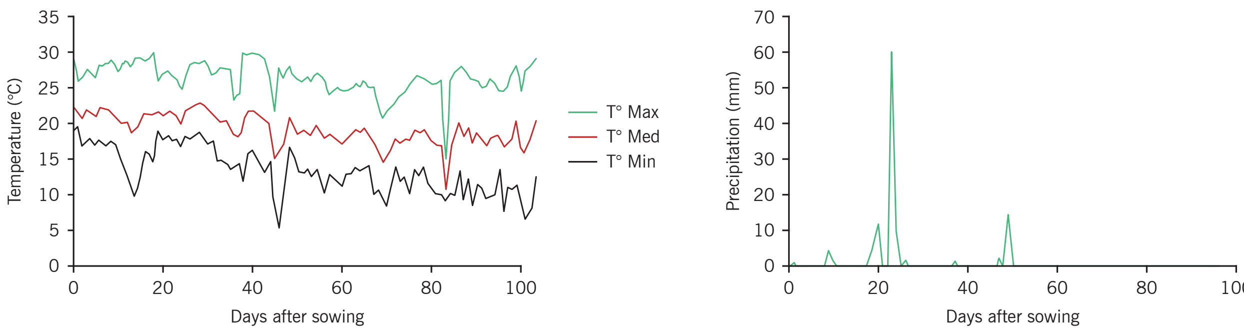
Water deficit (%)	Average water stress in the soil (kPa)	Blade applied (mm)
0	12.83	472
15	13.56	433
30	16.32	394
45	14.17	354

Source: Elaborated by the authors (2017).

Due to the daily irrigation during the work, the value of water stresses in the soil remained close to the field capacity, around 10 kPa. In a study conducted by Brito (2014) evaluating different water stresses in the soil (30 kPa, 40 kPa, 50 kPa, 60 kPa, and 70 kPa) in the cultivation of common beans, we observed that the stress of 30 kPa increased bean productivity positively.

After performing the calculations, we obtained the blades applied to each deficit during the experiment. Accumulated precipitation of 125.22 mm occurred during culture development (FIGURE 1). There was precipitation of 60.19 mm 24 days after the bean sowing.

Figure 1 – Temperature (maximum, average, and minimum) and precipitation in the experimental area of IFTM - Uberaba Campus. Uberaba/MG, 2017.



Source: Prepared by the authors (2017).

Adding the precipitation during the experiment, blades of 472 mm, 433 mm, 394 mm, and 354 mm were verified at deficits of 0 %, 15 %, 30 %, and 45 %, respectively. According to Cunha *et al*. (2013), in an experiment that analyzed different forms of irrigation management (Tank Class A, Tensiometry, and Penman-Monteith), with blades corresponding to 407.39, 272.04, and 341.63, the highest blade was observed to have provided the highest crop productivity.

The relative maximum, minimum and average air moisture during culture development were 52.62 %; 72.80 %, and 92.06 %, respectively. The temperature in the culture development period ranged from 5.60 ºC to 29.90 ºC, and the average temperature during the experiment was 19.1 ºC (FIGURE 1). The recommended temperature value for the full development of beans is 29 ºC during the day and 21 ºC during the night. Temperatures above 35 ºC are harmful to the culture and may affect productivity (GONZAGA *et al*., 2014).

Table 5 summarises the analysis of variance for the variables: grain yield, the mass of 100 grains, mass in R6, number of pods per plant (NPP), thermal sum, number of grains per plant (NGPl), number of grains per pod (NGP), grain hydration, water use efficiency (EUW), and leaf nitrogen content (Leaf N). There was a statistical difference for deficits ($p < 5$ %) for mass in R6 and the number of pods per plant (NPP). For the variables: grain yield, mass of 100 grains, hydration, thermal sum, effective use of water (EUW), and leaf nitrogen content, a statistical difference was observed ($p < 1$ %). There was no interaction between irrigation levels and nitrogen doses and the effect of nitrogen doses for any variable studied.

Table 5 – Summary of the Analysis of Variance table for the variables: grain yield (Prod.), mass of 100 grains, mass in R6, number of pods per plant (NPP), thermal sum, number of grains per plant (NGPl), number of grains per pod (NGP), grain hydration, water use efficiency (EUW), and leaf nitrogen content (Leaf N). IFTM - Uberaba Campus. Uberaba/MG, 2017.

SV1	DF2	Prod.	Mass 100 grains	Mass in R6	NPP	Thermal sum
Deficit (D)	3	0,0000[4]	0,0000[4]	0,0460[5]	0,0500[5]	0,0000[4]
Nitrogen Dose (N)	3	0,9870[ns]	0,4899[ns]	0,6791[ns]	0,1193[ns]	0,1454[ns]
D x N	9	0,6983[ns]	0,6882[ns]	0,8325[ns]	0,7391[ns]	0,3411[ns]
General Average		4174,24 kg ha^{-1}	24,78 g	22,89 g	15,69	855,51ºC
CV[3] (%)		21,23	11,3	23,46	29,36	1,75
SV1	**DF2**	**NGPl**	**NGP**	**Hydration**	**E.U.W.**	**Leaf N**
Deficit (D)	3	0,1865[ns]	0,6081[ns]	0,0004[4]	0,0067[4]	0,5757[ns]
Nitrogen Dose (N)	3	0,4048[ns]	0,1101[ns]	0,5642[ns]	0,9817[ns]	0,0000[4]
D x N	9	0,4503[ns]	0,2712[ns]	0,8306[ns]	0,6537[ns]	0,8373[ns]
General Average		85,92	5,40	1,61	10,06	31,77
CV[3] (%)		31,13	15,39	9,54	21,63	12,25

[1] sources of variation; [2] degree of freedom; [3] coefficient of variation; [4] significant at 1 % probability by F test; [5] significant at 5 % probability by F test; [ns] not significant by F test.

Source: Elaborated by the authors (2017).

Productivity was not influenced by the nitrogen doses applied in the experiment, possibly because the application was performed at V4, and the rainfall occurred in the period. This result corroborates the work carried out in the municipality of Aquidauana, MS, Brazil, by Pacheco *et al*. (2016), when the authors also did not observe a significant effect of the doses (0 kg ha^{-1}, 50 kg ha^{-1}, 100 kg ha^{-1}, and 150 kg ha^{-1}) of nitrogen. Some authors, such as Guimarães *et al*. (2017) and Sabundijian (2013), found no statistical differences in nitrogen doses for bean grain yield. Kolling and Ozelame (2017) found that for every 10 kg of nitrogen applied; there was an increase in crop productivity of 14 kg ha^{-1}.

Amaral *et al*. (2016), in an experiment conducted in the city of Jaboticabal, SP, evaluated five doses of nitrogen (0 kg ha^{-1}, 40 kg ha^{-1}, 80 kg ha^{-1}, 120 kg ha^{-1}, and 160 kg ha^{-1}) and observed that the doses influenced bean grain yield, in which the application of 136 kg ha^{-1} provided 2565 kg ha^{-1} of productivity.

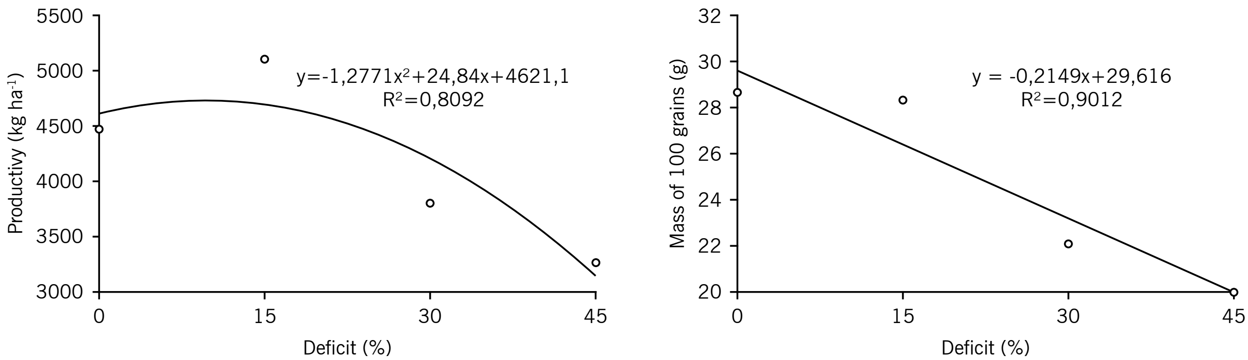
In a study conducted by Moreira *et al*. (2013) analyzing nitrogen doses (0 kg ha^{-1}, 40 kg ha^{-1}, 80 kg ha^{-1}, and 120 kg ha^{-1}) in irrigated beans, they found that a linear increase caused by nitrogen doses in sowing in grain yield occurred where, for each kg of this nutrient, there was an increase of 3.679 kg ha^{-1} in this variable, with a maximum yield of 2404 kg ha^{-1}.

Sabundijian *et al*. (2016), testing doses of 0 kg ha^{-1}, 40 kg ha^{-1}, 80 kg ha^{-1}, and 120 kg ha^{-1}, in coverage with the application in a total area of *Rhizobium tropici*, found a significant effect on grain yield in the first year of the experiment with the maximum point of production using 60 kg ha^{-1} of nitrogen. However, in the second year of the experiment, the author found no statistical differences with nitrogen doses, showing the difficulty of dynamics in the management of this nutrient.

Irrigation blades provided a significant effect on grain yield. The deficit of 9.72 % is indicated to achieve the highest productivity values (FIGURE 2). According to Aleman and Mignacca

(2015), for the Pearl cultivar, with water replacement levels in the soil of 25 %, 50 %, 75 %, 100 %, 125 %, and 150%, the maximum grain production was with the replacement of 75 % of water in the soil, showing the beneficial effect of water deficit on grain productivity.

Figure 2 – Productivity and mass of 100 grains as a function of the water deficit. Uberaba – MG



Source: Elaborated by the authors (2017).

In a study conducted by Sales *et al*. (2017), they found that the highest productivity of the cultivar BRSMG Majestoso was 3422.19 kg ha^{-1}, with a blade of 226.96 mm, which was around 29 % smaller than the blade with the highest value used in the experiment. In the analysis of co-inoculation and irrigation blades (100 % and 75 %), Peres (2014) found that the 75 % blade provided productivity equal to or higher than the 100 % blade in autumn/winter cultivation.

Torres *et al*. (2013) evaluated different soil coverings and irrigation levels (40 %, 70 %, 100 %, 130 %, and 160 % of daily evapotranspiration), also finding higher grain yield when 100 % replacement was used.

The mass of 100 grains was also influenced by the irrigation depths (FIGURE 2), with an inversely proportional relationship between grain weight and water deficit. With each unit increase in water deficit, there was a 0.72 % reduction in grain mass. These results are similar to Morais *et al*. (2017), in which the increase in the deficit resulted in a lower grain weight per plant. In the study, for every 1 % increase in water replacement, grain weight increased by 3.54 %.

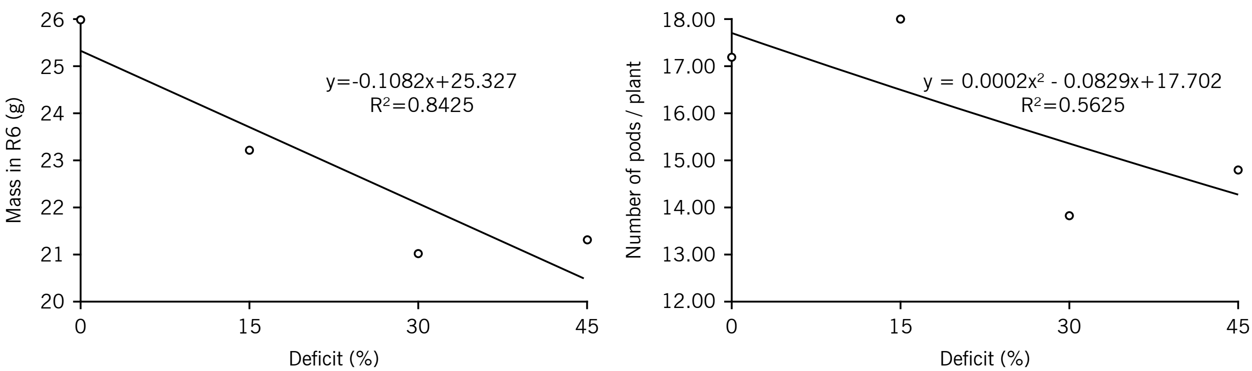
The fact that nitrogen did not affect the mass of 100 grains was also verified by Kolling and Ozelame (2017), who, using doses of 0 kg ha^{-1}, 25 kg ha^{-1}, 50 kg ha^{-1}, and 75 kg ha^{-1} of nitrogen, found no effect on seed mass. Other authors also found no differences in the effect of the nitrogen dose on the mass of 100 grains, such as Moreira *et al*. (2013); Guimarães *et al.* (2017), and Sabundijian *et al*. (2016).

The plant mass in R6 was also not influenced by nitrogen doses, a result similar to the one found by Silva, Silva, and Trevisam (2017a), in an experiment that evaluated the interaction between nitrogen and sulfur using doses of 80 mg dm^{-3} and 120 mg dm^{-3} of nitrogen, in which they did not observe a significant effect of this nutrient on the dry matter of the aerial part, with an overall average production of 9.77 g plant^{-1}.

In a study by Scherer *et al*. (2015), evaluating the time of application and doses of 0 kg ha^{-1}, 30 kg ha^{-1}, 60 kg ha^{-1}, and 120 kg ha^{-1} of nitrogen, they found statistical differences for bean dry matter, recommending a dose of 120 kg ha^{-1}, divided at 15 and 30 days after emergence. Schoninger *et al*. (2015) also observed a linear increase in shoot dry mass when using doses of (0 kg, 40 kg, and 80 kg of N ha^{-1}) of nitrogen in the BRS Requinte cultivar.

The water deficit affected this variable, in the same way as on the weight of 100 grains, being inversely proportional. For each 1 % increase in the water deficit, there was a 0.42 % reduction in the mass plant (FIGURE 3). The variable plant mass is interconnected with the weight of 100 grains, because the lower the plant weight, the lower its contribution, number, and size of leaves, resulting in a lower photosynthetic capacity and consequently a lower grain filling. The water deficit in the crop promotes decreased absorption of nutrients and changes in the behavior of the plant metabolism, which may have caused a decrease in the averages of the variables mentioned.

Figure 3 – Dry plant mass in R6 and number of pods per plant as a function of the water deficit. Uberaba - MG.



Source: Elaborated by the authors (2017).

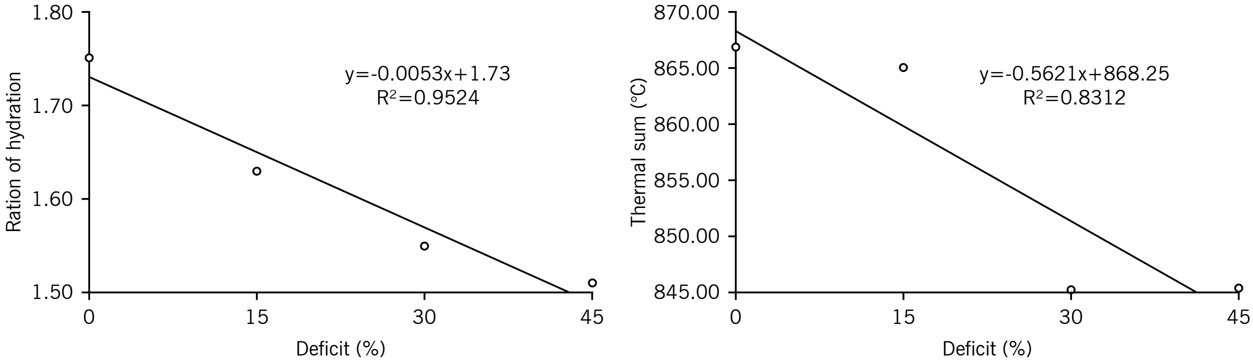
The number of pods suffered the effect of water deficit levels, at which, in the conduct of the experiment, the 15 % deficit resulted in an average of 18 pods per plant (FIGURE 3). This result explained the grain yield since the number of pods per plant directly influenced this variable; therefore, the deficit provided a higher number of pods and, consequently, higher productivity. Peres (2014), in an experiment conducted in 2013, analyzed co-inoculation and irrigation blades of 100 % and 75 % and found that the deficit of 15 % provided the highest value for this variable. Torres *et al.* (2013) reported that the number of pods was higher when 100 % replacement was used. Souza (2016), in a study with doses of 0 kg ha^{-1}, 50 kg ha^{-1}, 100 kg ha^{-1}, 150 kg ha^{-1}, and 200 kg ha^{-1}, observed a linear increase caused by doses of nitrogen in the number of pods per plant.

Under the conditions of the experiment, the number of average pod grains was 5.4 and was not influenced by the factors studied (TABLE 3). The variable number of grains per plant was also not influenced by the doses of nitrogen and irrigation levels, observing the average value of 85.02 (TABLE 5). Sabundijian *et al*. (2016), testing doses of 0 kg ha^{-1}, 40 kg ha^{-1}, 80 kg ha^{-1}, and 120 kg ha^{-1}, also found no significant effect of nitrogen on the number of grains per plant.

The hydration ratio was significant for water deficits (FIGURE 4). With the increased deficit, the hydration ratio was reduced, with values ranging between 1.75 and 1.51. This result can be explained with the aid of the mass of 100 grains, which presented the same behavior when analyzed. With the increase in the deficit, there was a decrease in grain mass and a decrease in grain size; consequently, the smaller the grain size, the lower its hydration capacity.

Amaral *et al*. (2016), analyzing doses of 0 kg ha^{-1}, 40 kg ha^{-1}, 80 kg ha^{-1}, 120 kg ha^{-1}, and 160 kg ha^{-1}, found no difference in time for hydration. They observed maximum hydration after the interval between 15 hours and 13 hours.

Figure 4 – Ratio of hydration and thermal sum as a function of the water deficit. Uberaba - MG.



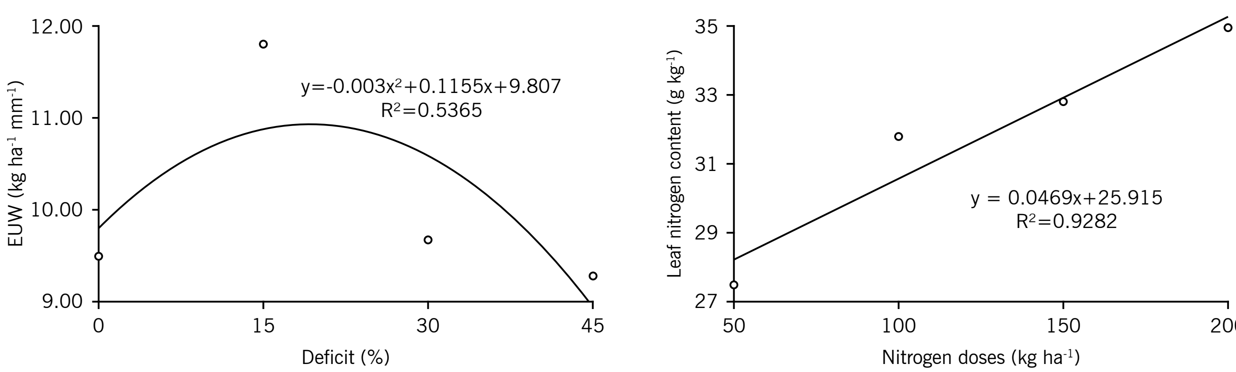
Source: Elaborated by the authors (2017).

According to Souza (2016), for the cultivar IAC Alvorada, there was no significant difference for the variables: hydration ratio, obtaining as an overall average the value of 2.02; maximum hydration time, observing the average of 11 hours and 35 minutes, and the crude protein content, which presented an average of 20.35 %.

The thermal sum was influenced by the water deficit (FIGURE 4), showing that the higher the deficit, the lower the crop cycle, with total values of 866 ºC, 864 ºC, 845 ºC, and 845 ºC, respectively, for deficits of 0 %, 15 %, 30 %, and 45 %, respectively. With the blade reduction applied, the plant receives a stimulus to finish its cycle in less time.

For water use efficiency (FIGURE 5), the highest values were verified for the deficit of 15 %, which presented an average of 11.79 kg ha^{-1} per mm $^{-1}$. Brito *et al*. (2016) evaluated the conduction of beans with and without water restriction, observed in treatments without water restriction the value of 0.50 kg m^{-3} for WUE, applying 376.4 mm of the total blade.

Figure 5 – Water use efficiency as a function of the water deficit and nitrogen content in the leaf as a function of nitrogen doses. Uberaba - MG.



Source: Elaborated by the authors (2017).

Pacheco *et al*. (2016) stated that the EUW is one of the essential parameters when analyzing the effect of agricultural practices. Analyzing doses of nitrogen (0 kg ha^{-1}, 50 kg ha^{-1}, 100 kg ha^{-1}, and 150 kg ha^{-1}) and estimating evapotranspiration by Hargreaves and Samani's (1985) method, they obtained a value of 0.40 kg m^{-3} for the EUW.

Soares *et al*. (2016), analyzing a control (rainfall), and 46 %, 73 %, 84 %, and 100 % of the replacement of the ETc, found that the treatment 100 % provided greater efficiency of water use with 0.26 kg m^{-3}, with the average of the experiment being 0.32 kg m^{-3}.

There was a linear increase in the nitrogen content in the leaves with the increase in the doses of this element (FIGURE 5), and they obtained values between 27.5 % and 34.97 %. No effect of irrigation blades on nitrogen content in leaves was observed. According to Silva (2017b), the nitrogen doses of 80 mg dm^{-3} and 120 mg dm^{-3} showed no significant difference.

Souza (2016), evaluating nitrogen doses of 0 kg ha^{-1}, 50 kg ha^{-1}, 100 kg ha^{-1}, 150 kg ha^{-1}, and 200 kg ha^{-1} in the cultivar IAC Alvorada, verified a linear increase in leaf nitrogen content, with an overall average of 31.8 g kg^{-1}. Bernardes *et al*. (2014), evaluating nitrogen doses in the BRS Supremo cultivar, found a significant effect of the doses of the element on the final content in bean leaves in flowering, obtaining a better adjustment by the quadratic model where the dose of 120.7 kg ha^{-1} provided the maximum value of 47.2 g kg^{-1} of nitrogen.

Conclusion

Nitrogen doses did not influence the yield of common beans under the conditions of the study. The higher water deficits caused a drop in crop yield. The water deficit of 9.72 % was favorable to achieve maximum grain yields and favors the number of pods per plant.

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