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PLANT ARRANGEMENT AND NITROGEN FERTILIZATION IN GRAIN SORGHUM PRODUCTION

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Abstract – The appropriate arrangement of sorghum plants combined with the supply of nutrients increases grain yield. In this context, the objective was to evaluate the agronomic performance of grain sorghum grown under different plant arrangements and nitrogen fertilization levels. Experiments were carried out in Rio Verde and Montividiu in a 3 x 2 factorial randomized completely block design with six replications, with three spacing between rows (reduced, traditional and double row) and the use or not of 90 kg ha^{-1} topdressing nitrogen. There was a beneficial effect of topdressing nitrogen fertilization on grain yield when sorghum was grown in double rows in both locations, and for the reduced arrangement in Montividiu. However, the effect of topdressing nitrogen fertilization on grain yield in the traditional arrangement was not found. The dry shoot biomass of sorghum plants increased with nitrogen fertilization in Montividiu. The arrangement or topdressing nitrogen fertilization did not influence the thousand-grain weight of Sorghum.

Keywords: Spacing, Plant population, second crop, *Sorghum bicolor.*

ARRANJO DE PLANTAS E ADUBAÇÃO NITROGENADA NA PRODUÇÃO DE SORGO GRANÍFERO

Resumo - O adequado arranjo de plantas de sorgo associado ao fornecimento de nutrientes potencializa a produtividade de grãos. Neste contexto, objetivou-se avaliar o desempenho agronômico do sorgo granífero cultivado em diferentes arranjos de plantas e adubação nitrogenada. Os experimentos foram conduzidos em Rio Verde e Montividiu no delineamento de blocos casualizados com seis repetições no fatorial 3 x 2, sendo três espaçamentos entre linhas (reduzido, tradicional e fileiras duplas) e o uso ou não de 90 kg ha^{-1} de nitrogênio em cobertura. Os resultados permitiram constatar efeito benéfico da adubação nitrogenada no aumento da produtividade de grãos quando o sorgo foi cultivado em fileiras duplas em ambas as localidades, como também em Montividiu para o arranjo reduzido. No entanto, não se constatou o efeito da adubação nitrogenada em cobertura em relação à produtividade de grãos no arranjo tradicional. A biomassa seca da parte aérea das plantas de sorgo respondeu positivamente ao fornecimento de nitrogênio em Montividiu. O peso de mil grãos do sorgo não foi influenciado pelo arranjo ou mesmo pela adubação nitrogenada em cobertura.

Palavras-chave: Espaçamento, População de plantas, Safrinha, *Sorghum bicolor*

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The grain sorghum acreage in Brazil for the 2021/2022 growing season is estimated at 865 thousand hectares, in which the state of Goiás is the largest producer of this cereal among the Brazilian states (46% national production) (Acompanhamento da Safra Brasileira de Grãos, 2022). In this context, the growing demand for sorghum grain by agro-industries installed in Central-West Brazil was a significant factor in the consolidation of the crop in the region (Silva et al., 2015).

Almost all sorghum grain production in the Cerrado is made in the second crop. This type of cultivation is characterized by planting sorghum after harvesting another plant species in the summer crop, usually soybeans. In this region, Sorghum is primarily planted between the second half of February and the first half of March. Therefore, the sowing of the crop may occur later when the expected rainfall volume is not enough to meet the water needs for corn cultivation (Menezes, 2015). Due to the lower water requirement concerning this crop, sorghum has been considered a versatile crop, with a high capacity to adapt to different climatic conditions and support periods of drought (Mahmood & Honermeier, 2012). In addition, these traits allow sorghum to grow under limited rainfall conditions for other plant species, such as corn.

Despite the high adaptability of the crop in Brazil, Sorghum's estimated average grain yield of Sorghum for the 2021/22 growing season was 2,856 kg ha^{-1} (Acompanhamento da Safra Brasileira de Grãos, 2022). This value is considered very low for the productive potential of the crop. In addition, factors such as the lack of specific technical recommendations adjustments for the primary hybrids or varieties available on the market, inefficient weed control, and the absence or insufficient fertilization for the crop may justify the low grain yield of sorghum found in Brazilian crops.

The availability of sorghum hybrids in the Brazilian market has grown significantly over the years. However, genotypes with different plant architecture traits, such as height, morphology, leaf angle, cycle, and production potential, cannot have a single recommendation for cultivation. Therefore, specific adjustments are required, considering regional aspects, such as soil and climate. In this sense, one possibility to maximize agricultural crop productivity is using different plant arrangements instead of those traditionally adopted. The definition of the ideal plant arrangement makes it possible for sorghum to be more efficient in capturing solar radiation and exploiting the water and nutrients in the soil (Albuquerque et al., 2010). Gradual reductions in row spacing in second crops have been occurring over the years in Brazil to facilitate the implementation of both crops. For sorghum, higher grain yields were obtained with 0.45 cm row spacing, compared to 0.60 and 0.90 m (Bishnoi et al., 1990).

Still, concerning the factors limiting the crop grain yield, differently from what has been advocated, the rusticity associated with sorghum does not mean that this plant species do not need nutrients or even does not respond to fertilization in general (Goes et al., 2011; Borges et al., 2016). Traditionally, the nutrition of sorghum plants derives from the use of residues from fertilization made in summer crops, such as soybeans, or even from the release of nutrients from the decomposition of crop residues. Despite this, sorghum may have a high nutritional requirement, especially when seeking high grain yield levels (Borges et al., 2016).

One of the primary nutrients required by sorghum is nitrogen, which accumulates in plants

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until maturity (Goes et al., 2011; Mateus et al., 2011). However, despite the great demand for this macronutrient, using nitrogen fertilization in topdressing is not common practice in cultivating grain sorghum in the second crop (Goes et al., 2011). This situation occurs because producers sometimes do not want to increase the crop cost production and because responses to topdressing fertilization are variable. These parameters are mainly conditioned to the genetic material, the expected yield, the soil organic matter content, and soil water availability (Mateus et al., 2011). Thus, adjustments in row spacing, respecting the cultivar's particularities, and using nitrogen fertilization can increase sorghum grain yield. Furthermore, this circumstance would bring additional benefits, such as helping to suppress the weed community, as the crop may have a superior competitive ability concerning weeds (Bishnoi et al., 1990; Braz et al., 2019).

In this sense, the objective of this study was to evaluate the agronomic performance of grain sorghum grown in different plant arrangements, as well as the response to topdressing nitrogen fertilization in crops grown after soybeans.

Material and Methods

Two field experiments were conducted in the state of Goiás; in the municipalities of Rio Verde (17°52'55" S; 50°55'43" W; and 741 m altitude) and Montividiu (17°22' 58" S; 51°22'40" W; and 910 m altitude), both installed in the second crop of 2018 (after soybeans in no-till soil). These two municipalities stand out in the sorghum grain production in the state due to the growing demand for raw materials for the manufacture of animal feed by agro-industries installed in the region.

The climate of these two municipalities is Aw, according to the Köppen classification, with a dry period in the winter and rainfall concentrated in the summer, with annual average temperatures of 23.3 and 23.0°C and an annual average rainfall of 1,663 and 1,512 mm for Rio Verde and Montividiu, respectively (Climate-Data, 2022). Data on rainfall, average temperature, and relative humidity from sowing to harvesting experiments, by location, are shown in Figure 1.

The soil of the experimental area in Rio Verde was classified as Red Latosol (Santos et al., 2018) with the following physical-chemical properties in the 0.0 to 0.2 m layer at the time of the experiment implementation: pH in $CaCl_2$: 5.3; Ca, Mg, K, Al, H + Al, CEC and SB: 4.1; 1.2; 0.3, 0.0; 2.8; 8.4 and 5.6; respectively in $cmol_c\ dm^{-3}$; P; Cu, Zn, Fe, and Mn: 37; 2.5; 1.9; 55.1; 147.1 in mg dm^{-3}, respectively; organic matter: 24.0 g dm^{-3}; clay, silt, and sand: 348; 121, 529 g kg^{-1}, respectively. Contrasting, the soil of the Montividiu experimental area was classified as Red-Yellow Latosol (Santos et al., 2018), with the following physical and chemical characterization in the 0.0 to 0.2 m layer: pH in $CaCl_2$: 5.9; Ca, Mg, K, Al, H + Al, CEC and SB: 3.0; 0.7; 0.2, 0.0; 3.6; 7.6 and 4.0 in $cmol_c\ dm^{-3}$, respectively; P, Cu, Zn, Fe, and Mn: 26.8; 3.6; 12.1; 56.8; 159.9 in mg dm^{-3}, respectively; organic matter: 18.7 g dm^{-3}; clay, silt, and sand: 225; 79 and 696 g kg^{-1}, respectively. Importantly, these results were obtained before planting sorghum since fertilization was applied before planting the soybean crop.

Experiments were installed in a 3 x 2 factorial randomized block design with six replications, corresponding to the following factors: three plant arrangements (reduced row spacing - 0.25 m and final population equivalent to 260,000 plants ha^{-1}; traditional row spacing - 0.50 m and final population

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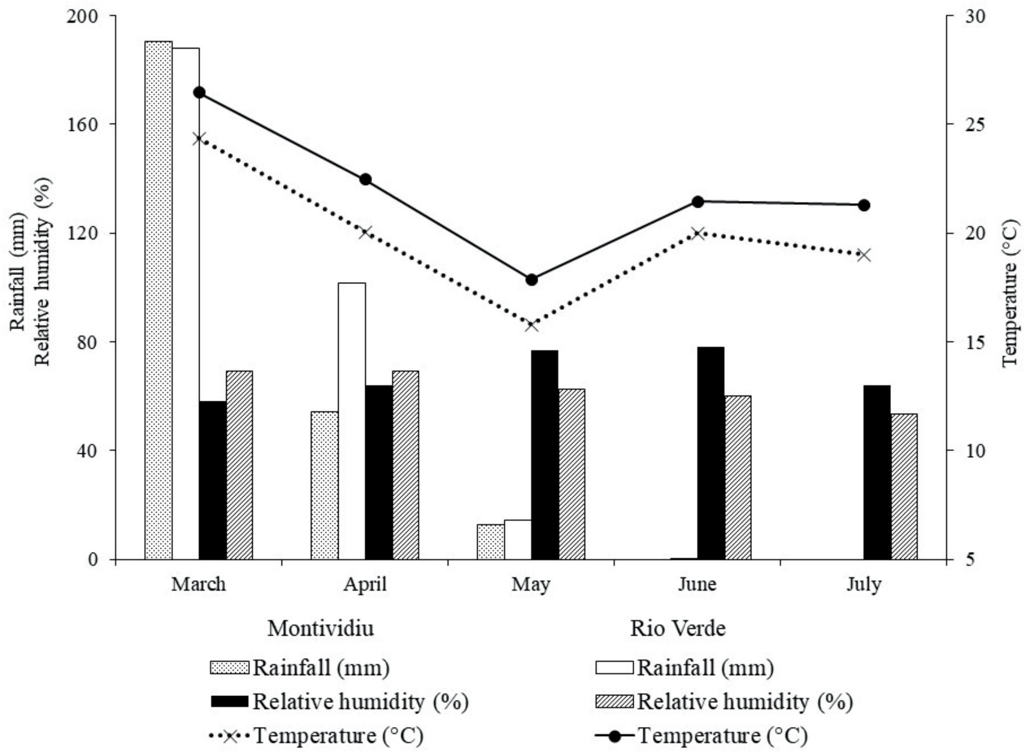

Figure 1. Data on rainfall (mm), relative humidity (%) and average temperature (°C) of the air during the experimental period. Rio Verde and Montividiu (GO), 2018.

equivalent to 190,000 plants ha^{-1}; and double row spacing - 0.25 x 0.75 m and final population equivalent to 190,000 plants ha^{-1}) combined or not with the application of 90 kg ha^{-1} nitrogen as urea. Nitrogen fertilization was carried out manually on the soil surface when sorghum plants had four fully developed leaves.

Experimental plots were 6.0 m long, containing eight rows spaced 0.25 m apart (reduced spacing), four rows spaced at 0.50 m (conventional spacing), and four rows spaced alternately at 0.25 and 0.75 m (double row spacing), totaling 12.0 m². The four (reduced spacing) or two external rows (conventional and double row spacing) and 0.50 m from each end of the plots were disregarded, totaling 5.0 m², for composing the helpful area.

In both experiments, the sorghum hybrid BRS 330, widely grown in the region, was sown mechanically on March 14 and 15 in Rio Verde and Montividiu, respectively, after soybeans. This hybrid has main characteristics: short size, medium cycle, semi-open panicles, red grains, and no tannin. Manual weeding was carried out during the experiments, maintaining the crop free from weed interference. According to the monitoring to detect pests and diseases, applying insecticides and fungicides in the experiments was unnecessary.

Evaluations of agronomic traits, obtained from the average of five plants harvested at random in the useful area of the plots, were similar in both experiments, carried out at 113 DAE. The traits evaluated were: plant height (from the soil to the top

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of the panicle), stem diameter (stem thickness at the base of the leaf sheath of the leaf closest to the ground), panicle length (from the base to the top of the panicle, disregarding the peduncle length), thousand-grain weight (with moisture corrected to 130 g kg^{-1}) and shoot dry biomass (weighing the shoots after forced air oven drying at 65°C for 72 h).

At the time of harvest, at 125 DAE, in the useful area, we determined the final plant population (number of plants with panicles), grain yield (harvest and panicle threshing, with the subsequent weighing of the grains with moisture correction to 130 g kg^{-1}) and the apparent harvest index (ratio of the grain weight, with grain moisture corrected, to the total shoot dry biomass).

Statistical analysis was performed separately for each experiment. Data were tested by analysis of variance by F-test, using Tukey's test ($p \leq 0.05$) when significance was detected for the factors tested or for the levels of each factor.

Results and Discussion

The results showed the interaction of plant arrangement with nitrogen fertilization for plant height in both locations (Table 1). For Rio Verde, under nitrogen fertilization, the sorghum grown in the traditional plant arrangement (0.50 m with 190,000 plants ha^{-1}) presented greater plant height than the arrangement with reduced spacing (0.25 m with 260,000 plants ha^{-1}). However, it did not differ from the value obtained in the double-row spacing (0.25 x 0.75 m with 190,000 plants ha^{-1}). Without nitrogen, no differences were detected in the height of sorghum plants.

Still, in the same municipality, nitrogen fertilization in the traditional plant arrangement allowed for increases in plant height of more than 10 cm compared to the management without fertilization (Table 1). Furthermore, results in the literature have reported the beneficial effect of nitrogen fertilization on increasing the height of grain sorghum plants when grown in-row spacing of 0.50 m compared to reduced (0.25 m) (Braz et al., 2019).

On the contrary, in Montividiu, without topdressing nitrogen fertilization, the traditional plant arrangement resulted in a greater height of sorghum plants than the other arrangements. However, there was no effect on the systems in the presence of nitrogen fertilization. When the effects of this nutritional management were evaluated within each plant arrangement, there was an increase in plant size with the use of nitrogen in the reduced and double-row spacing arrangements. It is important to emphasize that the increase in plant height, whether induced by nitrogen fertilization or the previously mentioned plant arrangements, did not cause sorghum lodging. This situation increases the losses of grains in the mechanized harvest of the crop, thus affecting the profitability of the rural producer.

Along with plant height, the larger stem diameter of sorghum plants provides greater tolerance to lodging. In the Montividiu experiment, there was no effect of nitrogen fertilization and plant arrangement on the variable in question, which did not occur in Rio Verde (Table 2). When nitrogen fertilization was carried out in this environment, the double-row spacing arrangement provided sorghum plants with the largest stem diameter. In the absence of nitrogen fertilization, the largest stem diameters were also observed in the traditional plant arrangement. The absence of significant differences for this variable according to plant arrangement is reported in the literature. Carmo et al. (2020) identified no changes in stem diameter as a function

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Table 1. Height of sorghum plants grown in three plant arrangements with or without topdressing nitrogen fertilization. Rio Verde and Montividiu (GO), 2018.

Nitrogen	--- Plant arrangement ---		
	0.25 m (260,000 plants ha^{-1})	0.50 m (190,000 plants ha^{-1})	0.25 x 0.75 m (190,000 plants ha^{-1})
		Rio Verde (cm)	
With N	123.8 Ba	132.5 Aa	131.2 ABa
Without N	126.3 Aa	121.8 Ab	128.8 Aa
CV (%)		4.23	
		Montividiu (cm)	
With N	120.7 Aa	119.1 Aa	116.3 Aa
Without N	108.5 Bb	120.7 Aa	108.7 Bb
CV (%)		5.07	

Mean values followed by different lowercases, in the same column, and uppercases, in the same row, are significantly different by Tukey's test at 5% probability.

Table 2. Stem diameter of sorghum plants grown in three plant arrangements with or without topdressing nitrogen fertilization. Rio Verde and Montividiu (GO), 2018.

Nitrogen	--- Plant arrangement ---		
	0.25 m (260,000 plants ha^{-1})	0.50 m (190,000 plants ha^{-1})	0.25 x 0.75 m (190,000 plants ha^{-1})
		Rio Verde (mm)	
With N	12.0 Ba	13.4 Bb	15.9 Aa
Without N	10.6 Ba	15.6 Aa	13.7 Ab
CV (%)		12.61	
		Montividiu (mm)	
With N	11.9 Aa	12.7 Aa	11.4 Aa
Without N	11.8 Aa	12.8 Aa	12.6 Aa
CV (%)		11.38	

Mean values followed by different lowercases, in the same column, and uppercases, in the same row, are significantly different by Tukey's test at 5% probability.

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of traditional spacing (0.50 m) or double-row spacing (0.25 x 0.75 m) as long as the same plant population was held.

As for plant height, in both locations, a significant mean effect was observed in plant arrangement and nitrogen fertilization in terms of panicle length (Table 3). In Rio Verde, plants from the double-row spacing arrangement were favored by nitrogen fertilization with the most extended panicle length, differing from the other plant arrangements for the same fertilization management. However, the absence of topdressing nitrogen did not influence panicle size in different sorghum plant arrangements.

Similarly, in Rio Verde, nitrogen fertilization did not influence panicle length when sorghum was grown in reduced spacing arrangements with a higher plant population and double row spacing (Table 3). Nevertheless, nitrogen fertilization in the traditional plant arrangement reduced the length of sorghum panicles.

In Montividiu, there were no differences between plant arrangements for panicle length when nitrogen was supplied as topdressing (Table 3). However, without this practice, sorghum plants grown in the traditional arrangement had greater panicle length than other arrangements. In the analysis of each arrangement, an increase in panicle length with topdressing nitrogen fertilization was found only in sorghum plants from the double-row spacing arrangement. The lack of effects of nitrogen doses up to 90 kg ha^{-1} on panicle length was also reported by Miko and Manga (2008) when evaluating the interaction of plant arrangement with topdressing nitrogen in sorghum cultivation.

Despite the differences in panicle size, the thousand sorghum grain weight was not influenced by the treatments, with average values of 22.9 and 23.7 g obtained in Rio Verde and Montividiu,

Table 3. Panicle length of sorghum plants grown in three plant arrangements with or without topdressing nitrogen fertilization. Rio Verde and Montividiu (GO), 2018.

	--- Plant arrangement ---		
Nitrogen	0.25 m (260,000 plants ha^{-1})	0.50 m (190,000 plants ha^{-1})	0.25 x 0.75 m (190,000 plants ha^{-1})
		Rio Verde (cm)	
With N	22.2 Ba	23.0 Bb	24.8 Aa
Without N	23.3 Aa	24.8 Aa	24.2 Aa
CV (%)		4.42	
		Montividiu (cm)	
With N	22.0 Aa	23.0 Aa	23.2 Aa
Without N	21.8 Ba	23.7 Aa	21.0 Bb
CV (%)		4.92	

Mean values followed by different lowercases, in the same column, and uppercases, in the same row, are significantly different by Tukey's test at 5% probability.

respectively. Albuquerque et al. (2010) pointed out that for every 1 cm increase in row spacing in grain sorghum cultivation, there is a 0.043 g decrease in the thousand-grain weight. If the same plant population is maintained, these effects are probably attributed to the increased demand for productive resources, such as water, light, nutrients, and physical space, which increases competition between plants in the sowing row.

The beneficial effects of topdressing nitrogen on sorghum can be observed by the increase in the plant shoot dry biomass in Montividiu, regardless of the plant arrangement (average increase of 20%) (Table 4). However, plant arrangements did not promote changes in the sorghum shoot dry biomass in both locations. Importantly, with a dry biomass production of approximately 20,000 kg ha^{-1} of the grain sorghum hybrid BRS 330, grown after soybean, it represents an exciting option for straw production for the no-till system, as highlighted by Rossi et al. (2013) for the same locality. Furthermore, sorghum biomass produced after soybean becomes an alternative for animal feed in integrated crop-livestock systems in the Cerrado (Oliveira et al., 2020a, 2020b; Santos et al., 2020; Sousa Júnior et al., 2020).

Sorghum grain yield was influenced by the interaction of plant arrangement and nitrogen fertilization in both locations (Table 5). For example, in Rio Verde, nitrogen topdressing in the traditional and double-row spacing arrangements provided higher grain yields than the reduced arrangement, with values above 5,000 kg ha^{-1}. However, when nitrogen fertilization was not carried out in this location, the traditional plant arrangement resulted in a higher grain yield than obtained in the double-row spacing arrangement, not differing from the value obtained in the reduced spacing arrangement with a higher plant population.

Also, in Rio Verde, topdressing nitrogen fertilization in double-row spacing increased grain yield by greater than 1,500 kg ha^{-1}. In the other arrangements, no effects of topdressing fertilization on sorghum grain yield were observed. The absence of responses to nitrogen fertilization in the plant arrangements mentioned above may be because sorghum was grown after soybeans. In this condition, soybean straw decomposition contributed to the supply of nitrogen to sorghum, as observed in the cultivation of corn after soybean (Duarte, 2013). It is important to recall that topdressing was carried out in early April when there was no water deficit (Figure 1), which favors the increase in nitrogen uptake.

Table 4. Shoot dry biomass of sorghum plants with or without topdressing nitrogen fertilization. Montividiu (GO), 2018.

Nitrogen	(kg ha^{-1})
With N	19,565 a
Without N	16,325 b
CV (%)	19.43

Mean values followed by different lowercases, in the same column, and uppercases, in the same row, are significantly different by Tukey's test at 5% probability.

Table 5. Grain yield of sorghum plants grown in three plant arrangements with or without topdressing nitrogen fertilization. Rio Verde and Montividiu (GO), 2018.

Nitrogen	--- Plant arrangement ---		
	0.25 m (260,000 plants ha^{-1})	0.50 m (190,000 plants ha^{-1})	0.25 x 0.75 m (190,000 plants ha^{-1})
		Rio Verde (kg ha^{-1})	
With N	3,875 Ba	5,090 Aa	5,126 Aa
Without N	3,909 ABa	4,866 Aa	3,524 Bb
CV (%)		15.93	
		Montividiu (kg ha^{-1})	
With N	5,794 Aa	5,174 Aa	5,955 Aa
Without N	4,487 ABb	4,971 Aa	3,727 Bb
CV (%)		14.37	

Mean values followed by different lowercases, in the same column, and uppercases, in the same row, are significantly different by Tukey's test at 5% probability.

This fact suggests the beneficial effects of sorghum cultivation after soybeans in terms of nitrogen use in agricultural production systems in the Cerrado.

In Montividiu, the results of sorghum grain yield revealed no differences between the arrangements under topdressing nitrogen fertilization. However, the traditional plant arrangement without nitrogen resulted in a higher yield value than the double-row spacing arrangement, similar to Rio Verde.

The absence of responses to nitrogen fertilization in the traditional plant arrangement and productivity increases by using nitrogen in the double-row arrangement occurred in both locations. However, the beneficial effect of N in the arrangement of plants under reduced spacing and the largest population of plants was observed only in Montividiu.

It is essential to highlight that the variation in sorghum grain yield observed between treatments is a function of the interaction of the crop and environmental factors. Adopting hybrids in a given population of plants and row spacing is essential to increase grain yield and financial return to producers (Fromme et al., 2012). The ideal population of grain sorghum plants can differ between cultivation environments, especially when evaluating environments with high potential and those with restrictions to obtaining high yields (Staggenborg et al., 1999). Since the agricultural areas of Montividiu are located at higher altitudes than those of Rio Verde, there is a more favorable environment for obtaining higher sorghum grains after soybeans, as suggested by Silva et al. (2015). In analyzing the apparent harvest index of the sorghum crop, the plant arrangements did not influence this variable in Montividiu, regardless of nitrogen fertilization (average value of 25%) (Table 6). However, this variable was influenced by plant arrangement and topdressing nitrogen fertilization in Rio Verde. The highest harvest index was observed

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Table 6. Apparent harvest index of sorghum plants grown with or without topdressing nitrogen fertilization (90 kg ha^{-1} N as urea). Rio Verde (GO), 2018.

Nitrogen	--- Plant arrangement ---		
	0.25 m (260,000 plants ha^{-1})	0.50 m (190,000 plants ha^{-1})	0.25 x 0.75 m (190,000 plants ha^{-1})
With N	25.0 Ba	24.3 Ba	28.5 Aa
Without N	22.9 ABa	25.1 Aa	20.9 Bb
CV (%)		9.69	

Mean values followed by different lowercases, in the same column, and uppercases, in the same row, are significantly different by Tukey's test at 5% probability.

in the double-row arrangement, and the opposite was verified in the absence of topdressing nitrogen using this practice. Furthermore, this plant arrangement was the only one in which increases in the harvest index were observed due to the use of topdressing nitrogen.

For all these reasons, the beneficial effect of nitrogen fertilization in topdressing to increase grain yield in grain sorghum is noticed. These increases are related to the growing environment, mainly when the crop is grown under responsive conditions, such as those in Montividiu. This result was very evident for new plant arrangements for sorghum, such as double-row spacing with the adoption of topdressing, regardless of the evaluated location, as well as the reduced arrangement and higher plant population in Montividiu.

Sorghum's response to nitrogen fertilization is strictly related to productive potential and the species previously grown, in addition to the sowing time of Sorghum in succession. Therefore, planting this cereal later due to a delay in soybean harvest, which did not occur in the present study, is advisable not to use topdressing fertilization for hybrids with morphophysiological traits similar to BRS 330. This choice is because water restriction during the vegetative development of sorghum limits nitrogen uptake and, consequently, higher grain yields. In this context, due to the results of the studied hybrid, when the conventional plant arrangement is adopted, it becomes more interesting not to apply nitrogen fertilization. In addition to providing greater yield concerning the double-row arrangement, the arrangement in question employs the same row spacing used in the soybean crop. This format becomes advantageous as it allows the producer not need to change the row spacing of the seeder to plant the crop in succession (grain sorghum).

If, on the other hand, sorghum is planted in conditions responsive to increases in yield, as in Montividiu, and using topdressing nitrogen fertilization, also aiming at increasing the dry shoot biomass for the no-till system, the use of conventional arrangement stands out again. Even though there are no differences in grain yield values between the arrangements in Montividiu, along with technical advantages of the conventional arrangement presented above, the operational issue of this plant arrangement becomes a decisive factor in the decision making of which arrangement to adopt in the crop to be cultivated after soybeans.

Conclusions

Nitrogen topdressing increases grain yield of the sorghum hybrid BRS 330 in the plant arrangement in double rows (0.25 x 0.75 m with 190,000 plants ha^{-1}), regardless of the evaluated locality, as well as in Montividiu in the reduced spacing in the largest plant population (0.25 m with 260,000 plants ha^{-1}).

Topdressing nitrogen fertilization does not influence grain yield when sorghum is grown, in both locations, under the traditional plant arrangement (0.50 m with 190,000 plants ha^{-1}).

Without topdressing nitrogen fertilization, the traditional plant arrangement (0.50 m with 190,000 plants ha^{-1}) results in higher sorghum grain yield than the double-row spacing arrangement (0.25 x 0.75 m with 190,000 plants ha^{-1}), regardless of location.

In environments more favorable for obtaining higher grain yields (Montividiu), the topdressing fertilization in grain sorghum favors increasing sorghum shoot dry biomass.

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