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Yield response to row spacing, irrigation and varieties of peanut in the semiarid region of Minas Gerais, Brazil

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ABSTRACT: Studies on the management of peanut crops in the semiarid region of Minas Gerais are scarce. Therefore, the objective was to evaluate the agronomic performance of four peanut cultivars under different irrigation systems and row spacing in northern Minas Gerais. The cultivars IAC 503, Runner IAC 886, IAC Tatu ST, and Crioula were grown at row spacing of 0.5, 0.7, and 0.9 m and irrigated or not irrigated. The following variables were evaluated: Total number of pods, number of commercial pods, number of seeds, mass of one hundred grains, grain yield index, oil content, pod yield, grain yield and oil yield. After analysis of variance, the average values were compared using the Scott-Knott method with a probability of 5%. The spacing of 0.5 m promoted higher productivity in pods, grains, and oil in both systems. Under irrigation, IAC 503 and IAC 886 were the most productive, while the cultivars did not differ under non-irrigated cultivation. Finally, irrigation resulted in an increase in grain yield of up to 50% compared to non-irrigated cultivation.

Key words: *Arachis hypogaea* L.; plant density; water stress

Resposta da produtividade ao espaçamento entrelinhas, irrigação e variedades de amendoim na região semiárida de Minas Gerais, Brasil

RESUMO: Estudos sobre o manejo da cultura do amendoim no semiárido mineiro são escassos. Diante disso, objetivou-se avaliar o desempenho agronômico de 4 cultivares de amendoim sob sistemas hídricos e espaçamentos no Norte de Minas Gerais. As cultivares IAC 503, Runner IAC 886, IAC Tatu ST e Crioula foram submetidas aos espaçamentos de 0,5, 0,7 e de 0,9 m entrelinhas e aos regimes irrigado e não irrigado. Foram avaliadas as seguintes variáveis: número total de vagens, número de vagens comerciais, número de sementes, massa de cem grãos, índice de rendimento de grãos, teor de óleo, produtividade de vagens, produtividade de grãos e produtividade de óleo. Após a análise de variância, as médias foram comparadas pelo método de Scott-Knott a 5% de probabilidade. O espaçamento de 0,5 m promoveu maior produtividade de vagens, grãos e óleo em ambos os sistemas. Sob irrigação, as cultivares IAC 503 e IAC 886 foram as mais produtivas, enquanto sob cultivo não irrigado, as cultivares não diferiram entre si. Por fim, o uso de irrigação promoveu o aumento na produtividade em até 50% em relação ao manejo não irrigado.

Palavras-chave: *Arachis hypogaea* L.; densidade de plantas; estresse hídrico

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Introduction

Peanuts (*Arachis hypogaea* L.) are the fourth largest oilseed cultivated in the world, with an estimated production of 50 million tons per year (USDA, 2021), and are one of the most important crops in tropical and subtropical regions (Pereira et al., 2016), being one of the main legumes grown in semiarid regions of the world (Rathore et al., 2021). However, in these regions, abiotic factors such as water deficit and high temperatures lead to low crop yields (Pandey et al., 2014). In the Brazilian semiarid region, the average rainfall is about 600 mm year^{-1} and the occurrence of water deficit in at least 70% of this period (Marengo et al., 2011). Under these conditions, peanuts are an alternative crop due to their tolerance to moderate water deficits (Pereira et al., 2016). However, as the duration of water deprivation increases, the plants adaptation responses are stimulated, such as the reduction of leaf area and the closure of stomata, among others, leading to a reduction in its production potential (Wang et al., 2018).

In this context, it is known that irrigation management is an alternative to increase production systems (Biswas et al., 2019), however, most peanut crops in the semiarid region are operated at a low technological level (Pinto et al., 2020). Therefore, selection of cultivars adapted to each of the cropping systems with and without irrigation allows better exploration of the productive potential of the crop and minimizes production losses under limiting conditions.

In combination with cultivars selection, adjusting plant spacing can optimize peanut production potential. As reported by Nakagawa & Rosolem (2011), greater row spacing produces a stronger plant response, especially in terms of pod number. However, too much spacing leads to a decrease in productivity because there is no compensation for the greater individual production relative to a lower number of plants per area. Usually, a spacing of 0.9 m is selected for peanut cultivation (Nakagawa & Rosolem, 2011). However, yield increases have been achieved by densifying the planting (Bani-Hani et al., 2018). However, their recommendation should take into account the technological level used and the growth habit of the variety, among other factors.

Studies on peanut production in the semiarid region of Minas Gerais state are scarce. Information on the profitability of production under different irrigation systems and plant arrangements could contribute to a better orientation for peanut producers in the region. Therefore, the objective of this study was to evaluate the influence of row spacing on the production performance of peanut cultivars under irrigated and non-irrigated systems in the semiarid region of Minas Gerais state.

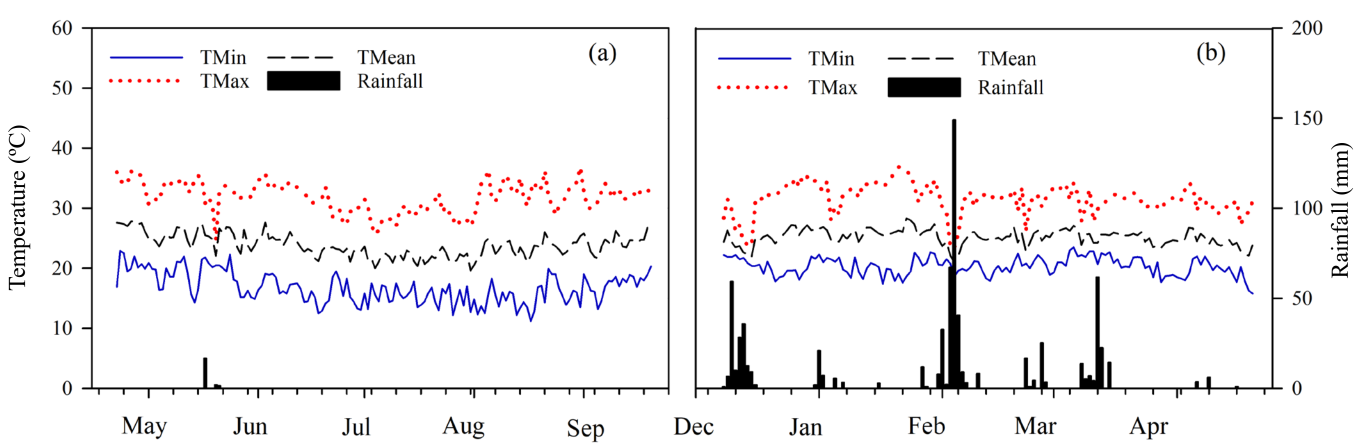
Materials and Methods

The experiments were conducted at the experimental site of the Instituto Federal do Norte de Minas Gerais, municipality of Januária, Minas Gerais state, Brazil (15° 29' S, 44° 21' W, and 434 m of altitude). The climate of the region is classified as Aw according to the Koeppen-Geiger climate classification, with a rainy season concentrated in the months of november to march, while the rest of the year has no significant rainfall for agricultural production.

The following cultivars were evaluated: IAC 503, Runner IAC 886, IAC Tatu ST, and Crioula (sourced from local farmers). The first two have a prostrate growth habit, while the others grow erect.

Two trials were conducted: The first was conducted from April to September 2017 under irrigation with conventional sprinkler systems (Figure 1A). The second experiment was conducted from December 2017 to April 2018 without irrigation (Figure 1B).

Decennial climatological water balance was estimated using climate data available from INMET (2020) for each growing season (Figure 2A and 2B). Calculations were performed according to the method proposed by Thornthwaite & Mather (1955) using the spreadsheets elaborated by Rolim et al. (1998). A 120-day cycle was considered for the crop, which was divided into three growing phases: development (Kc: 0.4), flowering and fruiting (Kc: 1.2), and maturation (Kc: 0.6)



Source: INMET (2020).

Figure 1. Climatic data for the period from April 2017 to September 2017, corresponding to the irrigated experiment (A), and for the period from December 2017 to April 2018, corresponding to the non-irrigated experiment (B).

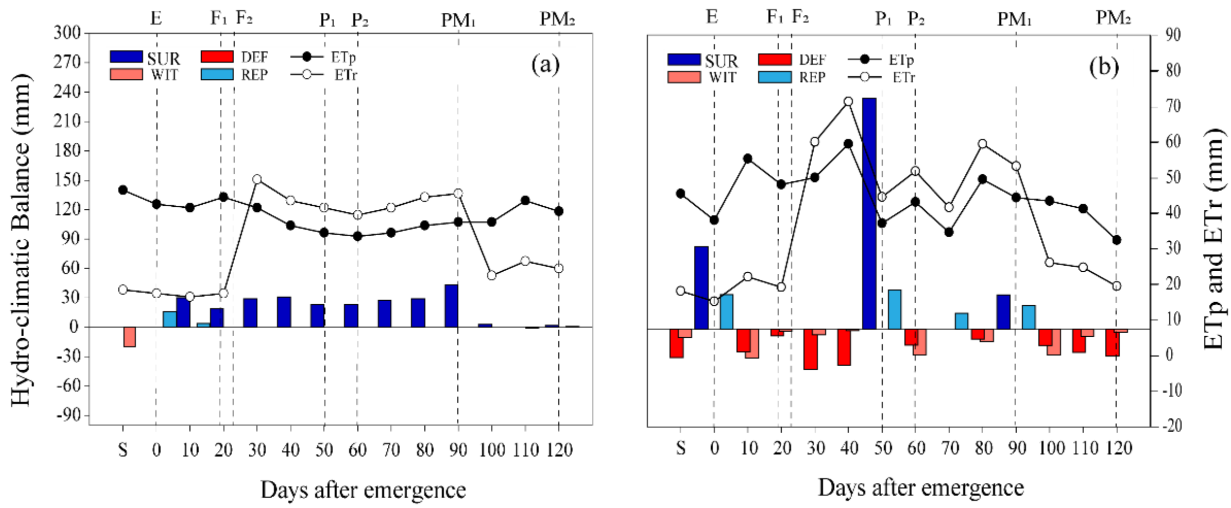


Figure 2. Decennial climatological water balance referring to the periods during which the experiments were carried out: irrigated (A) and non-irrigated (B). Values of water surplus (SUR), deficit (DEF), withdrawal (WIT), and replacement (REP). Emergence (E), flowering (F), pod initiation (P), and physiological maturity (PM). [1] IAC Tatu ST and Crioula; [2] IAC 503 and IAC 886. Januária, MG, Brazil, 2017/2018.

according to Allen et al. (1998). For the irrigation experiment, the irrigation blade was calculated from the daily reference evapotranspiration, obtained from the class-A evaporation pan, and from the crop coefficient (Kc) previously described.

The chemical analysis of the soil constituting the 0-20 cm topsoil for the irrigated experiment presented the following results: pH ($CaCl_2$) = 7.35; OM 8.0 g kg^{-1}; P = 10.2 mg dm^{-3}; K = 98 mg dm^{-3}; Ca = 2.7 cmol$_c$ dm^{-3}; Mg = 0.3 cmol$_c$ dm^{-3}; Al = 0.0 cmol$_c$ dm^{-3}; H + Al = 0.65 cmol$_c$ dm^{-3}; SB = 3.3 cmol$_c$ dm^{-3}; CEC = 3.9 cmol$_c$ dm^{-3}; and, V = 83.4%. The results of the experiment non irrigated are: pH ($CaCl_2$) = 7.89; OM = 7.0 g kg^{-1}; P = 29.4 mg dm^{-3}; K = 41 mg dm^{-3}; Ca = 3.0 cmol$_c$ dm^{-3}; Mg = 0.7 cmol$_c$ dm^{-3}; Al = 0.0 cmol$_c$ dm^{-3}; H + Al = 0.68 cmol$_c$ dm^{-3}; SB = 3.9 cmol$_c$ dm^{-3}; CEC = 4.6 cmol$_c$ dm^{-3}; V = 85.3%. Particle size analysis revealed sand = 79.0%, silt = 7.0%, and clay = 14.0%.

Soil preparation was done in a conventional manner with plowing and harrowing. At seeding, 80 kg ha^{-1} P_2O_5 and 60 kg ha^{-1} K_2O were applied in the seed furrow in both experiments. Seeding was done manually at a density of 15 seeds m^{-1}. Peanut cultivars were grown at row spacing of 0.5, 0.7, and 0.9 m, aiming to obtain an initial population of approximately 300,000, 214,285, and 166,667 plants ha^{-1}, respectively. The plots contained four rows of 5 m in length, with the two central rows considered as the crop area, except 1 m each end. The other cultural treatments were carried out as recommended for the crop. When the pods were mature, the plants were harvested in the crop area and the pods were dried in full sun for five days. Then, the production components such as total number of pods per plant (TNP), number of commercial pods per plant (NCP) and number of seeds per plant (NG) were analyzed. weight of one hundred grains (W100G) in eight replicates was also evaluated. The grain yield index (GYI) was determined by the ratio between the grain mass and the pod mass, and the results were expressed as a percentage.

For the determination of oil content (OC), 3 g of seeds crushed and wrapped in filter paper were immersed in 100 mL of the organic solvent hexane. This solution was heated for six hours in the Soxhlet oil and fat extractor (Marconi brand, model MA491/2). After extraction, the oil was placed in an oven at 70 °C for 12 hours to complete the evaporation of the remaining solvent. The oil content was determined by the difference of the masses and the result was expressed as a percentage (Negretti et al., 2011).

The pods and grains of each plot were weighed and the respective results were extrapolated to kg ha^{-1} to obtain the yield of pods (PV) and grains (PG), respectively. Based on these results, oil yield (PO) was determined by multiplying the oil content by the grain yield obtained.

The experimental design consisted of randomized blocks in a 4 × 3 factorial scheme, corresponding to four peanuts cultivars (IAC 503, Runner IAC 886, IAC Tatu ST, and Crioula), three spacings (0.5, 0.7, and 0.9 m) in which they were cultivated in two systems (irrigated and non-irrigated) in four replicates each. The data obtained were subjected to analysis of variance and F-test. When a significant effect was found between treatments, the averages were grouped using the Scott-Knott test with a probability of 5%.

Results and Discussion

During the irrigated experiment conducted in winter 2017, the accumulated rainfall was only 20.9 mm (Figure 1A), while the accumulated rainfall of the experiment conducted in summer 2017/2018 was 728.9 mm (Figure 1B). Although the total accumulated precipitation of the summer crop was significantly higher compared to the winter crop, the precipitation distribution during the summer was quite irregular, resulting in long periods of water deficit, especially during the period of pod formation, a fundamental step for determining the production potential of the crop (Figure 2B). Irrigation, on the other hand, provided sufficient moisture to the plants throughout their cycle (Figure 2A).

The interaction of the double factorial, row spacing × cultivars, was significant for all variables. In general, the best responses were obtained under irrigated cultivation, while under non-irrigated regime, most of the production components suffered a decrease.

Row spacing had no effect on the variables total number of pods (TNP) and number of commercial pods (NCP) in the irrigated trial, but in the non-irrigated cultivation, the cultivar IAC 503 performed better with a less dense spacing of 0.9 m (Table 1). These responses are related to the fact that a greater spacing between lines provides less competition between plants, thus providing a greater area available for the development of pods, in addition to resources such as water, nutrients and luminosity. The number of pods is one of the primary components of crop productivity, and is normally influenced by the density of planting, especially in peanuts (Nakagawa & Rosolem, 2011).

Cultivars differed with respect to TNP only at a spacing of 0.5 m and under irrigated conditions, and the cultivars with recumbent growth, IAC 503 and IAC 886, produced 35% more pods than the other cultivars with erect growth. With greater water availability throughout the crop, plants with prostrate habit could better express their genetic potential, with the emission of a greater number of pods in relation to cultivars with erect habit (Nakagawa & Rosolem, 2011).

In the non-irrigated cropping system, there was an average reduction of 60% in TNP and 47% in NCP compared to the irrigated system. Similar results were obtained by Azevedo et al. (2014) when they studied the effect of the period of water suppression on peanut production performance and found that the plants irrigated up to 45 days after sowing (DAS) had a decrease in the number of pods per plant of up to 53.65% compared to the plants irrigated up to 90 DAS.

In an irrigated system, the response to the variable NG was homogeneous with respect to spacing and cultivars, with an average of 58 seeds per plant. In a non-irrigated system, only the spacing of 0.9 m favored the cultivar IAC 503, with an average of 44 seeds plant^{-1}, while the other spacing produced an average of 16 seeds plant^{-1}. The increase in this trait could be related to the reduced intraspecific competition for nutrients, sunlight, and especially water, which is a limiting resource in a non-irrigated experiment. Due to the lower competition, plants invest in a larger number of branches, which favors the production of pods and grains. The greater the plant density, the more intense the competition for available resources, especially when they are scarce (Honda et al., 2019).

For the variable W100G (Table 2), there was no response in terms of spacing, but the cultivars with prostrate growth were higher than the cultivars with erect growth. The fact that the seeds of the prostrate cultivars have a larger grain mass is directly related to their botanical group, which is characterized by seeds with larger size and higher weight (Nakagawa & Rosolem, 2011).

As for GYI, the systems had little effect on its values, and there were no significant differences between the spacing of the two water systems. In general, the erect cultivars had a lower grain yield index than the low-lying cultivars, with average indices of 77.5 and 78.5% for cultivars IAC 503 and IAC 886, and of 72.0 and 73.0% for cultivars Crioula and IAC Tatu, respectively. These responses indicate a strong genetic influence on this trait, which was also confirmed by Bakal et al. (2020).

Row spacing of 0.5 m resulted in higher pod yield of 5,302, 5,188, and 3,261 kg ha^{-1} for cultivars IAC 503, IAC 886, and IAC Tatu, respectively, under irrigated cultivation (Figure 3A). In turn, the Crioula cultivar showed no response to the spacing tested.

Note that even for the cultivar IAC 503, which had the highest number of pods and grains plant^{-1} at 0.9 m spacing (Table 1), the increase in plant density offset productivity. Increasing plant density is an important measure to increase grain yield, but this higher yield is highly dependent on water

Table 1. Average values of the total number of pods (TNP), number of commercial pods (NCP), and number of grains (NG) of peanut cultivars under irrigated and non-irrigated crops. Januária/MG/Brazil-2017/2018.

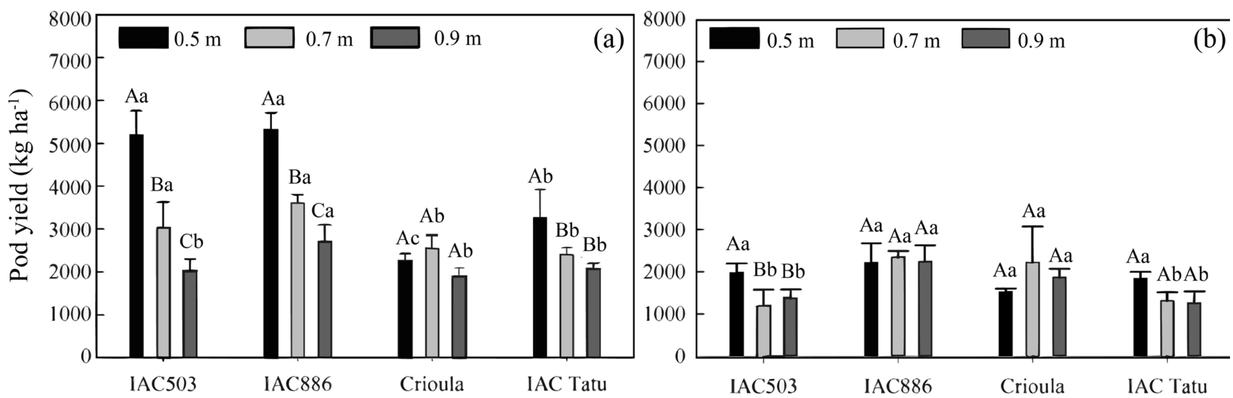
Genotype	Irrigated			Non-irrigated		
	Row spacing (m)					
	0.50	0.70	0.90	0.50	0.70	0.90
Total number of pods (n. plant^{-1})						
IAC503	62.93 Aa	49.27 Aa	59.36 Aa	14.15 Ba	12.65 Ba	26.80 Aa
R. IAC886	62.33 Aa	50.83 Aa	61.76 Aa	15.50 Aa	26.80 Aa	22.83 Aa
Crioula	41.78 Ab	47.47 Aa	50.41 Aa	11.93 Aa	16.20 Aa	21.57 Aa
IAC Tatu ST	39.93 Ab	49.07 Aa	44.38 Aa	14.43 Aa	18.27 Aa	17.47 Aa
Number of commercial pods (n. plant^{-1})						
IAC503	35.70 Aa	28.87 Aa	32.60 Aa	13.47 Ba	8.85 Ba	24.29 Aa
R. IAC886	37.80 Aa	34.10 Aa	31.10 Aa	14.81 Aa	18.39 Aa	15.39 Aa
Crioula	28.73 Aa	31.73 Aa	29.37 Aa	10.86 Aa	13.42 Aa	18.81 Aa
IAC Tatu ST	24.87 Aa	23.63 Aa	29.25 Aa	11.96 Aa	13.84 Aa	14.24 Aa
Number of grains (n. plant^{-1})						
IAC503	60.90 Aa	54.50 Aa	37.15 Aa	20.58 Ba	12.66 Bb	44.23 Aa
R. IAC886	67.45 Aa	53.90 Aa	61.87 Aa	25.30 Aa	42.98 Aa	32.95 Aa
Crioula	53.75 Aa	76.40 Aa	69.93 Aa	23.34 Aa	45.80 Aa	47.34 Aa
IAC Tatu ST	59.37 Aa	51.97 Aa	60.25 Aa	31.24 Aa	55.69 Aa	33.88 Aa

Averages followed by the same letter, uppercase horizontally and lowercase vertically, constitute a homogeneous group at 5% probability by the Scott Knott method.

Table 2. Average values of agronomic characteristics: weight of one hundred grains (W100G), grain yield index (GYI) of peanut cultivars under irrigated and non-irrigated crops. Januária/MG/Brazil-2017/2018.

Genotype	Irrigated			Non-irrigated		
	Row spacing (m)					
	0.50	0.70	0.90	0.50	0.70	0.90
	W100G (g)					
IAC503	51.02 Aa	51.76 Aa	52.91 Aa	54.85 Aa	54.70 Aa	53.56 Aa
R. IAC886	52.06 Aa	50.62 Aa	54.64 Aa	58.28 Aa	61.31 Aa	54.51 Aa
Crioula	44.24 Ab	38.10 Ab	40.43 Ab	39.46 Ab	39.04 Ab	40.18 Ab
IAC Tatu ST	45.59 Ab	42.86 Ab	46.73 Ab	47.54 Ab	32.80 Ab	42.37 Ab
	GYI (%)					
IAC503	78.52 Aa	77.02 Aa	74.41 Aa	77.70 Aa	78.84 Aa	77.42 Aa
R. IAC886	78.21 Aa	76.84 Aa	76.75 Aa	80.54 Aa	78.99 Aa	79.75 Aa
Crioula	72.71 Ab	74.17 Aa	75.12 Aa	70.84 Ab	73.12 Ab	66.76 Ac
IAC Tatu ST	73.99 Ab	74.77 Aa	75.49 Aa	69.52 Ab	72.87 Ab	71.71 Ab

Averages followed by the same letter, uppercase horizontally and lowercase vertically, constitute a homogeneous group at 5% probability by the Scott Knott method.



* Averages followed by the same letter, uppercase between the spacings and lowercase between the cultivars, constitute a homogeneous group according to the Scott Knott test at 5% probability.

Figure 3. Average yield values of pods of peanut cultivars submitted to row spacing and irrigation systems: irrigated (A) and non-irrigated (B). Januária/MG/Brazil-2017/2018.

availability (Zhang et al., 2021). This is because increasing plant density increases the interception of light radiation through the canopy, but this increase leads to higher soil water use, transpiration, and evapotranspiration (Li et al., 2018; Yang et al., 2019; Zhang et al., 2021). In addition, the increase in intraspecific competition is often related to dense plantings (Zhai et al., 2018). These factors may explain why the increase in productivity was more pronounced at reduced spacing under the irrigated regime.

The pod yield was considerably affected by the non-irrigated cultivation. Although both the irrigated (800.0 mm) and non-irrigated (812.9 mm) experiments received similar total water blade throughout the crop cycle, there were large volumes of rain concentrated in short periods during the summer growing season followed by long periods of dry spells. A large volume of water in sandy soils, as is the case in our experiments, is quickly percolated and remains in the soil for a shorter period of time (Scopel et al., 2013). In addition, the occurrence of dry periods in cultivation under water deficit can be considered as the main cause of reduced productivity and its components.

In peanut cultivation, the critical period for productivity in terms of water availability is during pod formation (Nakagawa & Rosolem, 2011). In the experiment conducted under water deficit, this stage was reached from 60 days after sowing (DAS) and lasted until 100 DAS for the erect cultivars and 124 DAS for the prostrate cultivars when pod maturation was observed.

During this period of 64 days, a total of 249.9 mm of precipitation fell (Figure 2B), but it was irregularly distributed, with occurrence of three dry spells: the first of 11 days (66 to 76 DAS), the second of 8 days (83 to 91 DAS) and the third of 21 days (99 to 120 DAS). At the same stage of development, plants in the irrigation experiment received 8 mm of water daily and a cumulative gross water volume of 512 mm. Thus, it appears that the irregular rainfall, especially during the grain filling period, significantly affected the yield potential of the cultivars.

According to Nakagawa & Rosolem (2011), there is a negative correlation between the percentage of productivity reduction and the percentage of the crop cycle with available moisture, i.e., the longer the period of water deficit, the greater the yield losses. Losses can exceed 80% if the crop remains less than 10% of its cycle with available moisture. Also according to these authors, a crop with a production potential of 3,000 kg ha^{-1} and a cycle of 100 days would lose up to 24.6 kg ha^{-1} of its grain yield each day if water is not available in the first 60 cm of soil.

It is noteworthy that the prostrate cultivars were more productive compared to the erect cultivars under irrigation conditions. The yield inferiority of the erect cultivars compared to the prostrate cultivars is due to the genetic characteristics of the botanical group to which they belong, because the Virginia (prostrate) botanical group is characterized by alternate branching and flowers distributed throughout the branch, and its architecture allows a greater number of gynophores to come into contact with the soil, which allows the formation of a greater number of pods. This effect is difficult in erect cultivars, considering that the valence group has fewer branches and fruits are concentrated at the base of the plant, as more flowers accumulate in this region (Nakagawa & Rosolem, 2011).

Under non-irrigated management, only cultivar IAC 503 was affected by row spacing, with 0.5 m inter-row spacing giving a better response with a yield of 1,984 kg ha^{-1}. This cultivar behaved similarly to the erect cultivar IAC Tatu ST, whose yield at the same spacing was 1,848 kg ha^{-1}. Both cultivars also showed the same statistical response at the other spacings. Moreover, the variety IAC 886 was equal to the variety Crioula at all row spacings. This response could indicate a high sensitivity of these cultivars to prolonged periods of water deficit. In addition, harvesting in dry soils due to the greater distribution of pods may have caused the pods of the Virginia group cultivars to remain in the soil (Goulart et al., 2017), especially those furthest from the base of the plant, while the pods of the erect cultivars are concentrated near the roots, favoring the harvest and reducing losses. In addition, the cultivars of the valence group can be used as an “escape strategy” from drought due to their rapid vegetative development (Duarte et al., 2013; Pereira et al., 2016). These traits make these cultivars more competitive for semiarid regions (Pereira et al., 2016).

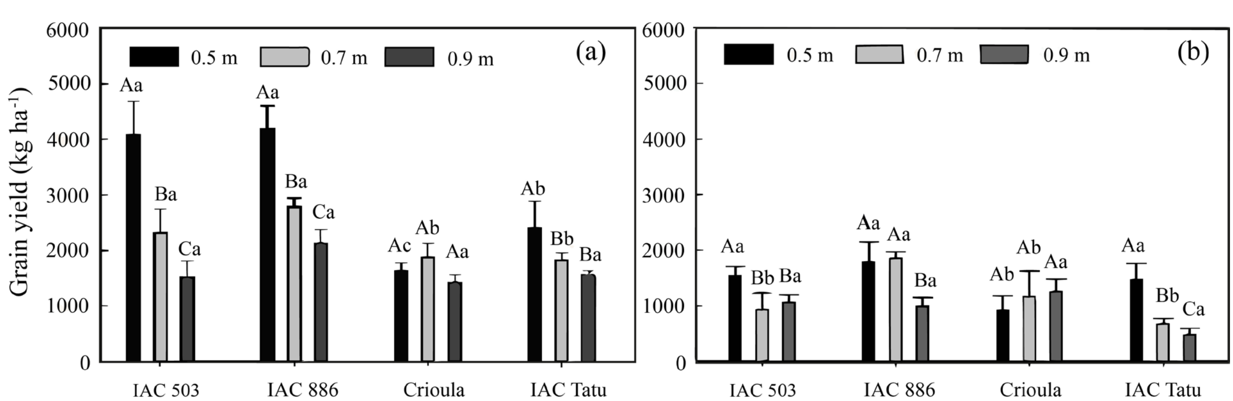
In terms of grain yield, cultivars IAC 503, IAC 886, and IAC Tatu performed better under 0.5 m row spacing in both regimes (Figure 4A and 4B). Under irrigation, these cultivars yielded 4,090, 4,181, and 2,416 kg ha^{-1}, respectively, at 0.5 m row spacing, while grain yield decreased by 35.0 and 51.0% at 0.7 and 0.9 m row spacing, respectively, compared to 0.5 m row spacing (Figure 4A). Similar behavior was observed in non-irrigated cropping, with average reductions of 28.0 and 47.0%, based on row spacing of 0.7 and 0.9 m, respectively, under 0.5 m row spacing.

Under non-irrigated cultivation, the grain yield of the cultivars decreased by an average of 49% compared to irrigated cultivation, and it can be observed that the yield reduction was more pronounced in the prostrate cultivars compared to the erect cultivars. On average, prostrate cultivars decreased their productivity by 37%, while erect cultivars decreased by 28%. These results reflect the greater drought resistance of the erect cultivars.

Oil content was not affected by the spacing studied in either management (Table 3). In irrigated management, the Crioula cultivar had the lowest oil content at all spacings, although it was similar to the other cultivars at the 0.5 and 0.9 m spacings in non-irrigated management. On average, the cultivars in non-irrigated cultivation showed a reduction in oil content of about 12% compared to irrigated cultivation, with average values of 36.64 and 41.97%, respectively.

Water stress decreases the expression of genes involved in lipid biosynthesis and increases the expression of genes involved in lipid degradation (Nakagawa et al., 2018). Under water deficit, plants close their stomata in order to avoid water loss through evapotranspiration, however, CO_2 assimilation also decreases, consequently the production of carbohydrates and, ultimately, lipids are negatively affected (Wang et al., 2018). Under these conditions, the catabolism of fatty acids into acetyl-CoA occurs, producing sugars for the maintenance of plant metabolism (Nakagawa et al., 2018).

Cultivars IAC 503 and IAC 886 had higher oil yield under irrigated system, but they were comparable to the others under non-irrigated cultivation. In general, the 0.5 m row spacing provided better responses, reaching yields of 1,867, 1,776, and 1,037 kg ha^{-1} for cultivars IAC 503, IAC 886, and IAC Tatu, respectively, under irrigated cultivation (Figure 5A). Under non-irrigated management, the oil yields of these cultivars were 608.0, 666.0, and 540.0 kg ha^{-1}, respectively (Figure 5B). The Crioula variety was not influenced by the spacing in both systems (irrigated and non-irrigated), but showed inferior behavior to the others, mainly under irrigated management.



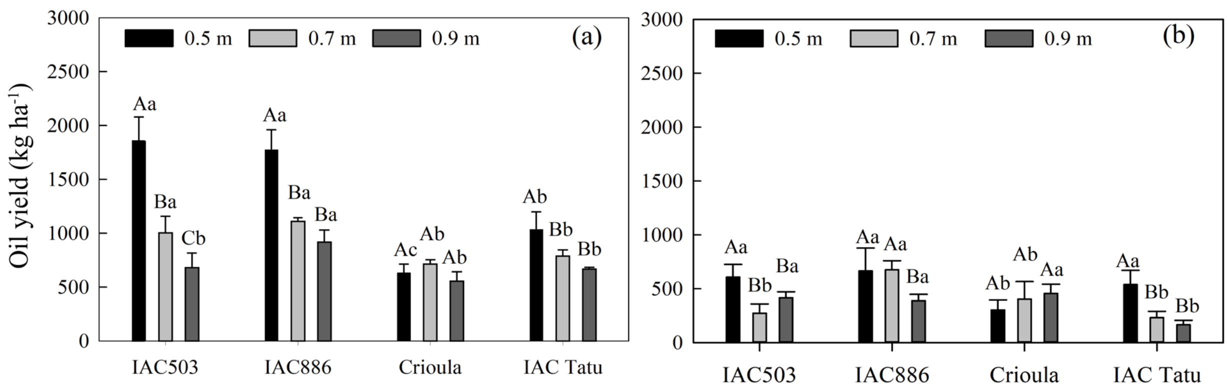
* Averages followed by the same letter uppercase between the spacing and lower case between the cultivars constitute a homogeneous group according to the Scott Knott test at 5% probability.

Figure 4. Average values of grain yield of peanut cultivars subjected to different spacing and water systems: irrigated (A) and non-irrigated (B). Januária/MG/Brazil-2017/2018.

Table 3. Average values of oil content (OC) of peanut cultivars cultivated under irrigated and non-irrigated crop. Januária/MG/Brazil-2017/2018.

Genotype	Irrigated			Non-irrigated		
	Row spacing (m)					
	0.50	0.70	0.90	0.50	0.70	0.90
	TO (%)					
IAC503	45.79 Aa	43.25 Aa	45.00 Aa	39.17 Aa	41.10 Aa	39.00 Aa
R. IAC886	42.43 Aa	40.00 Ab	43.29 Aa	36.85 Aa	36.26 Ab	39.16 Aa
Crioula	38.61 Ab	37.94 Ab	38.50 Ab	32.92 Aa	34.64 Ab	36.24 Aa
IAC Tatu ST	43.15 Aa	42.97 Aa	42.74 Aa	36.26 Aa	34.16 Ab	33.94 Aa

Averages followed by the same uppercase letter horizontally and lowercase letter vertically constitute a homogeneous group at 5% probability by the Scott Knott method.



* Averages followed by the same uppercase letter between the spacing and lowercase between the cultivars constitute a homogeneous group according to the Scott Knott test at 5% probability.

Figure 5. Average values of oil yield of peanut cultivars subjected to different spacing and water systems: irrigated (A) and water deficit (B). Januária/MG/Brazil-2017/2018.

Our study showed that, under conditions of adequate humidity and 0.5 m row spacing, the peanut cultivars had better productive performance, especially the cultivars IAC 503 and IAC 886, which were superior in relation to the others. However, under non-irrigated management, grain yield decreased by approximately 50%, and the prostrate cultivars were similar to the erect ones, even though the former had more productive genetic potential compared to the latter.

These results indicate that, under the conditions of the semiarid region of Minas Gerais state, not using irrigation can cause significant losses due to poor rainfall distribution. Under these conditions, the choice of cultivar had no significant effect on productivity, as the limiting environmental conditions prevented the expression of its genetic potential. On the other hand, the reduced row spacing of 0.5 m promoted an increase in the pod, grain and oil yields, even under water deficit.

Based on these results, to achieve high yields, it is essential to maintain soil moisture throughout the entire crop (Rossato et al., 2017). An alternative would be the use of supplemental irrigation, used during the dry spells (Biswas et al., 2019). Therefore, further studies with irrigation depths could optimize peanut production and boost its cultivation in the region. Thus, our work demonstrated that reducing the spacing to 0.5 m between rows and the use of prostrate cultivars can increase pod yield by up to 50%, provided there is moisture available at the critical stages of crop development. Such results are extremely relevant for agricultural development in the semiarid region of Minas Gerais state.

Conclusions

The 0.5 m increased the pod yield, grains and oil due to the greater disposition of plants in the area, being recommended even for plantations without the use of irrigation. In addition, cultivars IAC 503 and Runner IAC 886 had higher productivity when cultivated under irrigation. Finally, the maintenance of moisture throughout the crop is essential to obtain high yields, which is the most limiting factor for plant development in the semiarid region.

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Compliance with Ethical Standards

Author contributions: Conceptualization: AGF; Data curation: SLO, VJNS; Formal analysis: SLO, EFM; Investigation: SLO, VJNS, EFM; Methodology: SLO; Project administration: TGC, HRS; Supervision: AGF, TGC; Validation: AGF; Visualization: AGF; Writing - original draft: SLO, VJNS; Writing - review and editing: AGF.

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