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DESEMPENHO DO MINIMILHO SUBMETIDO A LÂMINAS DE IRRIGAÇÃO E DENSIDADES DE PLANTIO NO CERRADO MATO-GROSSENSE

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1 RESUMO

Objetivou-se com esse estudo avaliar a influência de lâminas de irrigação e densidades de plantio para a produção de minimilho. O experimento foi conduzido no delineamento em blocos casualizados, arranjados em parcelas subdivididas, avaliando 5 lâminas de irrigação (40, 60, 80, 100 e 120% da Etc) e cinco densidades de plantio (8, 10, 12, 14 e 16 plantas m^{-1}), com três repetições. Foram analisadas altura de planta, diâmetro de colmo, número de folhas e área foliar, altura de inserção de primeira espiga, massa seca da parte aérea, comprimento e diâmetro da espiga, teor de sólidos solúveis e eficiência do uso da água. As lâminas superiores a 98 % da ETc promoveram um incremento para a altura de planta, diâmetro de colmo, altura de inserção de primeira espiga, massa seca da parte aérea, área foliar e comprimento de espiga com palha. O aumento da densidade de plantio promoveu uma redução nas características fitométricas da cultura. A eficiência do uso da água diminuiu com o aumento das lâminas e acréscimo no aumento da densidade de plantio. O plantio adensado com menor lâmina de irrigação nas condições experimentais, proporcionaram valores de comprimento e diâmetro de espigas sem palha dentro dos padrões comerciais.

Palavras-chave: *Zea mays* L, manejo de água, população de plantas.

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2 ABSTRACT

The objective of this study was to evaluate the influence of irrigation depths and planting densities for the production of baby corn. The experiment was carried out in a randomized block design, arranged in subdivided plots, evaluating 5 irrigation depths (40, 60, 80, 100 and 120% of Etc) and five planting densities (8, 10, 12, 14 and 16 plants m^{-1}), with three repetitions. Plant height, stem diameter, number of leaves and leaf area, height of first ear insertion, shoot dry matter, length and diameter of the ear, content of soluble solids and water use efficiency were analyzed. Water depths greater than 98% of ETc promoted an increase in plant height, stem diameter, height of insertion of first ear, dry mass of the aerial part, leaf area and length of ear

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with straw. The increase in planting density reduced the crop's phytometric characteristics. The water use efficiency decreased with increasing water depths and increasing planting density. The dense planting with lower irrigation depth in the experimental conditions provided values of length and diameter of ears without straw within the commercial standards.

Keywords: *Zea mays* L., water management, plant populations

3 INTRODUCTION

The state of Mato Grosso is a major corn producer; however, in Brazil, most of its corn is used for animal feed. Notably, much of the corn produced is used for human consumption, with a focus on industrialized products such as flour, biscuits, canned goods, and others. There is also some production that is considered specialty corn, such as green corn and baby corn (SOUSA; PAES; TEIXEIRA, 2012).

The production of baby corn is a profitable alternative for farmers when comparing the profitability of a crop destined for grain production, since profitability can generate a net profit of up to 400% of the amount invested (PEREIRA FILHO, 2008).

According to Meneghetti et al. (2008), irrigated baby corn appears to be an economic alternative for family farming, as it has a shorter cycle and has the advantage of being harvested at the beginning of the reproductive phase, when there is a greater demand for water for corn cultivation.

Baby corn consumption in Brazil is promising; however, the industrialized product is mostly imported. Among the largest baby corn exporters is Thailand, which produces an average of 9 t ha $^{-1}$ (SINGH et al., 2015).

Baby corn (*Zea Mays* L.) is the name given to young ears, containing stigmas of up to three centimeters that are unfertilized, that is, before grain formation (RAUPP; GARDINGO; MORENO, 2008). Considering that its cultivation time has decreased, it can carry out up to five harvests per year (EMBRAPA, 2008). According to Silva et al. (2018), knowledge of the water needs of crops ensures increased production and has less of an environmental impact on this natural resource.

Corn is highly sensitive to water deficit and is affected from germination to maturity (KHALILI et al., 2010; EL-SABAGH et al., 2018). When stress occurs during the reproductive phase, the greatest losses occur, and the plant is most sensitive to stress during female flowering (EL-SABAGH et al., 2018).

For the production of baby corn, there is a lower requirement in terms of the total amount of water applied, as there is no need for a complete cycle since the ears are harvested young.

Corn crop management for baby corn production differs from that for grain cultivation, particularly with respect to seeding density. For baby corn cultivation, higher density levels are used, given that the final product does not have the same dimensions as the grain ears do (MENEGHETTI et al., 2008).

As the recommended planting density is three to four times greater than that of grain corn, Pereira Filho and Cruz (2001) recommend greater spacing between planting lines, aiming at ease of movement during cultural treatments.

Thus, the objective of this study was to evaluate the influence of irrigation depth and planting density on corn crops for the production of baby corn in the Cerrado region of Mato Grosso.

4 MATERIALS AND METHODS

The experiment was conducted in the field between August and November 2017 in the experimental area of the Federal University of Rondonópolis - MT, with geographic coordinates of 16°27'47” S, 54°34'44” W and an altitude of 284 m.

The cultivar used in the experiment was the hybrid AG 8690, one of the most widely used cultivars in Mato Grosso. Baby corn can be produced from any type of corn cultivar, whether hybrid or variety (Kumar; Venkateshwarlu, 2013); therefore, this cultivar was used because it is widely spread throughout the state. Furthermore, it is noteworthy that the production of baby corn from open-pollinated varieties presents a greater risk, as this type of cultivar commonly presents irregular ears (WANGEN; FARIA, 2013; MOREIRA; SANTOS; FAVARÃO, 2014) or, compared with hybrids, presents a greater percentage of ears that do not meet commercial standards (PEREIRA FILHO, 2008), compromising the final commercial yield of baby corn.

The dominant regional climate is tropical rainy, classified as AW, according to Köppen (1948), characterized by a hot and humid climate, with two well-defined seasons: rainy summer and dry winter, with an average annual temperature of 24.8°C and average annual precipitation of 1500 mm. During the study period, the average relative humidity was 51.6%, and the average temperature was 27.6°C, with a maximum reference evapotranspiration of 6.61 mm day $^{-1}$ and an average of 4.63 mm day $^{-1}$.

The soil in the experimental area was classified as a dystrophic Red Latosol, according to the Embrapa (2018) classification, with a medium texture. For soil analysis, 15 single samples were collected throughout the area at depths of 0–0.20 m. After collection, the material was sieved and homogenized to form a single composite sample, which was sent for chemical and granulometric analyses. The soil had a sandy loam texture, with sand, silt, and clay percentages of 490, 100, and 410 g kg $^{-1}$, respectively. The chemical characteristics of the soil are shown in Table 1.

Table 1. Chemical analysis of the dystrophic Red Latosol collected from the 0–0.2 m layer in the experimental area of the Federal University of Rondonópolis.

pH	P	K	Here	Mg	H	Al	SB	CTC	V	MO
($CaCl_2$)	-mg dm $^{-3}$ -		-------------------- cmol $_c$ dm $^{-3}$ --------------------						%	g dm $^{-3}$
4.7	2	73	1	0.5	3.2	0.2	1.7	5.1	33.2	15.6

To correct for soil acidity, dolomitic limestone (PRNT = 83%) was used to increase the base saturation to 60% (SOUSA; LOBATO, 2004). The limestone was broadcast over the entire area to ensure uniform distribution, incorporated with the aid of a plow, and then allowed to react for 30 days.

After the limestone reaction period in the soil, fertilization and sowing were carried out simultaneously. The same amount of nutrients was used for all the treatments, with nitrogen (N) in the form of urea (45% N) at sowing, ammonium sulfate (21% N) as the top dressing, and phosphorus (P_2O_5) in the form of triple superphosphate (45% P_2O_5) and potassium (K_2O) in the form of potassium chloride (58% K_2O). For fertilization with micronutrients, FTR-BR 12 was used as a source (calcium: 7.1%; sulfur: 5.7%; boron: 1.8%; copper: 0.8%; manganese: 2.0%; molybdenum: 0.1%; and zinc: 9.0%).

The recommended phosphate (P_2O_5) application rate is 300 kg ha $^{-1}$, which is applied at sowing. The nitrogen fertilizer used was 100 kg ha $^{-1}$ of nitrogen, which was divided into three equal applications, with urea used as the source at planting and ammonium sulfate applied 24 and 40 days after sowing. Potassium fertilization was divided into two equal parts: the first at sowing and the second 24 days after sowing, thus completing the recommended 100 kg ha $^{-1}$. For micronutrient application, 50 kg ha $^{-1}$ FTR-BR 12, which is applied at sowing, is recommended.

The statistical design used was randomized blocks, which were arranged in subdivided plots, with 5 irrigation depths (40, 60, 80, 100 and 120% crop evapotranspiration, etc.) and five planting densities of the hybrid AG 8690 (8, 10, 12, 14 and 16 plants m $^{-1}$), with three replicates, for a total of 75 experimental units. The subplots had dimensions of 2 m × 2.7 m (5.4 m²) and a useful area of 0.9 m × 1 m (0.9 m²), with corridors arranged between the 1 m blocks. Planting was carried out on 08/13/2017.

Irrigation management was carried out on the basis of the daily estimate of reference evapotranspiration (ETo), which was estimated via the Penman–Monteith method (FAO) (ALLEN et al., 1998).

The irrigation depths applied per treatment were calculated according to crop evapotranspiration, considering precipitation, the crop cultivation coefficient and irrigation system efficiency, via equation (1):

$$\mathrm{Li} = \frac{(\mathrm{ETo}*\mathrm{Kc}*\mathrm{Ka})-\mathrm{P}}{\mathrm{Ef}} \quad (1)$$

where:

Li – Irrigation depth (mm);
ETo – Estimated reference evapotranspiration in the period between irrigations (mm);
Kc – Crop coefficient (dimensionless);
Ka – Adjustment coefficient (dimensionless);
P – Precipitation during the period (mm);
Ef – Irrigation system efficiency (dimensionless).

Reference evapotranspiration values were obtained from meteorological variable data from the Automatic Meteorological Station (INMET, 2017), which is located near the experimental area. Crop coefficient values were differentiated according to crop development stages between August and October, the dry season in the region. Considering that irrigation was performed daily as needed, the crop coefficient (Kc) used varied from 1.0 to 1.2 at the corresponding crop stages (ALLEN et al., 1998).

For the drip irrigation system, the percentage of wetted area was obtained according to Pizarro (1996), and the adjustment coefficient Ka was verified via the Keller equation (1978), with a Ka value of 1. The irrigation system used was a dripper tube with a spacing of 0.10 m and a flow rate of 1.2 L h $^{-1}$, with one line of drippers for each row of plants. For phytosanitary management, chemical control was carried out via the use of herbicides and insecticides.

In this study, the following variables were determined: number of leaves; plant height (measurements were taken from the soil surface to the insertion of the leaf at the apex of the plant via a graduated tape measure); height of insertion of the first ear (measurements taken from the soil surface to the insertion of the ear in the stalk via a graduated tape measure); stalk diameter (above the adventitious roots) via a digital caliper; leaf area measurement via the *Area Meter* model LI-3100C; ear length and diameter (with and without straw), measured via a graduated ruler and digital caliper; soluble solids content, analyzed via a manual refractometer with a Brix scale between 0 and 32%; determination of shoot dry mass via a forced circulation oven at 65°C until constant mass; and water use efficiency, related to the amount of water applied per treatment during the field crop. The results were subjected to analysis of variance via the F test, and when significant, a regression test was applied at 5% probability via the SISVAR statistical program (FERREIRA, 2014).

5 RESULTS AND DISCUSSION

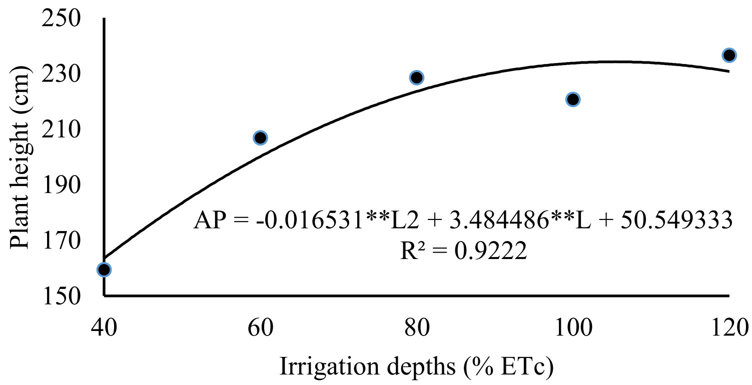
There was no significant difference for the interaction between the factors of irrigation depth and plant density, with only isolated effects up to 1% probability for the variables of plant height, stem diameter, height of insertion of the first ear, leaf area, dry mass of the aerial part, length of the ear with straw and water use efficiency.

For the phytometric variable number of leaves, there was no significant effect for the treatments, with an average value of 7 leaves per plant. For the production variables, the variables ear diameter (with and without straw), length of ears without straw, and soluble solids content did not have a significant effect, either for the interaction between irrigation depth and planting density or as an isolated effect for the factors, with the respective averages: 24 mm, 18 mm, 10 cm, and 5.6%.

For the plant height variable, there was no interaction effect between the irrigation depth and planting density factors; however, there was an isolated effect for the irrigation depth, which fit the quadratic regression model.

The water depth that provided the greatest plant height (234 cm) was 105% of the ETc, with a 30% increase in plant height compared with the water depth of 40% of the ETc (163 cm) (Figure 01). These results do not corroborate those obtained by Meneghetti et al. (2008), who evaluated the production of baby corn at different irrigation depths and reported no significant difference in plant height between treatments.

Figure 1. Height of corn plants under irrigation depths in baby corn production in the Cerrado region of Mato Grosso.



**Regression coefficient significant at 1% probability.

Water stress affects plants at different levels, causing morphological, physiological, biochemical and genetic changes, including transcriptional activation of metabolic genes; production; and accumulation of osmolytes to aid in water retention (MILLER et al., 2010). Thus, a lack of water availability affects all processes, causing the plant to underperform. Therefore, monitoring plant height is an indicator of corn crop development.

The greatest height of baby corn plants under irrigation depths (2.34 m) in this study (dose of 105% of ETc) remained within the standard considered optimal for the baby corn harvesting process, i.e., between 2 and 2.5 m (RODRIGUES; SILVA; MORI, 2004). The standard height of baby corn for harvesting becomes important since tall plants make harvesting difficult, which is done manually, and are more susceptible to toppling and lodging, especially where there is an incidence of strong winds.

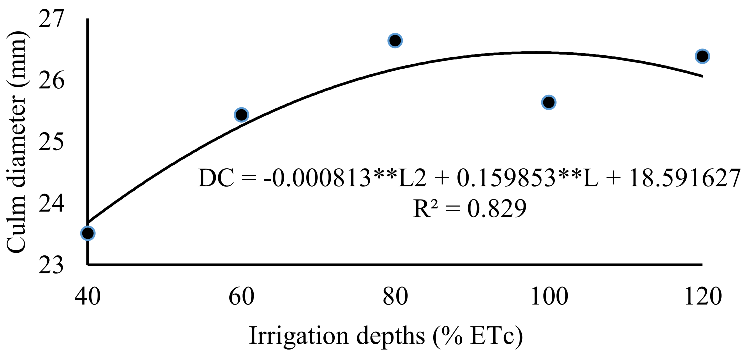
When evaluating irrigation depths in silage corn cultivation, Simões et al. (2017) reported an increase in plant height with increasing irrigation depth, reaching the highest height (150 cm) at depths above 100% ETc. This behavior was also observed by Pegorare et al. (2009), who evaluated the use of irrigation in off-season corn crops under no-tillage and reported an increase in plant height with increasing depth, with the highest plant height (200 cm) occurring at depths above 100% ETc.

When two corn cultivars (simple hybrid Itapuã 700 and variety AL Bandeirante) subjected to different irrigation depths for baby corn production were evaluated, Santos Neto (2012) reported a significant difference in plant height, with the cultivar AL Bandeirante presenting the highest value, 2.15 m, which was close to the highest value observed in this study (2.34 m).

For the stem diameter variable, there was a significant difference across the treatments; however, there was an isolated effect for irrigation depth and planting density, and the quadratic regression model for irrigation depth (Figure 2) and the linear regression model for planting density (Figure 3) were fit.

For the irrigation depths in this study, the largest stalk diameter (26.4 mm) was obtained at the 98% ETc irrigation depth, with an 11% increase compared with the 40% ETc irrigation depth (23.6 mm). In a study developed by Simões et al. (2017) for the production of corn for silage in the submiddle São Francisco Valley, the authors observed similar results for the stalk diameter, verifying a quadratic effect with the largest stalk diameter (18 mm) at the 98% ETc irrigation depth, demonstrating that its development can be affected by the deficit or excess water in the soil.

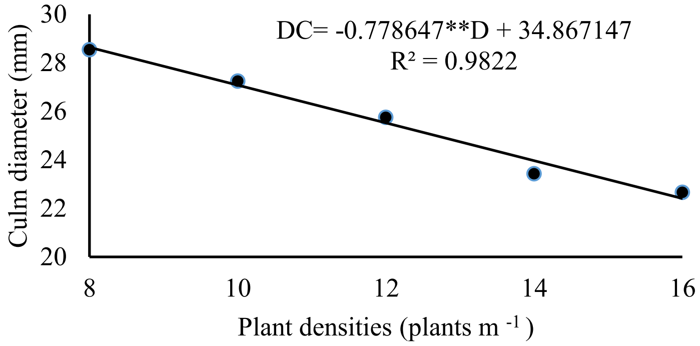
Figure 2. Stalk diameter of the corn plant under different irrigation depths for the production of baby corn in the Cerrado of Mato Grosso.



**Regression coefficient significant at 1% probability.

For the planting density factor, there was a 22% decrease in stem diameter when the lowest density was compared with the highest planting density. The highest value found for stem diameter was for the density of 8 plants m $^{-1}$ (28.6 mm), and the lowest value (22.4 mm) was obtained at the density of 16 plants m $^{-1}$ (Figure 3).

Figure 3. Corn plant stem diameter under various plant density levels for baby corn production in the Cerrado region of Mato Grosso.



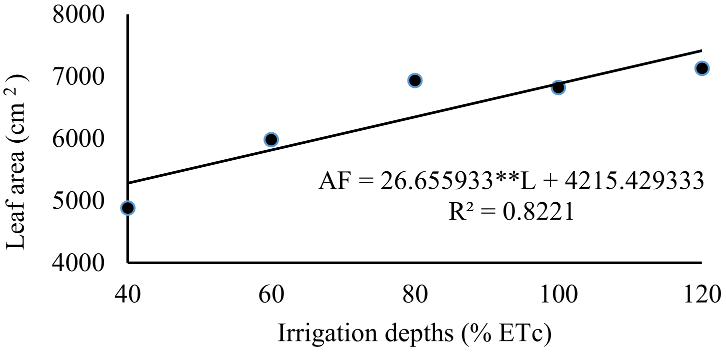
**Regression coefficient significant at 1% probability.

With respect to the performance of corn hybrids in different plant spatial arrangements, Kappes et al. (2011) reported a linear decrease in stalk diameter, with a 25% decrease with increasing plant density. This result corroborates that reported by Penariol et al. (2003), who evaluated corn hybrids with different spacings and population densities and reported a 20% reduction in stalk diameter with increasing sowing density.

High plant populations cause crops to use reserves and resources for faster growth to avoid shading, and this accelerated growth tends to reduce the stalk diameter and leaf area (TAIZ; ZEIGER, 2013). According to Foloni et al. (2014), when researching the corn cultivars AG 9010 and DKB 979, they reported a linear reduction in stalk diameter as a function of population increase, with the largest diameter observed at 60,000 plants ha $^{-1}$. Another important factor associated with increasing seeding density is the reduction in water and nutrient availability for the crop, which causes a reduction in stalk diameter. This reduction may make the use of some hybrids with relatively small stalk diameter characteristics unfeasible due to the possibility of lodging (KAPPES et al., 2011).

For the leaf area variable, there was no interaction effect between the irrigation depth and planting density, with an isolated effect for both. For the irrigation depth factor, an increasing linear effect was observed, with the smallest leaf area (5281 cm²) at an irrigation depth of 40% of the ETc and the largest leaf area (7414 cm²) at an irrigation depth of 120% of the ETc. A 29% increase in leaf area was observed for the deepest irrigation depth compared with the smallest irrigation depth (Figure 4). The reduction in leaf area due to plant density occurs due to competition between plants for water, light, and nutrients. These factors can accelerate the process of leaf senescence, decreasing the leaf area with increasing sowing density (VALENTINUZ; TOLLENAAR, 2004).

Figure 4. Leaf area of the corn plant under irrigation depths in the production of baby corn in the Cerrado of Mato Grosso.

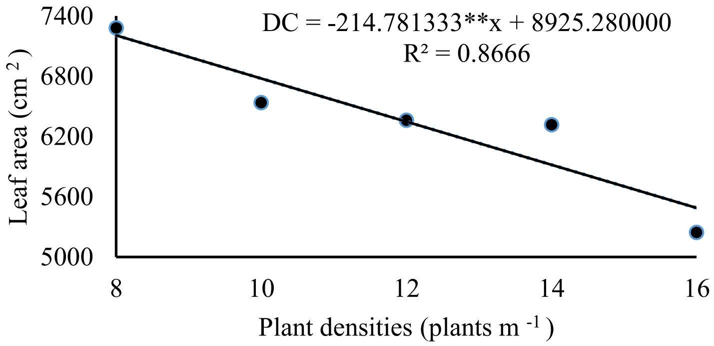


**Regression coefficient significant at 1% probability.

The leaf area is directly related to water availability, as corn is a crop sensitive to water stress, which limits physiological processes. Silva et al. (2017) reported similar results in southern Brazil when evaluating irrigation management on the basis of soil and climate, with a linear effect of increasing leaf area as irrigation depth increased.

With respect to the planting density, a decreasing linear effect was observed; the largest leaf area (7207 cm²) was observed at the lowest planting density (8 plants m $^{-1}$), whereas the smallest leaf area (5488 cm²) was observed at the highest density (16 plants m $^{-1}$). Thus, there was a 31% decrease in leaf area at the highest planting density compared with the lowest density (Figure 5).

Figure 5. Leaf area of the corn plant under plant density levels in the production of baby corn in the Cerrado of Mato Grosso.

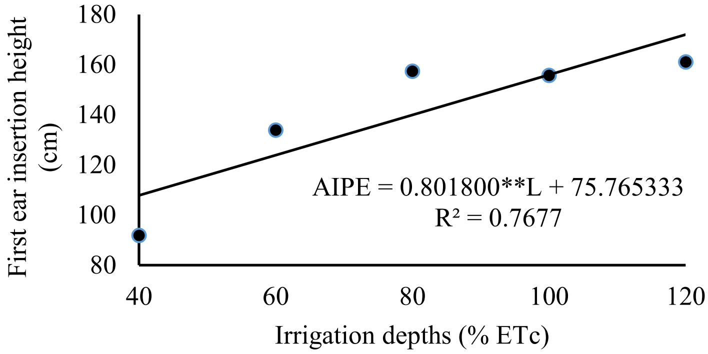


**Regression coefficient significant at 1% probability.

In a study carried out by Imran et al. (2015) in the city of Peshawar, Pakistan, a similar effect was observed on the basis of the effects of nitrogen levels and corn plant population. The authors reported that the leaf area decreased with increasing plant density, with the highest value for the leaf area per plant (2585 cm2) recorded for 65000 plants ha $^{-1}$ and the minimum leaf area per plant $^{-1}$ (2316 cm2) obtained from a planting density of 95000 plants ha $^{-1}$. When observing corn hybrids at different planting densities on the southern Santa Catarina Plateau, Sangoi et al. (2013) reported a reduction in leaf area with increasing planting density, with the largest leaf area (9900 cm²) occurring at the lowest planting density and the smallest area (6990 cm²) occurring at the highest density.

For the variable height of insertion of the first ear (Figure 6), a significant difference was observed for the treatments, with an isolated effect for irrigation depth, fitting the linear regression model.

Figure 6. Height of insertion of the first ear of the corn plant under irrigation depths in the production of baby corn in the Cerrado of Mato Grosso.



**Regression coefficient significant at 1% probability.

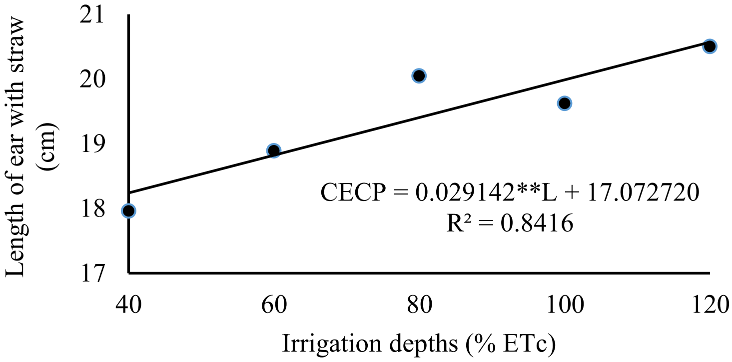
As the irrigation depth increased, the first ear insertion height increased linearly. The lowest height was observed at the 40% ETc depth (107 cm), and the highest height was observed at the 120% ETc depth (172 cm). A 38% increase in the first ear insertion height was observed at the highest irrigation depth compared with the lowest depth. Similar results were reported by Prado (2013), who evaluated irrigation depths and nitrogen rates in a dystrophic Red Latosol in southwestern Goiás. The author observed an isolated effect for the irrigation depths with linearly increasing behavior, in which the highest ear insertion height (116 cm) occurred at the highest irrigation depth.

A similar effect was reported by Ávila et al. (2011) when evaluating corn hybrids under irrigation depths in a dystrophic Red Latosol in northwestern Paraná, where they reported an increasing linear effect on the crop, with a greater ear insertion height (89 cm) at the highest irrigation depth, with a 9% increase in relation to the lowest depth (81 cm). According to Kumar and Singh (1999), the ideal insertion height of the first ear for baby corn is 0.50 m. Therefore, all the irrigation depths provided an insertion height higher than the recommended height.

In the study of ear length with straw, there was no significant effect on the interaction between the irrigation depth and plant density factors, with only an isolated effect for irrigation depth and planting density with adjustment to the linear regression model. For the irrigation depth factor, there was a significant effect, with the greatest length (20.5 cm) occurring at the 120% ETc depth and the shortest length (18.2 cm) occurring at the 40% ETc depth. An increasing linear effect can be observed, with a 12% increase in ear length with straw for the greatest irrigation depth compared with the smallest depth (Figure 7).

Santos et al. (2017) reported that the detrimental effects of soil water shortages are most severe between flowering and early grain filling. In a green corn experiment under various irrigation depths and phosphorus doses, Blanco et al. (2011) reported that the greatest ear lengths were determined at the highest irrigation depths. Silveira (2003), evaluating sprinkler-irrigated baby corn, obtained ear lengths with straws of 0.142 to 0.165 m and an average of 0.158 m. These values are close to those obtained in this study, confirming the effect of water depth on corn ear length.

Figure 7. Length of the ear with straw under irrigation levels in the production of baby corn in the Cerrado region of Mato Grosso.



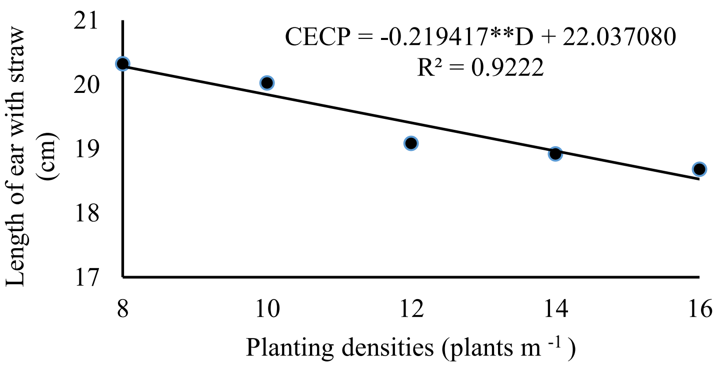
** Significant at 1% probability.

With respect to the planting density, a decreasing linear effect was observed, in which the greatest length of husked ear (20.3 cm) was obtained at a density of 8 plants/m, whereas the shortest length of husked ear (18.5 cm) was observed at a density of 16 plants/m. Thus, there was a 9% reduction in the length of the ear with husk at the highest planting density compared with the lowest density (Figure 8).

As the planting density increases, competition for light, water, and nutrients increases, and photoassimilates decrease. When cultivation is carried out at relatively low densities, Mubarak et al. (2020) reported that greater spacing between plants tends to favor crop growth, resulting in more vigorous and productive plants.

In the present study, the increase in planting density caused a reduction in the length of the ear with straw. Fumagalli et al. (2017) and Rocha, Fornasier Filho and Barbosa (2011) reported a reduction in ear length with a decreasing linear effect when evaluating a corn hybrid as a function of row spacing and planting density in a Red–Yellow Latosol.

Figure 8. Length of the ear with straw under different planting densities used in the production of baby corn in the Cerrado of Mato Grosso.

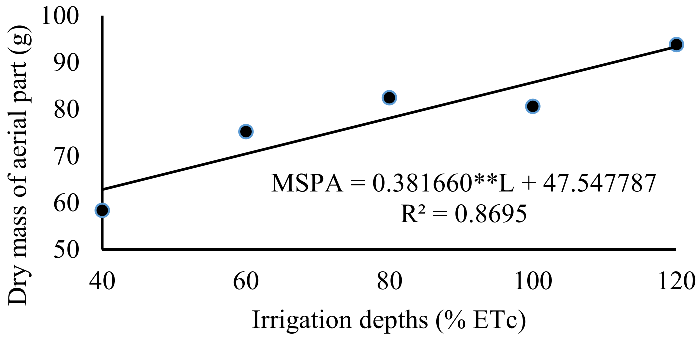


** Significant at 1% probability.

The commercial interest of baby corn lies not in the sale of husk-less ears but in husk-less ears. The length and diameter of baby corn can vary from 4.0 to 12.0 cm and from 1.0 to 1.8 cm, respectively (PEREIRA FILHO; CRUZ, 2001). In this study, the average husk-less ear length was 10 cm, and the husk-less ear diameter was 1.8 cm, which is in line with commercial recommendations. Thus, the use of a dense planting system and lower irrigation depths provides average husk-less ear length and diameter values within commercially required standards.

For the shoot dry mass, there was no significant difference in the interaction effect between the irrigation depth and seeding density, with an isolated effect for both factors. With respect to the irrigation depth factor (Figure 9), an increasing linear effect was observed, in which the highest value for shoot dry mass (93 g plant $^{-1}$) was obtained at a depth of 120% of the ETc, and the lowest value (62 g plant $^{-1}$) was obtained at a depth of 40% of the ETc. A 33% increase in shoot dry mass was observed at the highest depth compared with the lowest depth.

Figure 9. Dry mass of the aerial part of the corn plant under irrigation depths in the production of baby corn in the Cerrado of Mato Grosso.



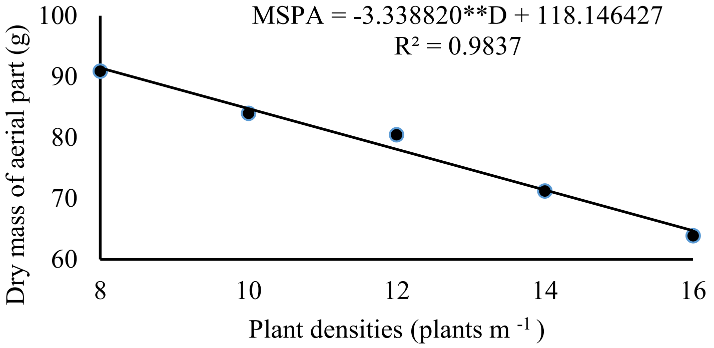
**Regression coefficient significant at 1% probability.

Santos et al. (2013) evaluated the adaptive capacity and response mechanisms of two Brachiaria cultivars brizantha (Marandu and BRS Pia tã) subjected to water deficit to water stress. The authors reported that water deficit caused a decrease in shoot biomass and leaf area in all cultivars.

The increase in water availability in this study led to an increase in shoot dry matter production in baby corn. When evaluating irrigation management via soil and climate, Silva et al. (2017) reported similar results in the southern region of Brazil, with a linear effect increasing with increasing irrigation depth.

For the planting density factor, a decreasing linear effect was observed, in which the highest value for the dry mass of the aerial part (91 g plant $^{-1}$) was verified at a density of 8 plants m $^{-1}$ and the lowest mass (64 g plant $^{-1}$) at a density of 16 plants m $^{-1}$ (Figure 10).

Figure 10. Dry mass of the aerial part of the corn plant under plant densities in the production of baby corn in the Cerrado of Mato Grosso.

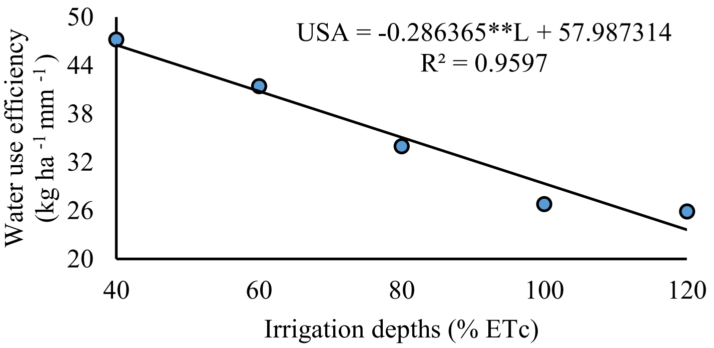


**Regression coefficient significant at 1% probability.

The dry mass of the aerial part per plant tends to decrease with increasing planting density, but this value is offset by increasing population density. Thus, this study corroborates the findings of Brachtvogel et al. (2012), who reported an increase in the total dry mass of the area with increasing planting density and a reduction in the dry mass of the aerial part per plant.

For water use efficiency, there was a significant isolated effect for the factors, with adjustment to the linear regression model for irrigation depth (Figure 11) and planting density (Figure 12). For the irrigation depth factor, a decreasing linear effect was observed for water use efficiency, in which the highest efficiency (46 kg ha $^{-1}$ mm $^{-1}$) was observed at a depth of 40% of ETc, whereas the lowest efficiency (23 kg ha $^{-1}$ mm $^{-1}$) was observed at a depth of 120% of ETc (Figure 11).

Figure 11. Water use efficiency of corn under irrigation depths in the production of baby corn in the Cerrado of Mato Grosso.



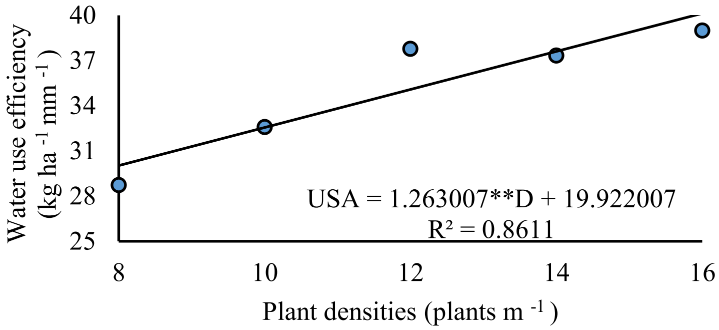
**Regression coefficient significant at 1% probability.

With reduced soil water availability, plants reduce transpiration flow through stomatal closure and osmotic adjustment, aiming to maintain water absorption and complete its cycle, becoming more efficient. This phenomenon requires greater energy expenditure, thus affecting crop production (TAIZ; ZEIGER, 2013).

When studying the physiology of sweet corn under water stress, Brito et al. (2013) reported the highest water use efficiencies with the lowest irrigation depths. This result corroborates that reported by Blanco et al. (2011), who, when evaluating irrigation depths and phosphorus doses in a Yellow Latosol, observed lower efficiency with increasing irrigation depth.

For planting density (Figure 12), an increasing linear effect was observed for water use efficiency, in which the lowest efficiency (30 kg ha $^{-1}$ mm $^{-1}$) was observed at a density of 8 plants m $^{-1}$, and the highest efficiency (40 kg ha $^{-1}$ mm $^{-1}$) was observed at a density of 16 plants m $^{-1}$. When evaluating irrigation depths and plant densities for second-crop corn in the southern region of Brazil, Ben (2015) reported results similar to those of this work, demonstrating increasing water use efficiency with increasing planting density.

Figure 12. Water use efficiency of corn under various plant densities in baby corn production in the Cerrado of Mato Grosso.



**Regression coefficient significant at 1% probability.

6 CONCLUSIONS

An irrigation level higher than 98% of the ETc promoted increases in the variables plant height, stem diameter, first ear insertion height, aerial part dry mass, leaf area and ear length with straw.

The variables stem diameter, leaf area, length of the ear with straw and dry mass of the aerial part were significantly influenced by plant density, with a reduction in the values of the variables with increasing planting density.

For a lower irrigation depth (40% of ETc) and a higher seeding density (16 plants ha $^{-1}$), greater water use efficiency was obtained.

The variables ear diameter (with and without straw), length of ears without straw and soluble solids content were not affected by the differentiation of blades and planting densities.

The use of a planting system with greater density and a lower irrigation depth for baby corn provided average values of the length and diameter of the cob without straw within commercial standards.

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