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DESEMPENHO AGRONÔMICO DA CULTURA DO MILHO VERDE SOB REGIMES HÍDRICOS E COBERTURA MORTA VEGETAL

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1 RESUMO

A cultura do milho verde (*Zea mays* L.) apresenta grande importância na alimentação humana, ganhando cada vez mais destaque na segurança alimentar e na geração de emprego e renda. Objetivou-se avaliar desempenho agronômico da cultura do milho verde (*Zea mays* L.) irrigado com diferentes regimes hídricos e aplicação de cobertura morta vegetal. O experimento foi realizado na Universidade da Integração Internacional da Lusofonia Afro-Brasileira (UNILAB), no município de Redenção, Ceará, Brasil. O delineamento experimental utilizado foi em blocos casualizados, em esquema fatorial 4 x 2, com quatro regimes hídricos (60%, 80%, 100% e 120% da evapotranspiração potencial do milho, com e sem cobertura morta vegetal, com quatro repetições. Foram avaliadas as variáveis: altura da planta (cm), diâmetro do caule (mm), massa seca da parte aérea (g), massas das espigas com palha e sem palha (g), comprimento da espiga sem palha (cm), diâmetro da espiga sem palha (mm), produtividade (kg ha^{-1}) e eficiência do uso da água (kg ha^{-1} mm^{-1}). O uso da irrigação com lâmina de 120% da evapotranspiração da cultura, associado a cobertura morta vegetal, promove melhor desempenho no milho verde (*Zea mays* L.) para altura da planta, massa seca da parte aérea, massa da espiga e na produtividade em condições de semiárido.

Palavras-chave: cobertura do solo, estresse hídrico, *Zea mays* L.

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AGRONOMIC PERFORMANCE OF GREEN CORN CROPPING UNDER DIFFERENT WATER REGIMES AND VEGETABLE MULCH

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2 ABSTRACT

The cultivation of green corn (*Zea mays* L.) is highly important for human nutrition, gaining increasing prominence in food safety and in the generation of employment and income. The objective of this study was to evaluate the agronomic performance of green corn (*Zea mays* L.) irrigated with different water regimens and the application of mulch. The experiment was carried out at the University of International Integration of Afro- Brazilian Lusophony (UNILAB) in the municipality of Redenção, Ceará, Brazil. The experimental design used was randomized blocks in a 4 × 2 factorial scheme with four water regimes (60%, 80%, 100% and 120% of the potential evapotranspiration of corn, with and without mulch), with four replicates. The following variables were evaluated: plant height (cm), stem diameter (mm), dry mass of the aerial part (g), masses of the ears with and without straw (g), length of the ear without straw (cm), diameter of the ear without straw (mm), productivity (kg ha $^{-1}$) and water use efficiency (kg ha $^{-1}$ mm $^{-1}$). The use of irrigation at a depth of 120% of crop evapotranspiration, associated with mulch, promoted better performance on green corn (*Zea mays* L.) in terms of plant height, dry mass of the aerial part, ear mass and productivity under semiarid conditions.

Keywords: ground cover, hydrical stress, *Zea mays* L.

3 INTRODUCTION

Corn (*Zea mays* L.) originates from Mexico and is currently the main agricultural crop grown worldwide. It has great economic and social importance since its grains can be processed and used directly in human and animal food, promoting food security and generating employment and income (Contini *et al.*, 2019; Kandil *et al.*, 2020).

Crop production in semiarid regions of the world, such as Northeast Brazil, faces several challenges, mainly due to high temperatures, low annual temperature ranges, and unevenly distributed rainfall, with long dry periods. This scenario has led to unstable water conditions for agricultural crops, as the potential evapotranspiration rate is usually higher than the rainfall rate for most of the year. Thus, water deficits lead to stomatal closure, limiting CO_2 assimilation and directly impacting crop productivity (Barbosa *et al*., 2020; Silva *et al*., 2020).

In this context, proper irrigation management is an essential strategy to ensure stable crop production, especially in semiarid regions. Fernandes *et al*. (2022), who studied corn irrigated with 150% crop evapotranspiration (ETc), equivalent to 600 mm of water during the cycle, reported a linear increase in productivity 81 days after sowing. On the other hand, irrigation depths corresponding to 75% of the ETc resulted in reduced corn yield. Therefore, it is essential to adopt practices that minimize water use without compromising productivity. Among these practices, the application of mulch stands out (Goes *et al*., 2023).

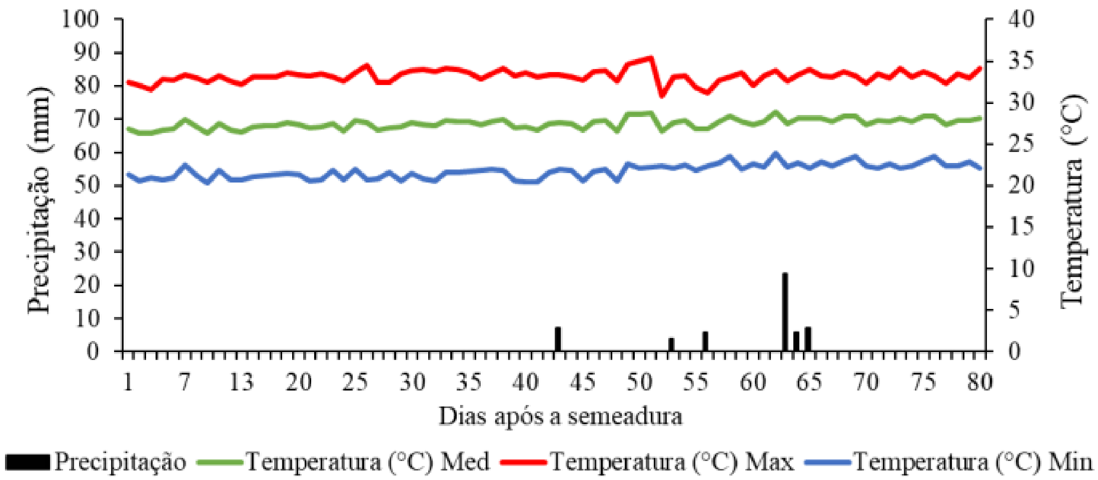
Mulching is a conservation technique that aims to protect the soil by promoting the conservation of beneficial microorganisms, reducing soil temperature, maintaining moisture, reducing leaching and the emergence of invasive plants, in addition to contributing to fertility and increasing organic matter levels. It also acts to reduce erosion processes, promoting a reduced need for irrigation, which can reduce environmental impacts and production costs (Costa *et al*., 2021; El--Beltagi *et al*., 2022). In view of the above, the objective of this study was to evaluate the agronomic performance of a green corn crop (*Zea mays*

L.) irrigated with mulch under different water regimes.

4 MATERIALS AND METHODS

The experiment was carried out in 2022, during the dry season (September to November), in an experimental area of the University of International Integration of Afro-Brazilian Lusophony (UNILAB), Liberdade Campus, located in the municipality of Redenção, Ceará, Brazil, between coordinates 04°13'21.05” S and 38°43'33.37” W. The average altitude of the region is 88.8 m. The local climate is of the BSh type, characterized by rainfall concentrated in the summer and autumn seasons, in addition to high temperatures throughout the year (Alvares *et al*., 2013). The rainfall and temperature values recorded during the experimental period are presented in Figure 1.

Figure 1. Meteorological data during the experiment.



Before the experiment began, soil samples were collected from the experimental area and subsequently sent to the soil laboratory, where chemical attributes were analyzed according to the methodology described by Teixeira *et al*. (2017) (Table 1). In terms of physical attributes, the soil in the area is classified as Red--Yellow Argisol, with a predominantly sandy texture (Santos *et al*., 2018).

Table 1. Soil chemical attributes before application of treatments at a depth of 0–20 cm.

MO	N	P	K	Ca^{2+}	Mg^{2+}	In the $^{+}$	H^{-} + Al^{3+}	CTC	SB	V	pH
----- g kg^{-1} -----		------------------------- cmol $_c$ kg^{-1} -------------------------								%	1:2.5
8.38	0.53	26	0.30	2.5	2.20	4.5	1.32	6.32	5.0	79.11	6.5

MO: Organic matter; CEC: Cation exchange capacity; SB: Sum of bases; V: Base saturation; and pH: Hydrogen potential (H2O).
Source: Authors (2025).

Sowing was performed manually, with a spacing of 1.0 × 0.2 m between rows and between plants. Five seeds were sown per hole, and eight days after sowing (DAS), thinning was carried out, leaving two plants in each hole.

At 15 DAS, mulch, composed of spontaneous crop residues, was applied to the proposed treatments, forming a layer of approximately 10 cm above the soil around the plants. During mulch application, direct coverage of the stems was avoided to prevent moisture accumulation and the emergence of diseases (Gruda, 2008).

randomized blocks, in a 4 × 2 factorial scheme, with four replications. The first factor corresponded to four water regimes (60%, 80%, 100% and 120% crop evapotranspiration (ETc)), whereas the second factor consisted of the presence or absence of mulch.

Irrigation was performed via a drip system, with one dripper per hole, according to the treatments. The spacing between the drippers and planting rows was 0.2 × 1.0 m, and the emitter flow rate was 8.0 L h^{-1} per dripper. The daily estimate of the water regimes (60%, 80%, 100%, and 120% of ETc) was based on the reference evapotranspiration (ETo) determined by the Class A tank method, as shown in Equation 1:

$$ETo = ECA \times Kp \quad (1)$$

where:
ETo = reference evapotranspiration (mm);
ECA = Class A tank evaporation (mm); and
Kp = Tank coefficient (dimensionless).

Crop evapotranspiration (ETc) was estimated via equation 2:

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

where:
ETc = crop evapotranspiration (mm);
ETo = reference evapotranspiration (mm); and
Kc = Cultivation coefficient (dimensionless).

For the cultivation coefficient (Kc), cultivation coefficients (Kc) of 0.90 (from 0--40 DAS), 1.3 (from 40--60 DAS), and 1.2 (from 60--72 DAS) were used, according to the methodology of Doorenbos and Kassam (1994).

To determine the irrigation time, equation 3 was used:

$$Ti = (ETc \times Ep)/(Ea \times q) \times 60 \quad (3)$$

where:
Ti = irrigation time (minutes);
ETc = crop evapotranspiration (mm);
Ep = spacing between drippers (cm);
Ea = application efficiency (0.92); and
q = flow rate (L/h).

At 40 days after sowing (DAS), the following variables were evaluated: plant height (AP), using a tape measure graduated in centimeters; aerial part dry mass (MSPA), obtained via a precision scale and expressed in grams; and stem diameter (DC), measured with a digital caliper and expressed in millimeters.

At 72 DAS, the following variables were evaluated: ear weight with straw (MECP) and ear weight without straw (MESP), measured with an analytical balance and expressed in grams; ear length without straw (CESP), determined with a ruler graduated in centimeters; ear diameter without straw (DESP), measured with a digital caliper and expressed in millimeters; and productivity (PROD), determined on the basis of the total mass of grains as a function of the cultivated area, expressed in kg ha^{-1}.

Water use efficiency (WUE), expressed in kg ha^{-1} mm^{-1}, was calculated from the relationship between productivity and the total irrigation depth applied.

To assess data normality, the variables were subjected to the Kolmogorov–Smirnov test ($p \leq 0.05$). The data were subsequently analyzed via analysis of variance (ANOVA) via the F test. When the effects of water regimes were significant, regression equations were adjusted; for the effects of mulch, Tukey's mean test was applied at the 1% and 5%

significance levels via ASSISTAT 7.7 Beta software (Silva; Azevedo, 2016).

5 RESULTS AND DISCUSSION

An analysis of variance (ANOVA) (Table 2) verified that the effects of irrigation depth and mulch on the variables plant height (AP), shoot dry mass (MSPA), ear mass with straw (MECP), ear mass without straw (MESP), productivity (PROD) and water use efficiency (EUA) were significant ($p \leq 0.05$). For ear length without straw (CESP), an isolated effect of both the water regime and mulch was observed ($p \leq 0.05$).

Table 2. Summary of analysis of variance (ANOVA) related to the variables stem diameter (DC), plant height (AP), shoot dry mass (MSPA), ear weight with straw (MECP), ear weight without straw (MESP), ear diameter without straw (DESP), ear length without straw (CESP), productivity (PROD) and water use efficiency (EUA) in green corn (*Zea mays* L.) as a function of water regime and the presence (with) or absence (without) of mulch.

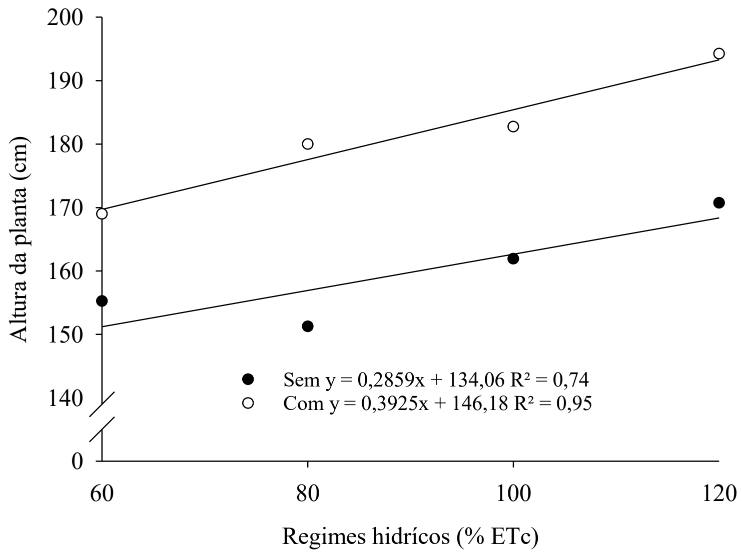
FV	GL	Mean square					
		A.D	AP	MSF	MECP	MESP	DESP
HR	3	19.73 ns	310.2 **	496.08 **	1929.53 **	1398.25 **	2.32 ns
Coverage	1	30.38 ns	264.5 **	1711.12 **	5921.28 **	144.50 ns	0.02 ns
HR x C/S	3	2.92 ns	110.2 **	26.20 **	2032.86 **	5402.25 **	4.39 ns
Treatment	7	14.07 ns	642.2 **	468.28 **	9223.06 **	6228.14 **	2.71 ns
Residue	24	1.00	19.06	4.89	17.05	89.41	4.9
Total	31	-	-	-	-	-	-
CV	-	6.01	2.62	5.77	0.45	1.49	3.94

FV	GL	Mean square		
		CESP	PROD	USA
HR	3	6.55 **	24841.3 **	49.52 **
Coverage	1	8.23 **	600424.9 ns	80.94 **
HR x C/S	3	2.34 ns	34429.1 **	26.11 **
Treatment	7	9.27 **	26259.4 **	43.98 **
Residue	24	0.89	412798.1	1.62
Total	31	-	-	-
CV	-	4.65	12.48	11.75

FV = source of variation; GL = degree of freedom; CV = coefficient of variation; RH = water regime; C/S = with and without mulch, ns = not significant; (**) significant at the 0.01 probability level ($p < 0.01$).
Source: Authors (2025).

Plant height was influenced by the factors studied: water regime and mulch. Linear height growth was observed with increasing irrigation depth. Furthermore, the presence of mulch promoted greater height development in corn plants (Figure 2).

Figure 2. Plant height of green corn (*Zea mays* L.) irrigated with different water regimes in the presence (with) and absence (without) of mulch.

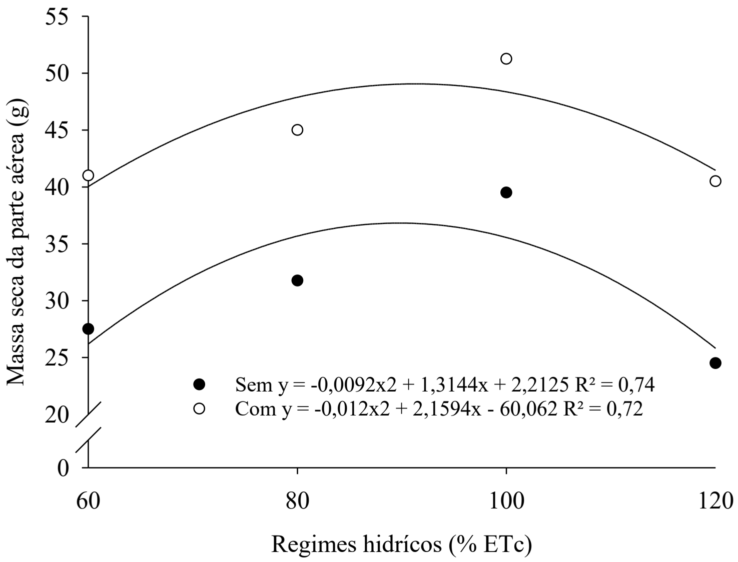


Source: Authors (2024).

The data obtained for plant height were similar to the results of the study by Sousa *et al*. (2017a), who evaluated the agronomic performance of irrigated sorghum under different irrigation depths and soil cover applications. The authors observed greater plant height values at greater depths, equal to 821.15 mm. Similarly, Lessa *et al*. (2019) reported a reduction in sorghum plant height in the absence of plant cover.

For the dry mass of the aerial part, the quadratic polynomial models were the ones that best fit the data, indicating a maximum increase of 36.98 g for a water regime corresponding to 95.43% of the ETc, in the absence of mulch, and of 49.18 g for 96.71% of the ETc, with the presence of mulch (Figure 3).

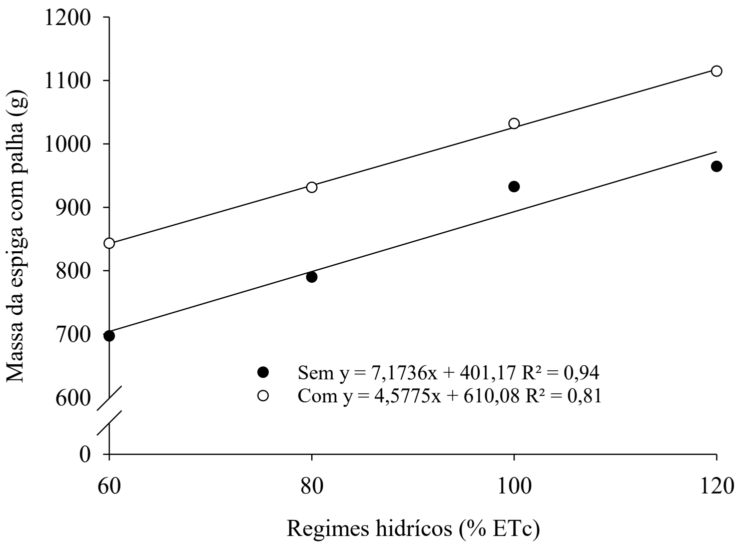
Figure 3. Dry mass of the aerial part of green corn (*Zea mays* L.) irrigated with different water regimes in the presence (with) and absence (without) of mulch.



Source: Authors (2024).

Ear weight with straw was influenced by the interaction between the water regime (RH) and mulch. However, the linear model best fit the data, both in the mulch and unmulched treatments (Figure 4).

Figure 4. Corn cob mass with husks (*Zea mays* L.) irrigated with different water regimes in the presence (with) and absence (without) of mulch.

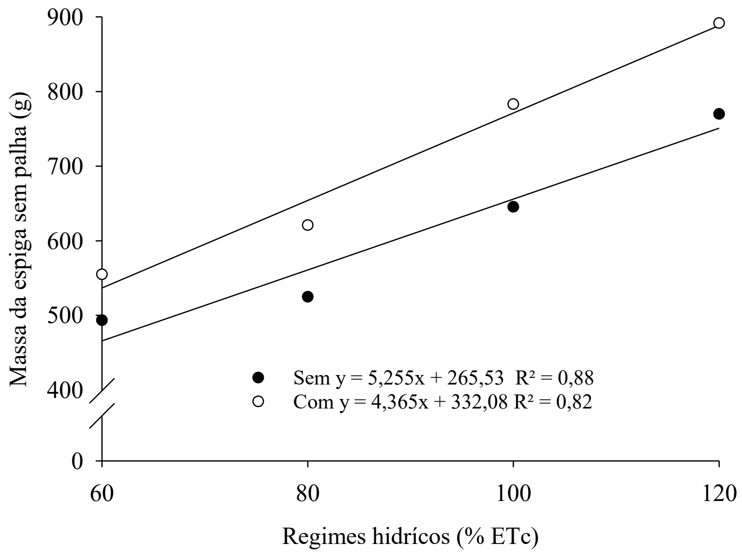


Source: Authors (2024).

The increases in ear mass are directly linked to the use of mulch, which provides thermal mechanisms in the soil, enabling moisture conservation and reducing water evaporation (Orrillo *et al*.). 2016). The results of this study are similar to those of Torres *et al*. (2020), who studied irrigation depths and mulch in corn crops. These same authors reported that ear weight with straw presented maximum values at the greatest depth, regardless of the presence or absence of mulch, highlighting the importance of the water regime in ear growth and development.

The water regimes and mulch interacted for the ear mass variable without straw, presenting a linearly increasing behavior for both mulch treatments and without mulch (Figure 5). However, the mulch treatment presented the highest values compared with those in the absence of mulch in the highest water regime.

Figure 5. The mass of the cob without straw of green corn (*Zea mays* L.) irrigated with different water regimes and in the presence (with) and absence (without) of mulch.



Source: Authors (2024).

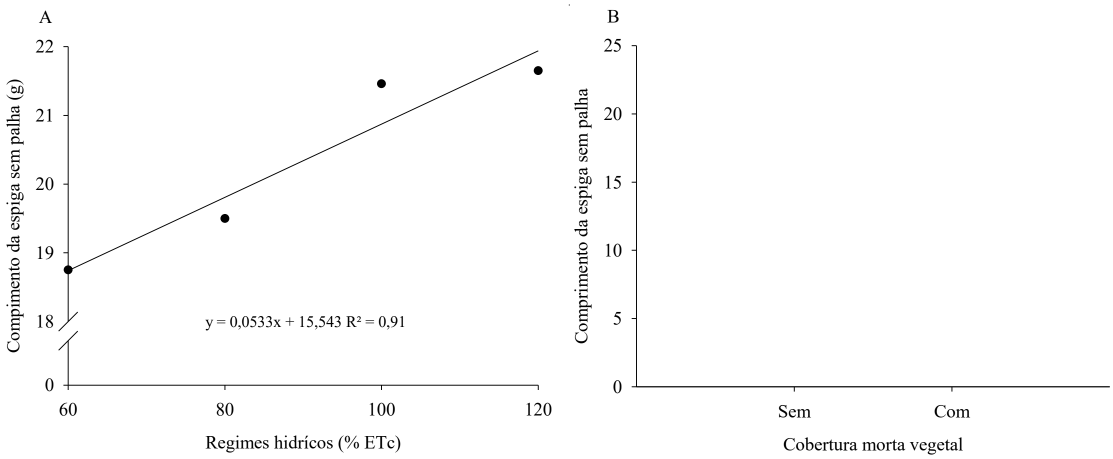
For the dry mass of the aerial part, water availability possibly influenced the negative response, since, in a study developed by El-Beltagi *et al.* (2022), these researchers highlighted that increased water regimes can lead to conditions of excess moisture in the soil, causing negative effects on root development and nutrient absorption by corn plants, which is reflected in reduced biomass.

Studies carried out by Sousa *et al.* (2017b), when researching the agronomic performance of sorghum (*Sorghum bicolor* [L.] Moench) crops under different irrigation depths and soil cover, reported a considerable decrease in biomass as the irrigation depth increased.

Maintaining soil moisture may have provided greater nutrient displacement to the corn plants, favoring an increase in the mass of the ear without straw (El-- Beltagi *et al.*, 2022). Similar results were reported by Andrade Neto *et al.* (2020), when studying corn cultivars irrigated with different depths and soil cover, they reported an increase in the weight of husked ears with increasing water regimes.

No interaction effect between water regime and mulch cover was observed on the length of the ear without straw. Figure 6A shows linear growth as a function of water regime. In this case, the soil is at field capacity, which favors ideal conditions for nutrient translocation and ear formation.

Figure 6. Length of the ear without straw of green corn (*Zea mays* L.) irrigated with different water regimes (A) and with (with) and without (without) mulch (B). Different letters indicate the means according to Tukey's test (p≤ 0.05); vertical bars represent the standard error (n=4).



Source: Authors (2024).

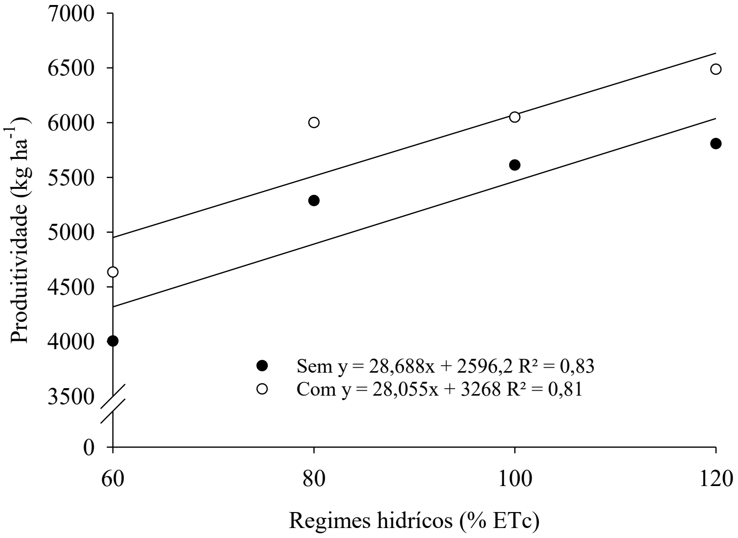
The application of soil protection reduces leaching and contributes to reducing soil temperature, in addition to increasing organic matter levels (Costa *et al*., 2021). When investigating the length of corn cobs sown under different irrigation conditions, with and without mulch, Torres *et al*. (2020) reported results consistent with those presented in the present study, in which the greatest length of the husked cob occurred in the treatment with the greatest irrigation depth.

Results similar to those of the present work were reported by Sousa *et al*. (2018), when studying mulch in corn, they reported that plants subjected to mulch were superior to those subjected to mulch without mulch.

The increase in morphological variables due to the increase in water regimes can be explained by the fact that mulch allows the maintenance of soil moisture, reduces leaching, reduces the incidence of weeds, contributes to the reduction in soil temperature, and significantly increases the organic matter content (Costa *et al*., 2021).

Corn yield was influenced by the factors studied (Figure 7). The increasing linear model fit best for both the mulch and nonmulch treatments. The mulch treatment resulted in a 51.05% increase, which was greater than the 40% increase observed in the unmulched treatment.

Figure 7. Productivity of green corn (*Zea mays* L.) irrigated with different water regimes in the presence (with) and absence (without) of mulch.

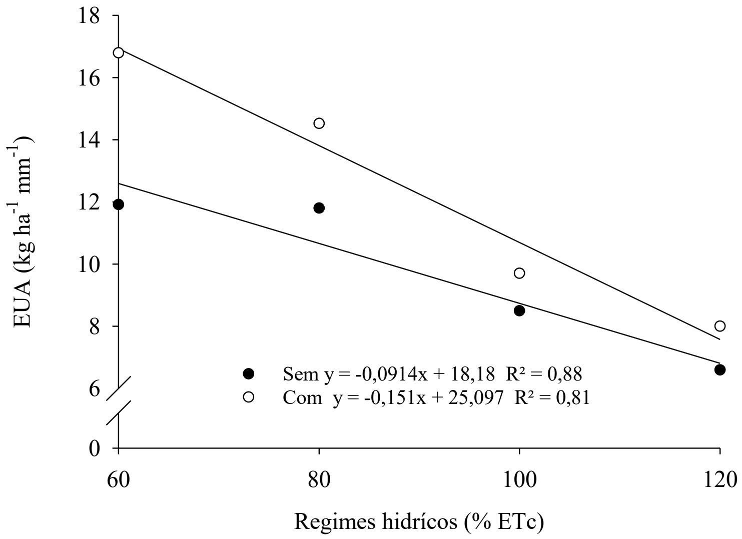


Source: Authors (2024).

The increase in productivity occurred in response to increased water regimes due to greater soil water storage, which mitigated water stress and increased the moisture available for the crop, directly reflecting productivity (Goes *et al*., 2021). Similar results were reported by Torres *et al*. (2020), who studied irrigation depths and mulch in intercropping with cowpea *(Vigna unguiculata (L.) Walp.*) and corn, reported an increase in corn productivity in treatments with mulch.

The water use efficiency (WUE) decreased linearly as the water regime (RH) increased, both in the treatments with and without mulch. On average, the WUE was 52.36 kg ha $^{-1}$ mm^{-1} with mulch, whereas in the treatments without mulch, the average value was 43.13 kg ha $^{-1}$ mm^{-1} (Figure 8).

Figure 8. Water use efficiency of green corn (*Zea mays* L.) irrigated with different water regimes in the presence (with) and absence (without) of mulch.



Source: Authors (2024).

There was a reduction in water use efficiency (WUE) in response to changing water regimes. The observed discrepancies can be attributed to the influence of mulch on corn evapotranspiration. This pattern is correlated with increased water demand during the reproductive phase. In situations of moderate water stress, there is a tendency toward increased water use efficiency (Taiz *et al.*, 2017). Similar results were reported by Ramos *et al.* (2014), who studied green cowpea productivity as a function of water regime and reported a reduction in water use efficiency with increasing water regime. Souza *et al.* (2011), when investigating the impact of mulch on water use for corn cultivation in cerrado areas, also reported a reduction in water use efficiency, regardless of the presence or absence of mulch.

6 CONCLUSION

The use of irrigation at a depth equivalent to 120% of crop evapotranspiration, associated with mulch, promotes better performance in green corn (*Zea mays* L.) crops, reflected in plant height, dry mass of the aerial part, ear mass and productivity, especially under semiarid conditions.

The 60% evapotranspiration layer of the crop showed greater efficiency in terms of water use but was less intense in the presence of mulch.

Mulching is an effective conservation practice to mitigate water stress in the semiarid region of Northeast China.

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