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AJUSTE DA LÂMINA DE IRRIGAÇÃO NO DESEMPENHO AGRONÔMICO DA CULTURA DO MILHO*

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1 RESUMO

O milho é, mundialmente, um dos cereais mais importantes. Sua produtividade pode ser afetada pela ocorrência de déficit hídrico; dessa forma, é necessária a busca por formas de manejo e sistemas de irrigação eficientes. Portanto, o objetivo deste trabalho foi avaliar os componentes de rendimento, produtividade, eficiência do uso da água e composição bromatológica da cultura do milho, submetida a diferentes lâminas de irrigação, e validação da planilha “Lâmina” para a recomendação de irrigação. O delineamento experimental utilizado foi blocos inteiramente casualizados, com quatro repetições, e os tratamentos foram: sem irrigação (controle); ajuste da lâmina de irrigação (planilha “Lâmina”); manutenção da umidade do solo equivalente à capacidade real de água no solo (55% da capacidade total de água do solo) e manutenção da umidade do solo equivalente em 100% da umidade da capacidade de campo. As produtividades foram similares entre os tratamentos irrigados, não apresentando diferenças significativas com o tratamento controle, possivelmente, devido ao alto volume e à boa distribuição da precipitação durante o ciclo da cultura. Comparado aos demais sistemas irrigados, o tratamento utilizando a planilha “Lâmina” contribuiu para o uso racional da água sem interferir na produtividade, aumentando o teor de proteína bruta no grão.

Palavras-chave: *Zea mays*, água, umidade do solo.

ALMEIDA, P. M. de; FORTUNA, V.; MARCO, N. K. de; ALMEIDA, K. R. de; PAZZINI, E. P.; PIAZZETTA, H. V. L.
ADJUSTMENT OF THE IRRIGATION DEPTH ON THE AGRONOMIC PERFORMANCE OF THE CORN CROP

2 ABSTRACT

Corn is one of the world's most important cereals. Its productivity can be affected by the occurrence of water deficit, so it is necessary to search for efficient irrigation systems and

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management methods. Therefore, the aim of this work was to evaluate the yield components, productivity, water use efficiency, and bromatological composition of the corn crop, subjected to different irrigation depths, and to validate the “Lâmina” spreadsheet for recommending the irrigation depths. The experimental design used was entirely randomized blocks, with four replications, and the treatments were: no irrigation (control); adjustment of the irrigation depths (“Lâmina” spreadsheet); maintenance of soil moisture equivalent to the actual water capacity in the soil (55% of the total water capacity of the soil) and maintenance of soil moisture equivalent to 100% of the field capacity moisture. Yields were similar between the irrigated treatments, with no significant difference from the control treatment, possibly due to the high volume and good distribution of rainfall during the crop cycle. Compared to the other irrigated systems, the treatment using the “Lâmina” spreadsheet contributed to the rational use of water without interfering with productivity, increasing the crude protein content in the grain.

Keywords: *Zea mays,* water, soil moisture.

3 INTRODUCTION

Considering the most produced and consumed cereal in the world, corn (*Zea mays* L.) is a plant of Mexican origin that belongs to the Poaceae family and was domesticated approximately 7,500--12,000 years ago. It is the second most important crop in Brazilian agriculture, since together with soybeans, it contributes approximately 80% of national production (DUARTE; GARCIA; MIRANDA, 2011).

In Brazil, among the grains that are cultivated, corn is one of the most significant, with its production mainly intended for internal supply, although recently, its export volume has grown annually (CONTINI *et al*., 2019). Corn is grown in different production systems and is produced mainly in the Central-West, Southeast and South Regions of the country. Its importance extends beyond the economic aspect, presenting relevance in human and animal nutrition, as well as in the viability of other crops, thus reducing the possibility of the incidence of diseases related to crop rotation.

Brazil is among the three largest corn producers worldwide, behind only the United States and China. According to the Conab survey in 2022, for corn cultivation, the estimate for the 2022/23 harvest indicates a production of 312.2 million tons, 15% or 40.8 million tons higher than that obtained in 2021/22, with the 2021/22 harvest indicating that the lack of rain harmed the development of corn, especially in the southern region and in the state of Mato Grosso do Sul (MILHO, 2022).

The corn crop is particularly sensitive to water stress, since this factor causes a reduction in photosynthetic activity, changes in plant growth, reduced transpiration and acceleration of senescence and leaf abscission (TAIZ; ZEIGER, 2009; MELO *et al*., 2019).

In this context, the importance of regularizing water availability in corn cultivation is noted to avoid the incidence of water stress (ALMEIDA: ALMEIDA; OLIVEIRA, 2021), which is why proper irrigation becomes a technology with great potential for achieving greater productivity (MOREIRA *et al.).* , 2012).

In view of the above, the objective of this work was to evaluate the yield, productivity, water use efficiency and bromatological composition of corn grains subjected to different irrigation depths and to validate the spreadsheet “Blade” as an irrigation management tool.

4 MATERIALS AND METHODS

The experiment was conducted in the experimental area of the Federal University of Fronteira Sul, Erechim campus, under the coordinates of latitude -27°43'44" S and longitude -52°17'08" W at 760 m altitude, from May 2016 to April 2017. At the site, the soil was classified as a humic Aluminoferric Red Oxisol according to the Embrapa classification (2006).

The municipality of Erechim has a Cfa climate (subtropical climate) according to the Köppen climate classification (1931), with temperatures in the hottest month above 22°C and below 18°C in the coldest month, in addition to rainfall that is well distributed throughout the year. Table 1 presents climatic data for the municipality considering the climatological normal 1976--2005.

Table 1. Climatological normal (1976--2005) in the municipality of Erechim, RS is almost 16 cm, words cut,

Months	Average temperature (°C)	Rainfall (mm)	Relative Humidity (%)	Potential evapotranspiration (mm/month)	Solar radiation (MJ/m²/ day)
January	22.6	171.7	77.6	117.0	21.6
February	22.1	143.2	79.3	97.7	20.8
March	21.2	132.9	79.7	93.5	17.7
April	18.5	145.2	79.2	65.2	14.4
May	15.7	159.6	82.6	46.4	12.3
June	13.9	156.4	81.9	34.8	10.6
July	13.5	177.7	80.8	35.1	11.1
August	15.0	129.5	79.4	45.0	13.4
September	15.7	173.0	76.0	50.3	15.7
October	18.2	210.1	76.0	61.3	19.5
November	20.0	155.4	75.3	87.8	22.3
December	21.7	145.1	75.6	110.9	22.6
Annual	18.2	1869.4	78.6	844.9	16.8

Source: Matzenauer, Radin e Almeida (2011)

The treatments consisted of rainfed cultivation (control treatment), irrigated cultivation with an irrigation depth applied to maintain 100% of the field capacity humidity (CC treatment), irrigated cultivation with a depth equivalent to the actual water capacity in the soil (CRA treatment), corresponding to 55% of the soil's total water capacity, and cultivation irrigated with an irrigation depth adjusted according to the value provided by the "Lâmina" spreadsheet (blade treatment).

randomized blocks with four replications. Each experimental unit consisted of a paddock measuring 3 m wide by 3 m long, totaling 9 m², separated by a 1 m wide path. The soil acidity correction was carried out through the application, without incorporation, of limestone filler at a dose of 2,000 kg ha $^{-1}$ $_{CaCO3}$ (PRNT 60%), with the aim of increasing the base saturation to 70%.

The establishment of the culture was carried out according to the recommendation established by the Agroclimatic Zoning of Rio Grande do Sul, determined by the Ordinance of the Ministry of Agriculture, Livestock and Supply No. 162/2016 for corn cultivation, in accordance with the recommendation for the selected cultivar. Thus, sowing was carried out on November 31, 2016, via a precision seeder-fertilizer set whose seed-metering mechanism was shaped like a honeycomb disc and regulated to obtain a final population of 80,000 plants ha $^{-1}$, a spacing of 0.5 m and a sowing depth of 2 cm.

The corn cultivar selected was the hybrid Impacto Viptera 3, which is recommended for the state of Rio Grande do Sul. The cultivar's seeds were previously treated with Standak Top at a dose of 200 mL 100 kg $^{-1}$ of seeds.

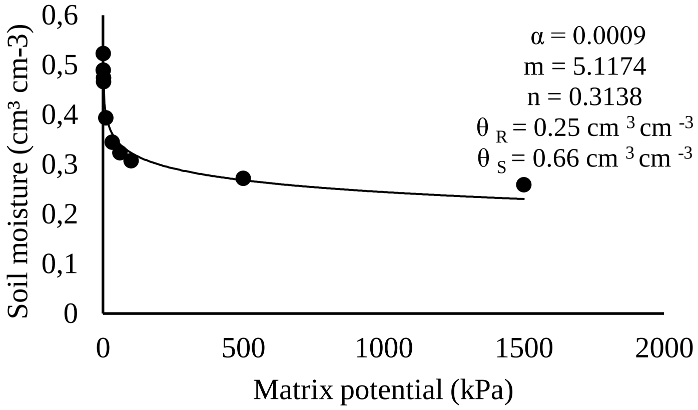
The dose of fertilizer used was defined on the basis of the chemical conditions demonstrated by soil analysis, followed by interpretation and recommendation in accordance with the Fertilization and Liming Manual for the States of Rio Grande do Sul and Santa Catarina (SBCS, 2004). Therefore, 700 kg ha $^{-1}$ of 5-20-20 fertilizer was used at the time of sowing, and 300 kg ha $^{-1}$ of urea was used as the top dressing and was applied at the V6 vegetative stage.

Prior to the experiment, the area was cultivated with black oats; for coverage, before sowing, mowing was performed, and then the postemergent herbicide with the active ingredient *glyphosate was applied* at a dose of 3 L ha $^{-1}$. The herbicide atrazine was applied at a dose of 4 L ha $^{-1}$ after the first emergence flush. Pest and disease control was carried out with chemical treatment whenever the level of economic damage was reached; thus, three applications of Engeo Pleno insecticide, from the neonicotinoids and pyrethroids chemical groups, were carried out throughout the crop development cycle.

To understand the hydraulic properties of the soil, its retention curve was constructed according to the Richards chamber methodology described by Richards and Fireman (1943) and Embrapa (1997). Therefore, 15 undisturbed soil samples were collected in cylindrical rings of known volume at depths of 0–10 cm with the aid of a “Uhland ”-type auger. After collection, the samples were taken to the laboratory for determination. To construct the curve, the following stress points were adopted: 6, 10, 30, 100, 300 and 1,500 kPa, and the corresponding volumetric humidity was determined.

After the equilibrium humidity at all the applied stress points was determined, the water retention curve in the soil was constructed, and the humidity values were adjusted through the use of the mathematical model proposed by Van Genuchten (1980). be observed in Figure 1.

Figure 1. Soil water retention curve in the experimental area.



The humidity at field capacity was 30 kPa, and the humidity at the permanent wilting point was 1,500 kPa. Thus, values of 34% humidity for field capacity and 26% humidity for the permanent wilting point were verified.

The treatments proposed in this project were applied from sowing to harvesting the crop. For the control treatment (without irrigation), the availability of water was due to the natural occurrence of rain in the experimental area, which was monitored by an automatic meteorological station. The macrosystem Vantage Pro 2 model, which is equipped with a datalogger, is installed close to the area.

For the CC treatment, which maintained 100% field capacity, the soil moisture was determined with the aid of a TDR probe (time domain reflectometry) standard model 6005 L coupled to the MiniTrase moisture meter with *a datalogger*. For this purpose, a probe was installed in each plot of each treatment. After the soil moisture was read, the amount of water necessary to reestablish the field capacity humidity was determined, following the results provided by Equation 1, proposed by Bernardo (2005).

$$LL = \frac{(\theta_{CC} - \theta_f)}{10} \times z \quad (1)$$

where LL = liquid irrigation depth; Θ_{CC} = volumetric soil moisture at field capacity (%); Θ_f = volumetric soil moisture at the time of measurement (%); and z = effective depth of the root system, considered 0.6 m.

For the CRA treatment, the real soil water capacity was maintained according to the soil depletion factor for the crop established by Allen *et al.* (1998). After the soil moisture was determined via the TDR probe, the applied irrigation depth was determined via Equation 2, which was taken from Bernardo (2005).

$$LL = \frac{(\theta_{CC} - \theta_f)}{10} \times z \times f \quad (2)$$

where LL = liquid irrigation depth; Θ_{CC} = volumetric soil moisture at field capacity (%); Θ_f = volumetric soil moisture at the time of measurement (%); z = effective depth of the root system, considered 0.6 m; and f = crop water depletion factor for corn, 0.55.

In the blade treatment, the irrigation depths were determined via the “Lâmina” spreadsheet, a tool developed by the team for this project, following the recommendations established by Allen *et al.* (1998). This spreadsheet uses local data related to soil, irrigation systems, crops and climatic factors to determine the water balance in the soil in relation to the crop cultivated at that time, and a recommendation is subsequently made for an irrigation depth that meets the needs of the culture.

Daily data on global solar radiation (MJ m-² day-1), average air temperature (°C), average and minimum relative humidity (%), wind speed (m s- 1) and rainfall (mm day-1) in the “Lâmina” spreadsheet, with the values being those recorded by the meteorological station located close to the experimental area.

The “Lâmina” spreadsheet was also fed with latitude, longitude and altitude values of the experimental area and data related to soil characteristics (moisture at field capacity and humidity at the permanent wilting point) and culture conditions (species and stage of development). . The irrigation interval (watering shift) adopted was 2 (two) days.

In all the treatments, the total amount of water received by the crop during its development was determined, which made it possible to relate the amount of water applied with the yield components and crop productivity. Irrigation was carried out via sprinklers placed in the center of each plot, with the amount of water measured by digital flow meters.

To carry out the determinations, the borders that corresponded to 0.5 m on each side of the plot were ignored, thus leaving 4 m² of usable area to be harvested.

When the crop reached physiological maturity, 5 (five) plants, which were randomly selected from the plot, were cut close to the ground to determine the dry biomass of the aerial part. To do this, the ears were separated, and the plants were crushed to facilitate packaging. Then, the samples were placed in an oven with forced air circulation at a temperature of 60°C, where they remained until a constant weight was obtained. Biomass was determined by weighing on a semianalytical balance, thus considering the dry mass of the plants added to their cobs and grains. The grains from this evaluation were added to the grains harvested from the plot. The useful portion was harvested manually on April 27, 2017, and the ears were removed. All ears were subsequently dried in a forced-air circulation oven at a temperature of 60°C until humidity was reached, which allowed the manual threshing process to occur.

The yield components analyzed were the number of rows per ear, the number of grains per row and the number of grains per ear. These variables were analyzed from five randomly chosen ears in each plot. The mass of a thousand grains was determined according to the methodology proposed by Brazil (2009). Next, the grain moisture was determined and adjusted to 13%, which allowed the calculation of the grain productivity estimate in kg ha $^{-1}$, where the plant population was corrected to 80,000 plants ha $^{-1}$. Water use efficiency was calculated as the ratio of liters of water per kilogram of grain produced (L kg $^{-1}$).

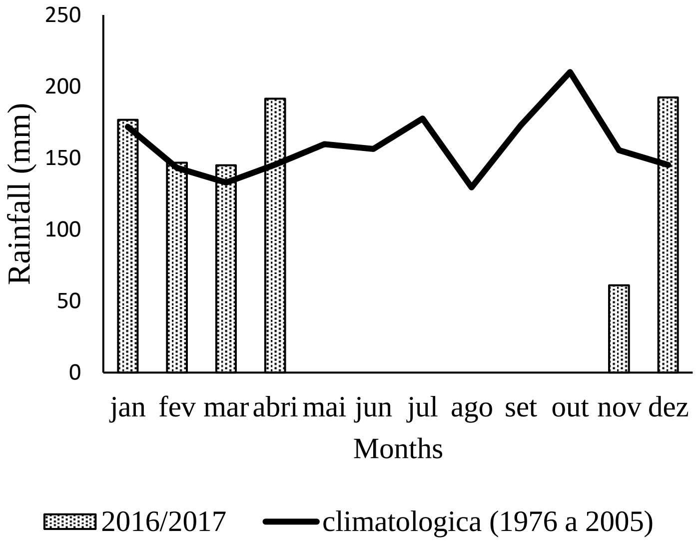
To carry out bromatological analyses of the grains, they were first crushed in a Wiley-type mill, and then the methodology suggested by Silva and Queiroz (2002) was applied to determine their dry matter, mineral matter, and protein gross contents.

The data were subjected to analysis of variance, and the means were compared via the Tukey test at 5% probability via the statistical program SPSS v.24.0.

5 RESULTS AND DISCUSSION

The 2016/17 corn harvest in most parts of Rio Grande do Sul was characterized by heavy, accumulated and well-distributed rain. In the Erechim region, rainfall was within or slightly above the climatological normal, as shown in Figure 2.

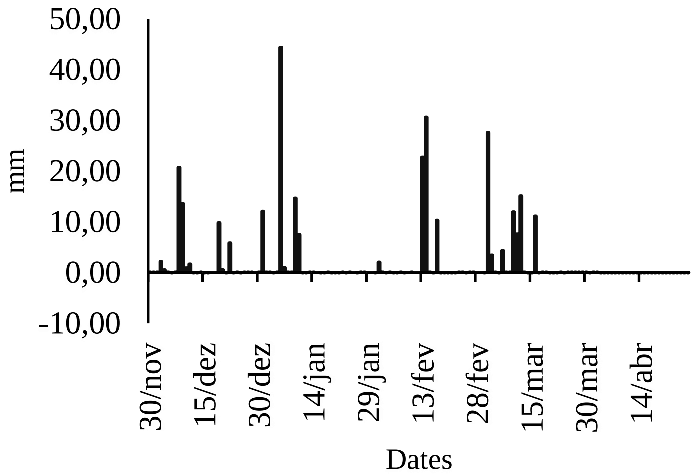
Figure 2. Normal rainfall and that recorded in the 2016/2017 harvest in Erechim/RS



From sowing to harvesting , approximately 721.8 mm of rain was recorded, with the climatological normal average being equivalent to 615.4 mm. According to Mello and Silva (2009), the water requirement for corn cultivation can vary from 400 to 800 mm; thus, it is possible to state that the rainfall accumulated throughout the crop cycle was able to satisfy its needs. water.

The crop developed from sowing to harvest with average rainfall; therefore, no water deficit was recorded, as shown in Figure 3.

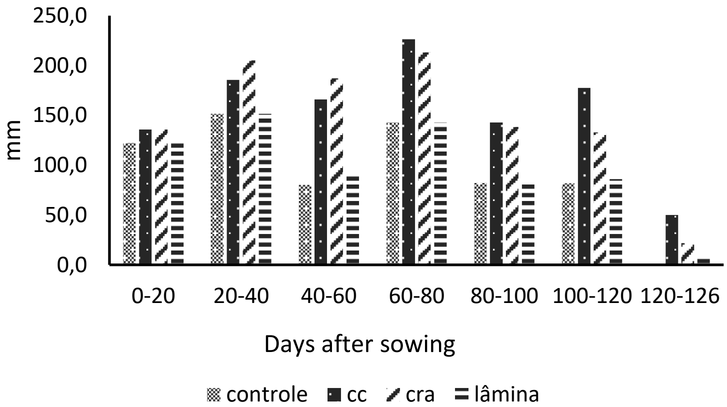
Figure 3. Daily water balance from November 29, 2016, to April 14, 2017



Owing to high rainfall, the end of 2016 and beginning of 2017 can be considered normal for the municipality of Erechim, RS. However, it is worth highlighting that the rains had a high volume and were well distributed, since, according to Ferreira (2014), every 10 years, 7 (seven) years present a water deficit in the South Region; even in regions with high rainfall, dry periods can occur due to the temporal variability in precipitation throughout the year.

In accordance with the methodology used, the timing and quantity of water to be applied in each treatment varied depending on the availability of water for the plants. Figure 4 shows the average values, referring to periods of 20 days from sowing until the plant reached physiological maturity, of the irrigation depth (rain + irrigation) for each treatment.

Figure 4. Average water depth (rain + irrigation) of each treatment over a period of 20 days throughout the corn crop cycle



Control= No irrigation; CC= Irrigation to maintain 100% of field capacity; CRA= Irrigation to maintain 55% of the soil's total water capacity; Blade= Irrigation adjusted according to the value provided by the “Lâmina” spreadsheet.

Figure 4 shows that the time when irrigation was most common was 40--60 days after sowing because the amount of precipitation was lower than that at other times in the crop cycle; however, as shown in Figure 3, there was no significant water deficit, consequently not causing damage to plants that did not receive irrigation.

Table 2 shows the total water depth (rain + irrigation) for each treatment and the results of the Tukey test at the 5% probability level.

Table 2. Total water depth (rain + irrigation) of each treatment and Tukey test results

Treatment	Water (mm)*
CC	1,083.69th
CRA	1,023.44th
Blade	744.95b
Control	721.80b
CV (%)	20.07

*Means followed by the same letter do not differ statistically from each other according to the Tukey test ($P \leq 0.05$).
Control= No irrigation; CC= Irrigation to maintain 100% of field capacity; CRA= Irrigation to maintain 55% of the soil's total water capacity; Blade= Irrigation adjusted according to the value provided by the “Lâmina” spreadsheet; CV= Coefficient of variation.

The CC and CRA treatments differed significantly from the blade and control treatments. This result may be due to the methodology used for the blade treatment, whose irrigation adjustment takes into account several factors, one of which is precipitation, since high precipitation occurred and was very well distributed throughout the cultivation period, and almost no irrigation was necessary in this treatment. The CC and CRA treatments only consider the instantaneous soil moisture; therefore, although the amount of rainfall was high and well distributed, there were situations in which the moisture content was lower than that indicated for both treatments; thus, irrigation was carried out. However, precipitation subsequently occurred, which explains the total depth in these treatments (Table 2). This fact also occurred in the work of Serpa *et al.* (2012), who, owing to the high rainfall that occurred during the experiment, found a quantity of water well above the average in the irrigated treatments.

In Table 3, the averages corresponding to the yield components of the corn crop are presented. There was no significant difference ($P \leq 0.05\%$) between the analyzed variables. However, it is important to highlight that the variables biomass, rows per ear, grains per row and number of grains per ear presented the highest averages in the CC treatment. The nonsignificant results can be explained by the nonoccurrence of significant water deficit throughout the crop cycle due to the high rainfall recorded and its favorable distribution from sowing to crop harvest.

Table 3. Results of the Tukey test for comparing means of the variables: biomass, rows per ear, grains per row, number of grains per ear and weight of one thousand grains.

Treatment	Biomass (kg ha $^{-1}$)	Rows per ear	Grains by rows	Grains per ear	Weight of a thousand grains (g)
Control	19,217.38 nos	15.75ns	27.85ns	438.75 nos	292.52ns
Blade	20,819.80	16.30	28.55	471.10	287.75
CRA	23,994.33	15.90	31.05	498.80	275.12
CC	24,974.55	16.40	31.35	515.20	277.27
CV (%)	17.42	4.27	10.67	12.52	4.47

ns: do not differ statistically from each other according to the Tukey test ($p \leq 0.05$).
Control= No irrigation; CC= Irrigation to maintain 100% of field capacity; CRA= Irrigation to maintain 55% of the soil's total water capacity; Blade= Irrigation adjusted according to the value provided by the "Lâmina" spreadsheet; CV= Coefficient of variation.

According to Magalhães and Durães (2006), the formation of leaves and ears per plant and the number of rows per ear occur in the vegetative period, more precisely, between the V3 and V8 stages, and during this period, both the lack and the excess humidity can cause damage to the crop. Considering that during the period mentioned, the crop did not suffer water deficit, there was no significant difference between the treatments in the analysis of the variables of biomass production and the number of rows per ear.

In most corn cultivars, the number of kernels per ear is defined at the V17 stage; however, at the R1 stage, the real number of eggs that will actually be fertilized is determined (RITCHIE; HANWAY; BENSON, 1993). The R1 stadium occurred between January 31st and February 5th. Therefore, when analyzing Figure 3, it is clear that the water balance in this period was close to the zero limit but never below, which explains the lack of statistically significant differences between treatments for this variable.

Bergamaschi *et al.* (2004), when different irrigation depths were tested for corn crops, which experienced a water deficit 60 days after planting, they reported satisfactory results for the variable number of grains per ear, with the best average observed for the treatment whose irrigation was carried out to maintain soil moisture at 100% of field capacity. This result is in line with those reported in the present study for the CC treatment (Table 3).

These findings agree with the results obtained in the present work (Table 3). Parizi (2007), when testing different irrigation depths for corn crops, also did not obtain significant results between treatments because of the occurrence of above-average rainfall, which was well distributed throughout the study.

Serpa *et al.* (2012) reported that excess irrigation can lead to losses of nitrogen in the soil, which may have contributed to the reduction in the weight of a thousand grains in irrigated treatments (Table 3), since nitrogen is the nutrient that most limits corn crop productivity. Notably, the CRA and CC treatments presented the lowest values for this variable, with those that received the highest levels (rain+irrigation) (Table 1).

In my opinion, this excerpt does not fit as an element for the results and discussion section and can only be used in the introduction (MATZENAUER *et al*., 1995).

When evaluating the effects of water deficit on corn crops, Serpa *et al*. (2012) reported different results between the agricultural years evaluated (2008/09 and 2009/10), observing that for the year 2009, in which below-average rainfall occurred, the use of irrigation positively influenced most of the components analyzed, verifying that there were statistically significant differences; however, in the following year, in which above-normal rainfall occurred, the use of irrigation throughout the crop cycle did not result in a significant difference, corroborating the results found in this work.

Table 4 presents the results for final productivity and water use efficiency. There was no statistically significant difference between treatments for these variables. This can be explained by the occurrence of rainfall, as rainfall occurs within the average range and is well distributed; therefore, there is no critical water deficit at any time during the cultivation cycle.

Table 4. Productivity (kg ha $^{-1}$) and water use efficiency (L kg $^{-1}$) of corn crops

Treatment	Productivity (kg ha $^{-1}$)	Water use efficiency (L kg $^{-1}$ g)
Control	9,231.81 ^{ns*}	796.13 ^{nos}
Blade	9,615.58	812.85
CRA	10,670.24	975.25
CC	10,700.26	1022.55
CV (%)	16.50	20.39

ns: do not differ statistically from each other according to the Tukey test (p≤0.05).
Control= No irrigation; CC= Irrigation to maintain 100% of field capacity; CRA= Irrigation to maintain 55% of the soil's total water capacity; Blade= Irrigation adjusted according to the value provided by the “Lâmina” spreadsheet; CV= Coefficient of variation.

According to Parizi (2007), irrigation management involves deciding how much water to apply and when to irrigate. If there is no relationship between these two variables, we will have inefficient use of water, either by applying it in excess or in quantities lower than the plant's water needs.

Table 5 presents the average values found in the bromatological analyses of the grains for the variables dry matter, mineral matter, crude protein and ether extract.

Table 5. Dry matter (DM), mineral matter (MM), crude protein (CP) and ether extract (EE) of corn grains

Treatments	MS (%)	MM (%)	PB* (%)	EE (%)
Control	84.31ns	1.55ns	10.04 to	5.80ns
Blade	84.53	1.43	10.35th	4.87
CRA	84.41	1.59	8.53b	5.12
CC	84.22	1.54	8.37b	5.32
CV%	0.84	9.59	4.82	14.63

*Means followed by the same letter do not differ statistically from each other according to the Tukey test ($p \leq 0.05$).
ns: do not differ statistically from each other according to the Tukey test ($p \leq 0.05$).
Control= No irrigation; CC= Irrigation to maintain 100% of field capacity; CRA= Irrigation to maintain 55% of the soil's total water capacity; Blade= Irrigation adjusted according to the value provided by the "Lâmina" spreadsheet; CV= Coefficient of variation.

Research related to the chemical composition of corn grains revealed that approximately 76.5% of the dry mass is composed of starch, 9.5% protein, 9% fibers, 4% lipids and only 1% mineral matter (PIOVESAN; OLIVEIRA; GEWEHR, 2011).

There was no statistically significant difference between the treatments in the analysis of dry matter, mineral matter or ether extracts of corn grains (Table 5). Therefore, in years with normal and well-distributed rainfall, irrigation has little influence on these variables.

The contents of the crude protein content in the grains from the CRA and CC treatments were similar to those from the control and blade treatments (Table 5). This behavior can be explained by the high amount of water applied in these treatments (Table 2), which was much greater than that in the control and slide treatments. The application of excess water may have caused the leaching of nutrients such as nitrogen, which, according to Kerbauy (2006), is part of the protein structure, thus influencing the attainment of the lowest crude protein values in the CRA and CC treatments, which were equal to 8.53 and 8.37%, respectively.

For annual plants, such as corn, to begin their reproductive cycle, there is a large remobilization of nutrients from the leaves to the fruits. In this case, older leaves and, in some species, stems and roots also become sources, providing sugars, amino acids and minerals for the biosynthesis of reserve compounds in seeds (Taiz; Zeiger, 2006).

According to Kerbauy (2006), in cereal crops, low concentrations of soil nitrogen are common after flowering (anthesis); thus, during the remobilization process, during the grain-filling period, nitrogen is gradually translocated from vegetative organs to grains. According to the same author, grains require a large amount of nitrogen to meet the demand for protein that occurs during their development.

Serpa *et al* . (2012) reported a possible loss of nitrogen due to excess water available throughout the crop cycle. In this work, as shown in Table 2, 1,083.69 and 1,023.44 mm of water made available in the CC and CRA treatments, respectively, were recorded, confirming that the amount of water received by the crop was well above the water requirements. usually recorded for a crop, which, according to Mello and Silva (2012), is in the range of 400--800 mm. Therefore, the results of the present study corroborate the findings of Kerbauy (2006) and Serpa *et al*. (2012).

Therefore, the lower values of crude protein in the grains observed in the treatments that had greater amounts of water applied (CRA and CC) may have been due to nitrogen leaching during the period in which the crop was in the vegetative stage. Therefore, there was possibly less absorption of this nutrient by the plants at the time of grain filling.

6 CONCLUSION

In years of heavy rainfall and well distributed throughout the day, the use of irrigation, regardless of the management method, did not significantly influence the productivity, water use efficiency or bromatological composition of corn grains (impacto Viptera 3 hybrid) grown in Erechim, Rio Grande do Sul.

Irrigation management using only instantaneous soil moisture as an indicator did not prove to be adequate, as the risk of applying a volume of water greater than that required by the crop increases. On the other hand, the use of the "Lâmina" spreadsheet, compared with other irrigated systems, allowed a better adjustment of the volume of water applied, allowing the use of water resources to be rationalized while maintaining good productivity and high protein content raw in the grain.

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