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IRRIGATION EFFICIENCY SIMULATION FOR COMMON BEAN DURING DRY SEASON, IN THE MUNICIPALITY OF GOIÂNIA, GOIÁS

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ABSTRACT: Goiás State is considered the major common beans producer in the autumn/winter season. In this season, the common beans production is fully irrigated by Center Pivot. However, due to the water scarcity water, the water dispute among human consumption, power generation, industries and agriculture is increasing. Then, it is important to optimize their consumption in the agriculture. Crop models are excellent tools for that and were used in this study to simulate the irrigation efficiency during the winter season for two cultivars, Pérola and BRS Radiante. Five planting dates from April to August and five irrigation amounts (10, 15, 20, 25 and 30 mm) applied when the soil water content reaches 50% of field capacity (CC) were considered. For cultivar Pérola, longer cycle, the best irrigation efficiency was obtained at the end of planting season, in the month of August, for the fixed irrigation amounts of 20 and 25 mm respectively. In the other hand, for the short cycle cultivar, BRS Radiante, the best irrigation efficiency was obtained only at the begin of planting date season, April.

KEYWORDS: *Phaseolus vulgaris*, cropgro, modeling.

SIMULAÇÃO DA EFICIÊNCIA DE IRRIGAÇÃO NO FEIJOEIRO COMUM DURANTE O PERÍODO DA SECA, NO MUNÍCIPIO DE GOIÂNIA, GOIÁS

RESUMO: O estado de Goiás é considerado o maior produtor de feijão na safra de outono/inverno. Nesta safra, a produção de feijão é em grande parte irrigada por Pivô

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Central. Entretanto, devido à escassez de água, a disputa deste recurso para o consumo humano, geração de energia, industrias e agricultura está aumentando. Sendo assim, é importante a otimização do consumo na agricultura. Modelos de crescimento de cultura são excelentes ferramentas para este uso, e foram utilizados neste estudo para simular a eficiência de irrigação durante a safra de inverno, para as cultivares Pérola e BRS Radiante. Foram considerados cinco datas de plantio, de abril a agosto, e cinco lâminas de irrigação (10, 15, 20, 25 e 30 mm) aplicadas quando a quantidade de agua no solo atinge 50% da capacidade de campo (CC). Para a cultivar Pérola, de ciclo mais longo, a melhor eficiência de irrigação foi obtida no final do ciclo, no mês de agosto, para os valores fixos de lâminas de 20 e 25 mm, respectivamente. Por outro lado, para a cultivar de ciclo mais curto, BRS Radiante, a melhor eficiência de irrigação foi obtida no início da safra, em abril.

PALAVRAS-CHAVE: *Phaseolus vulgaris*, cropgro, modelagem.

INTRODUCTION

The region of brazilian savanna is characterized by 2 common seasons, presenting a dry period between months of May to September and wet period in October to April (Klein, 2000). Goiás , one of the most important agricultural states of Brazil, is located in savanna's region, presenting in average 3 planting dates for common beans crops (Conab, 2015a).

The common bean is one the main products of consumption in human feed in Brazil (Embrapa, 2002), where Goiás is placed as one of the main producers in the country, being expected for 2015 to be the state with highest productivity (Conab, 2015b). The crop is cultivated during the entire year, even in dry season (autumn/winter), due the fast economic return and profitability under sprinkling irrigation (Azevedo, 2008), like Center Pivot.

Water is used for the production of innumerous products, in industry, agriculture and others. However is also a resource in low supply for the future, due the most varied uses of this precious resource in several activities. For these reasons, it is important to perform studies related to well manage the water usage and irrigation optimization.

Crop growing models are good options to study and get results, modifying some aspects of crop management, as irrigation, under short time period (Boote et al., 1996). The

Decision Support System for Agrotechnology Transfer (DSSAT) is a computational program created to generate information by mathematical modelsand help with decision making to agricultural management (Jones et al., 2003).In DSSAT interface there is 28 crops approached by different crop models systems (CSM), among them, the CROPGRO is used to study and simulate common bean crops, under many routines to execute and process information, like water availability response and planting dates (Boote et al., 1998).

Environmental aspects, which affects the crop development, as irrigation application or dry periods, can be easy manipulated by CSM and are useful for this kind of study (Egli & Bruening, 1992). Once these models are calibrated and verified for those conditions, the models can measure with precision the plant behavior due different effects (Dallacort et al.,2006).

The aim of this study was determine through crop simulations, which fixed irrigation amount presents the best efficiency regarding the production of common bean crops, at different sowing dates during the savanna's dry season, in Goiânia, central region of Goiás.

MATERIAL AND METHODS

The experiment was made using a CSM, CROPGRO, already calibrated and validated for two genotypes of common bean, used to describe the crop response in dry season conditions. The cultivar Pérola has a longer cycle (85 to 95 days) with potential production of 3903 kg ha^{-1} (Embrapa, 2015). As short cycle material, the cultivar BRS Radiante (less than 75 days) has a potential production of 2877 kg ha^{-1}, in the state of Goiás (Faria et al., 2002).

The weather data was obtained in the web site of Agrometeorological Monitoring System(Agritempo), which contains the historical climatic data for the municipality of Goiânia, used by the crop model to build the simulations. Was collected 30 years of data (1983 - 2013) related to minimum and maximum temperature (ºC), sun radiation (MJ m^{-2}) and rain precipitation (mm).

The irrigation amounts were considered as fixed depths of 10, 15, 20, 25 and 30 mm per irrigation applied when 50% of field capacity is reached.

Five planting dates distributed in savanna's dry season period were used to measure the results related to irrigation efficiency, as grain yield and amount irrigated. They are April 1st, May 1st, June 1st, July 1st and August 1st.

To execute the simulation, was necessary create a soil information file to be read by the crop model and applied in the calculations of simulated results. The soil represented was a Rhodic Ferralsol, in WRB classification, or Latossolo Vermelho Distrófico, in thebrazilian system of soil classification, SiBCS (Dalmolin et al., 2004).

Since that is an experiment conducted through simulations, the repetitions were treatments applied year by year, being a total of 30, running one simulation for each year of climatic data collected. The experiment also was built in a factorial scheme (2 genotypes x 5 fixed irrigation amounts x 5 planting dates) to well study the effects of irrigation efficiency to the crop in dry season period.

The planting distribution at the sowing was in rows of 0.45 m of spacing and population of 33 plants m^{-2} at seeding and emergence stage, being planted at depth of 0.05 m.

The CROPGRO model dispose of several routines to execute the calculations of water demand and reposition by irrigation, due the conditions in the plant metabolic activity. The description and execution of those calculation can be seen in Jones et al. (2010).

After the simulations, the outputs were organized to manage data in statistical programs. The values were separated in yield grain, irrigation amount and number of irrigations, for each treatment genotype: irrigation depth: planting date and by year, resulting in 1500 simulation runs.

Aiming to minimize the data set and make easier to manipulate all this numbers, was calculated the average value of all treatments by the years, resulting in 50 values per variable.

To determine the irrigation efficiency, was necessary make a division of average grain yield and amount irrigated per season, creating the new variable called irrigation efficiency.

RESULTS

The climatic effects may be noticed in data analysis, since the presence of rains in the plant emergence or maturity can severely affect the productivity at the end of cycle. Whereas the region of savannas has normally a scarcity of rains in the period of middle May to end of September, the grain yield and the amount of water applied by irrigation were direct effects of water availability to the plants in different stages, due the variation in the sowing dates.

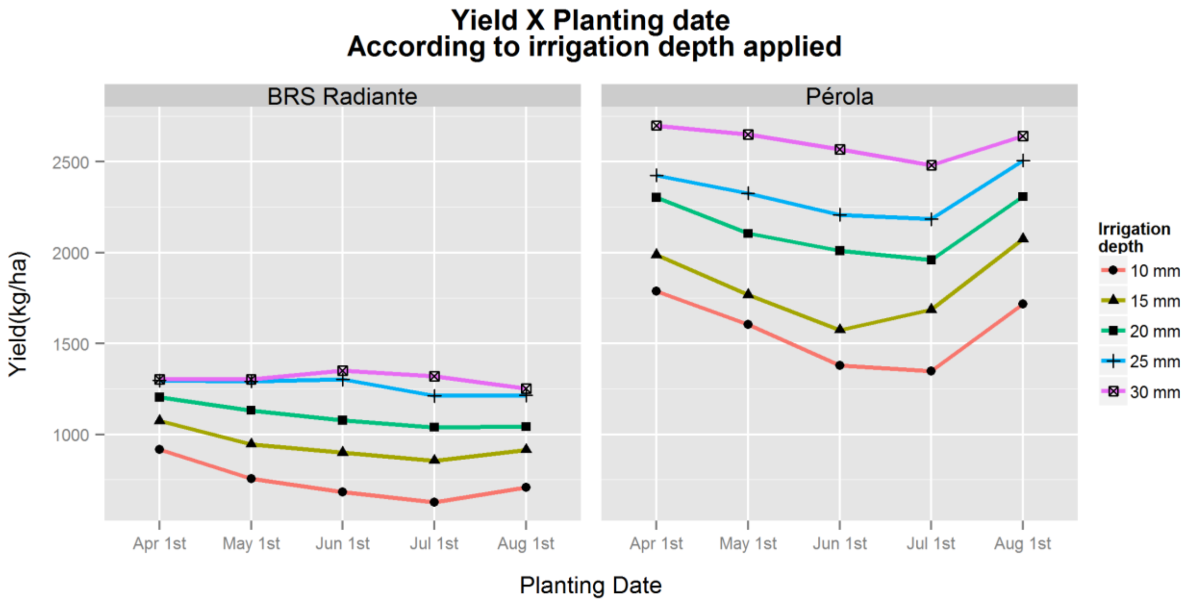

Figure 1. Differences in yield (productivity) related by irrigation depths in distinct planting dates.

The grain yield must be first analyzed by the perspective of cultivars, and then by the climatic point of view.

The cultivar Pérola has a longer period between planting and maturity, which means longer periods of water stress in dry season. April is the end of wet season, having some rains until middle of May, providing some water content for plantings started at this moments. The same happens for crops initiated in August, where the maturity phase and harvest will coincide at the beginning of rain periods, offering water to the plants well conclude their grain production, if during the entire cycle, plants were well supplied with irrigation.

At the same time, the cultivar BRS Radiante has showed a different development scale. Being a short period cultivar, the effect of water stress it is not so strong, once the crop stays less time in the field. In this case, due to April still have rains and after August it returns, the presence of irrigation in high amounts will decrease the total production, while plantations started at the middle of dry season, May to July, if well irrigated, will result in a better yield. The identical behavior of cultivar Pérola, may be seen in plants with fixed irrigation depth of 20 mm to below, with an average production of 1000.00 kg ha^{-1}.

For cultivar Pérola, the best yield results were at April, May and August, producing 2699.31, 2650.38, 2642.87 kg ha^{-1}, respectively, for fixed irrigation depth of 30 mm.

However, BRS Radiante showed the best results in June and July, 1351.90 and 1320.69 kg ha^{-1}, for the same irrigation.

Those results of yield may be better if the sowing was done in summer, at the wet season, where the luminosity and sun duration are higher, increasing the photosynthesis rate. The crops planted in dry season, normally has the lowest productivities compared to the other seasons, once the most of planting dates are close to the winter, when the sun duration is becoming shorter and luminosity comes down.

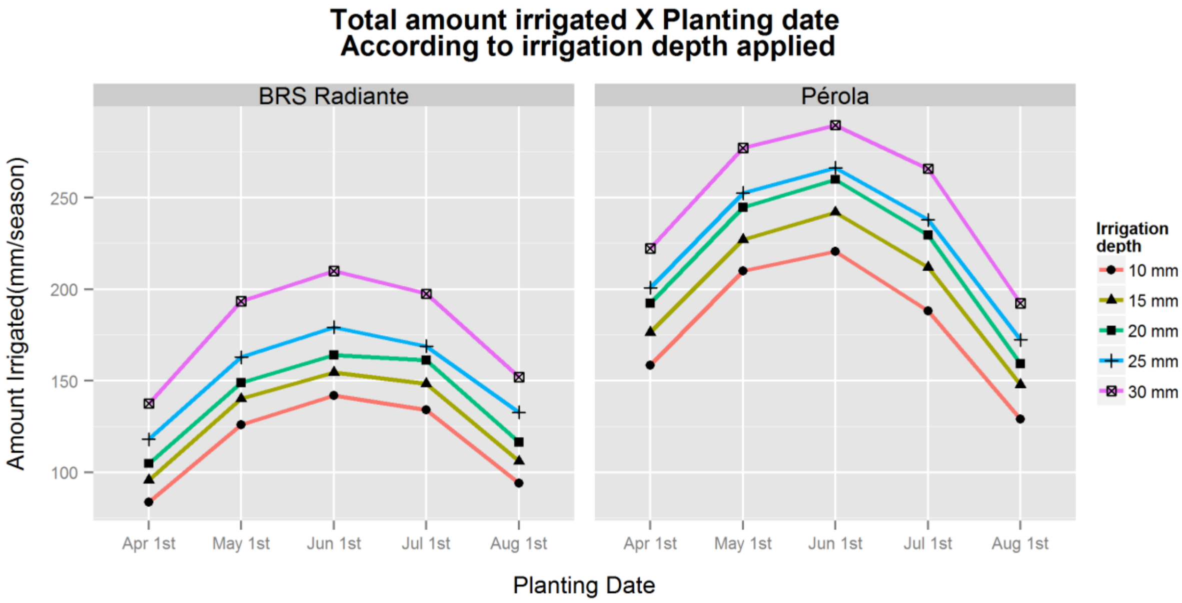

Figure 2. Amount of water irrigated during the cycle, considering the irrigation depths in different planting dates.

The cultivar cycle aspect in the field is also seen at the total amount of irrigation during the plant season. For both cultivars, the fixed amount of 30 mm was intensively applied, with irrigation peak at June, where there is the lowest levels of humidity in dry season. However, due the different field time and proper water needs inherent of both cultivars, the amount irrigated for Pérola, is higher than BRS Radiante, being 289.65 mm for the first, and 210 mm to the second one.

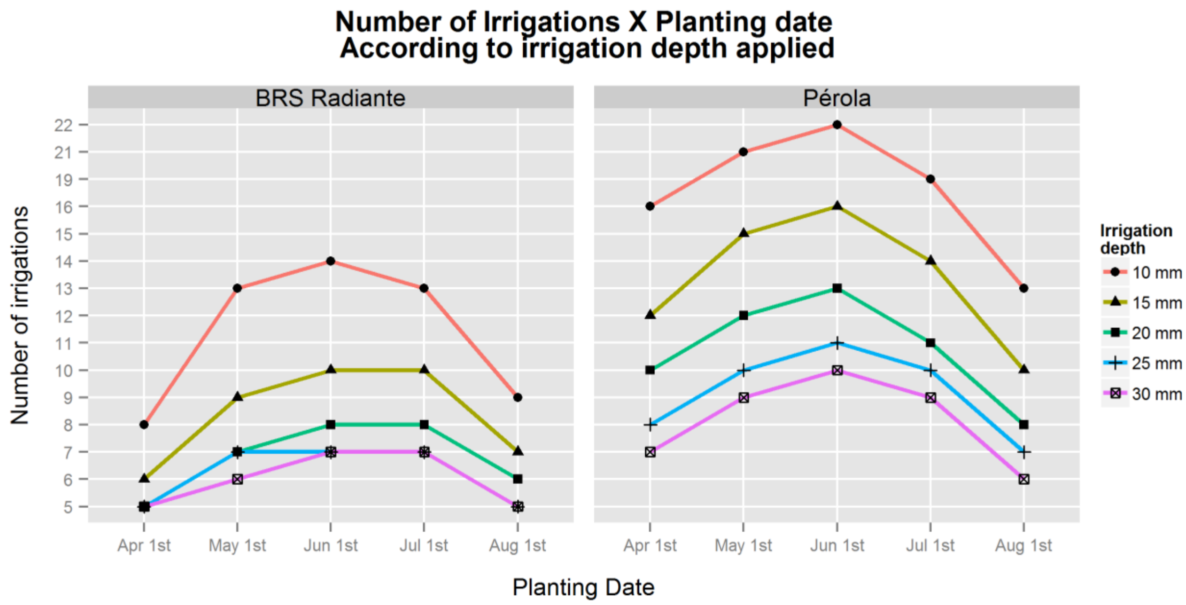

Figure 3. Operation number of irrigations during the plant cycle, in different irrigation depths and planting dates.

The total amount of water irrigated also reflects in the number of irrigations during the plant season. Lower quantities of irrigation depth applied results in a higher number of operations for irrigate the area, once greater the water demand, larger is the number of irrigations during the cycle.

Irrigation depths of 15 mm to below has shown some pronounced effects in the water stress, being required more irrigations during the cycle for this amount of water. For lower quantities of water applied by time, the humidity will concentrate at the first levels of soil reaching quickly the 50% of CC, in the period of high demand (May to July).

An elevated number of irrigations will results in more operations and waste of time for water supply to the crop. In a normal plantation, dozens of activities are done to maintain the stand of plants, and for all activities is required time. Some of crop treatments may not be made if the irrigation is activated, or has been held shortly before. Operationally thinking, it is more profitable maintain the irrigation depths of 25 mm or higher, that will minimize the number of irrigation and earn time to apply the different cultural practices in the area. Considering the graphs seen before, it also provide the better results in grain yield, for both cultivars.

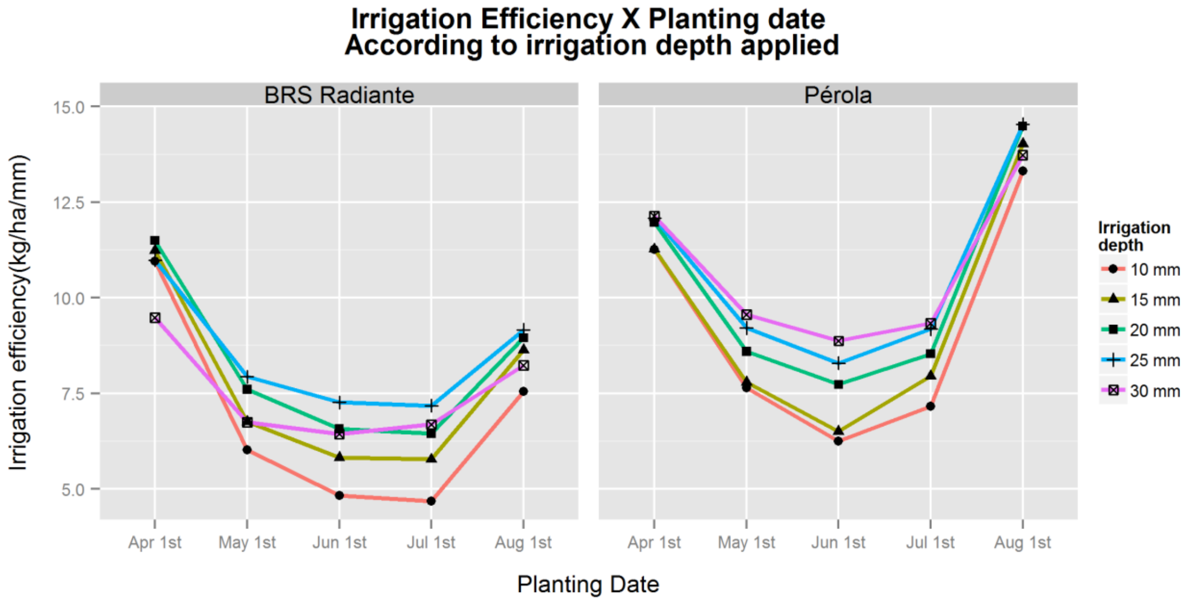

Figure 4. Irrigation efficiency for a long and short period cultivars, in different irrigation depths and planting dates.

According to Figure 4, the key points of irrigation efficiency is in the crops initiated at April and August, where the grain yield reaches higher values and lower irrigation amounts, both results are justified by the elevated incidence of rains and better conditions of luminosity, in some phases at the plant growth.

Irrigation depths of 20 and 25 mm presents the higher values of irrigation efficiency. By the point of view of water consumption, those values of irrigation depths represents the best choices in the water crop management, wherein at that amount, the grain yield are not the highest values but is bigger enough to consider the production by the quantity of water applied in the irrigation, what can be better seen for the cultivar BRS Radiante.

Regarding the cultivar Pérola, the top value of irrigation depth, 30 mm, reaches the best irrigation efficiency on planting dates at the middle of the dry season, May to July. However, as BRS Radiante, the irrigation depths of 20 and 25 mm shows higher or close irrigation efficiency values, related to 30 mm, for the months of April and August.

CONCLUSION

For dry season bean crops, sowing performed in April or August results in a better yields and irrigation efficiency.

The cultivar of longer period, Pérola, presented the highest values of irrigation efficiency at the end of planting season, August. However, BRS Radiante, considered as the short period cultivar, has presented the best results at the beginning of planting season, in April.

Irrigation depths ranging between 20 and 30 mm shows the best values of yield and irrigation efficiency, for both cultivars.

Sowing dates must be planned according to rainfall distributions, trying to minimize the amount of water applied in the season and aiming the highest productions, where the months of April and August could be viewed as the best choices, considering just the weather conditions to dry season plantations.

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