INFLUENCE OF HYDROGEL USE ON SOYBEAN CULTIVATION HYDRICAL STRESS

INFLUÊNCIA DO USO DO HIDROGEL NO CULTIVO DA SOJA SOB ESTRESSE HÍDRICO

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ABSTRACT: Among the agricultural production factors, the water deficit is one of the main reasons that limits soy production in Brazil. In order to mitigate losses due to water stress in the plants, hydrogels appear as soil water conditioners. They are polymers capable of absorbing large amounts of water and are being used as a viable alternative to improve the storage of water in areas of scarcity. Hydrogen concentrations between 14 and 18 kg ha^{-1} resulted in higher plant height, number of pods, one hundred grain mass and grain yield.

KEYWORDS: *Glycine max* (L.). Management. Soil conditioner. Dry. Cerrado. Short Drought.

INTRODUCTION

Water availability has been considered the climatic factor with the greatest effect on agricultural productivity, since crops under stress have a reduction in the germination and vigor of newly emerged seedlings (FERRARI et al., 2015). Thus, the search for new techniques or cropping practices that can minimize the effects of water stress on the plants is of fundamental importance, in order to reduce losses of the soybean crops and to adjust the scarcity of the water resources.

In that context, hydrogels appear as water conditioners in the soil, acting as a water reserve for the plant, and making it available at times of water stress, improving plant development and productivity (VENTUROLI; VENTUROLI, 2011). Those polymers have contributed to increase water retention capacity, improve soil properties and reduce nutrient lixiviation, allowing more effective use of soil and water resources, contributing to improved crop development and yield, reducing time of germination, decrease of plant mortality and better development of the root system (AZEVEDO et al., 2002).

In Brazil, some water-absorbing polymers have been used on the production of fruits, vegetables and seedlings of various species, such as the formation of lawns in gardens, soccer fields and golf courses. However, the use of these superabsorbent polymers in the cultivation of annual plants is still a little studied subject, being necessary to know and quantify the contribution of the application of those polymers in the water availability of those cultures. Therefore, the objective of this study was to evaluate the efficiency of hydrogel use in different concentrations on the retention and availability of water for the development and production of soybeans during its cultivation.

CONTENTS

The experiment was installed in the southern region of the State of Tocantins, at the Experimental Station of the Federal University of Tocantins, Campus of Gurupí, on December 18, 2015, 2015/2016 cropping years. The climatic data regarding the period of conduction of the experiments are shown on Figure 1.

For the study, soybean cultivar Mon Soy 8644 with different concentrations of hydrogel and sources of the commercial product (hydrogel - soil conditioner that retains water and nutrient for the plants) were used. The statistical design adopted was a randomized complete block design with four replicates, in a 5 x 2 factorial scheme, with five product concentrations (0, 5, 10, 15 and 20 kg ha^{-1}) and two sources of hydrogels (Hydroplan and POLIM -AGRI).

Then, the soil fertilization was carried out according to the soil analysis followed by incorporation of the fertilization. Subsequently, the hydrated hydrogel (each gram of product was diluted in 400 ml of water) was added in the concentrations of 1 g (5 kg ha^{-1}), 2g (10 kg ha^{-1}),

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3g (15 kg ha^{-1}) and 4g (20 kg ha^{-1}) per seeding line. Cultural treatments were made according to need and recommendation for the culture. The experimental data were submitted to analysis of variance and, when significant by the F test, the regression test was applied using the statistical program SISVAR.

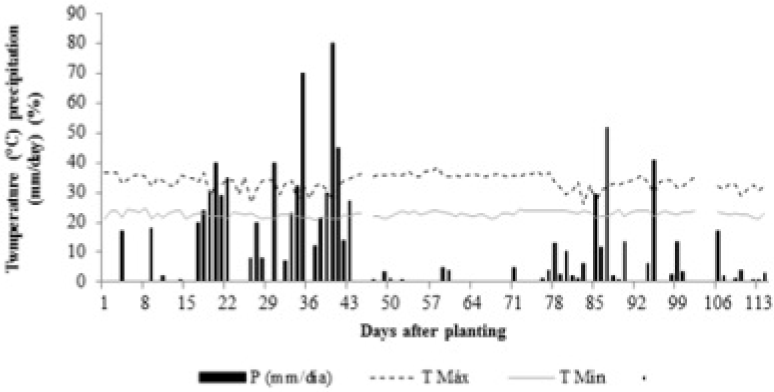

Figure 1. Pluvial precipitation (mm) and maximum and minimum temperatures (° C) occurred during the soybean cultivation under the hydrogel influence, in the cropping season of 2015/2016 (IMET, 2016).

On the summary of the variance analysis (Table 1), can be verified that there was a significant effect on the interaction between concentrations and sources for the characteristics plant height and grain yield, showing that the factors were dependent. For the characteristics of pods per plant and mass of 100 grains, there was no effect of the interaction, showing that there is no dependence between the evaluated factors. No significant effect was verified for hydrogel sources in any of the characteristics evaluated, probably due to the similarity of the polymers, as regards to their granulometry, polymer chain structure, crosslinking density, acrylamide quantity, among others: can be verified that there was a significant effect on the interaction between concentrations and sources for the characteristics plant height and grain yield, showing that the factors were dependent). Brito et al. (2013) explain that the swelling process of a hydrogel is governed by physical factors intrinsic to the 3D network and external factors. Some physical factors, such as the presence of hydrophilic groups in the polymer chain structure, lower crosslinking density and high flexibility of the polymer network, contribute to a greater swelling of the material. However, analyzing the source of variation, concentrations, can be observed a significant effect for the characteristics of 100-grain mass, number of pods per plant and grain yield.

Table 1. Summary of variance analysis for plant height (PHT) Mass of one hundred grains (M100), number of pods per plant (Pp) and yield (Yd) in a soybean cultivar with five concentrations and two sources of hydrogels. Gurupi, TO. 2015/2016

V.S	D.F	PHT	M100	Pp	Yd
Repetition	3	15.83	2.01	73.59	87448.2
Sources	1	0.75^{ns}	0.11^{ns}	9.22^{ns}	38545.47^{ns}
Concentrations	4	311.987^{ns}	18.3**	907.4**	3179127.2**
C x F	4	63.48*	0.89^{ns}	3.4^{ns}	98017.78**
Residue	27	22.35	0.75	38.22	20047.56
C. V. (%)		6.79	4.88	12.42	7.28
General Mean		69.66	17.76	49.77	1943.95

^{ns} not significant; ** significant for $P \leq 0.01$; * significant for $P \leq 0.05$ by the F test.

As for plant height, quadratic behavior was observed for both products analyzed (Figure 2). The soybean plants obtained a higher average plant height (76.2 and 79.6 cm) at the concentration of 15 kg ha^{-1}, obtaining an increase of 38.8 and 45% in relation to the control (concentration 0) for hydrogel 1 and hydrogel 2, respectively. Thus, the increase in plant height can be associated with the retention action and availability of water that the hydrogels provide to the plants in moments of water stress. Although the pluviometric regime has averaged 915 mm during the crop cycle, it can be observed in Figure 1 that there was irregularity in the rainfall distribution on areas classified as medium to high climatic risk. According to Azevedo et al. (2002), the water-retentive polymers function as an alternative for situations where there is no water availability in the soil, water stress conditions or long periods of drought, when low soil moisture adversely affects growth and the development of plants.

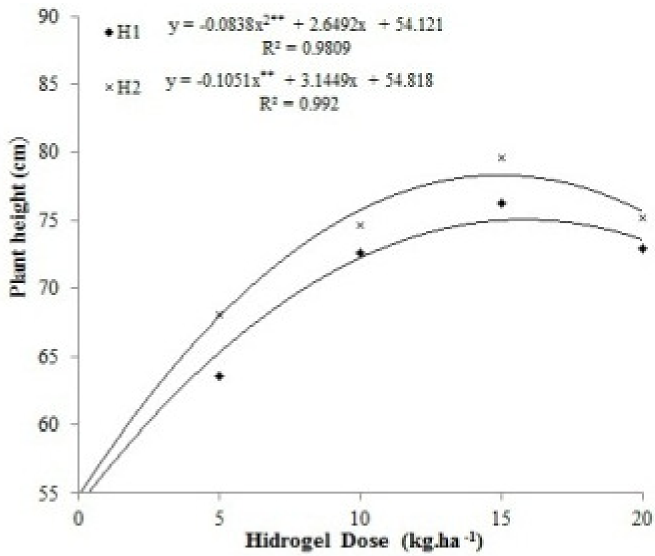

Figure 2. Plant height of the soybean cultivar MSOY 8644 submitted to different concentrations (0; 5; 10; 15; 20 kg ha^{-1}) and commercial products (H1: Hydroplan; H2: Polim-agri). ^{Ns} not significant; ** significant for $P \leq 0.01$; * Significant for $P \leq 0.05$ for the F test.

Because of the water deficit, several physiological events are triggered in the plant, such as reduction of leaf water potential, stomata closure that decreases stomata conductance, causing a reduction of the internal CO2 concentration, and consequently decreasing the photosynthetic rate (HONG -BO et al., 2008). According to Carneiro et al. (2011), water besides being necessary for the growth of cells, is an essential element for the maintenance of turgescence. Under water deficiency, the first change that occurs in plants is the reduction of turgescence, leading immediately to the decrease of growth. Thus, the reduction in its aerial part can be considered as the first reaction of the plants submitted to lack of water (FERRARI et al., 2015).

As for the mass of one hundred grains (Figure 3), there is an increase in the averages independently of the hydrogel source up until the concentrations of 15 and 18 kg ha^{-1} for hydrogels 1 and 2, respectively, adjusting the quadratic response for the evaluated polymers.

There was an average increment of 28 and 23.4% in relation to the control. An increase that may be associated with the availability of water supplied by the polymers to the plants during the period of water stress. Borrmann (2009), in studies on the physiological responses of the soybean crop under water deficit, states that in the soybean grain filling phase the water stress can cause a reduction in the size and mass of the grains, besides that, can affect the retention of the green color of those because lack of water impairs the activity of the enzymes responsible for the degradation of chlorophyll, which results in high content of green grains.

For the characteristic number of pods per plant a quadratic behavior was observed for both hydrogels as the polymer concentrations increased (Figure 4). The 15 kg ha^{-1} dosage resulted in higher averages, with 67.15 e 65 pods per plant, producing about 110 and 105.6% more than the 0 concentration, for hydrogel 1 and hydrogel 2, respectively, when subjected to severe stress of approximately 33 days without water with maximum temperatures ranging from 35 to 38 °C at the beginning of flowering. Fioreze et al. (2011) studied the same characteristic in three soybean cultivars submitted to intense water stress, but of short duration in the flowering phase in a greenhouse in the state of Paraná, and observed average values between 59 and 52. Therefore, analyzing the severity of the water stress to which the plants were submitted in the present study, the hydrogels proved to be efficient in providing water to the plants and to minimize losses of production in the soybean crop. Even with the use of the lowest concentration of the hydrogels tested (5 g kg ha^{-1}); there was an increase of 53 and 50%, respectively (H_1 and H_2), in relation to the control.

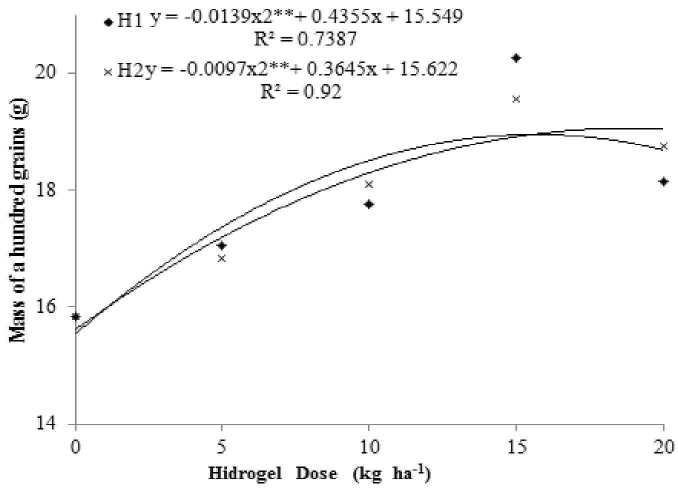

Figure 3. Mass of 100 grains of soybean MSOY 8644 submitted to different concentrations (0; 5; 10; 15; 20 kg ha^{-1}) and commercial products (H1: Hydroplan; H2: Polim-agri). ^{Ns} not significant; ** significant for $P \leq 0.01$; * Significant for $P \leq 0.05$ for the F test.

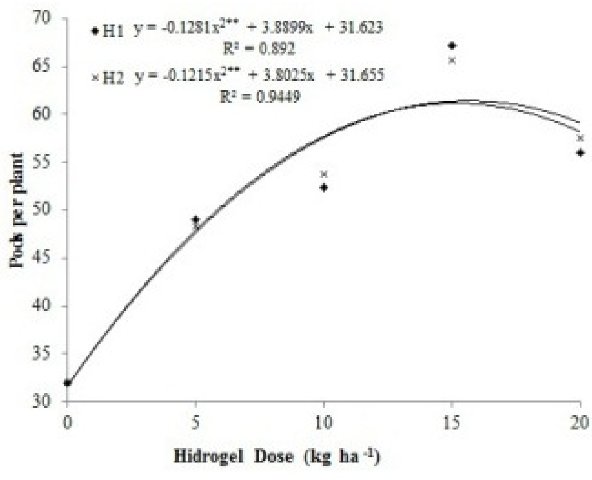

Figure 4. Pods per plant of MSOY 8644 soybean cultivar submitted to different concentrations (0; 5; 10; 15; 20 kg ha^{-1}) and commercial products (H1: Hydroplan; H2: Polim Agri). ^{Ns} not significant; ** significant for $P \leq 0.01$; * Significant for $P \leq 0.05$ for the F test.

The need for water increases during the development of the crop, reaching the maximum in the period of flowering / filling of grains. Analyzing Figure 1, there is an intense water deficit in the reproductive phase of the crop 44 (DAE), totaling a mean of 33 days without significant rainfall (above 5 mm), thus evidencing the potential of the water-retention polymers, as they favored the absorption of water by the plant resulting in higher pod production in its critical period. The occurrence of abortion of large quantities of flowers and pods is commonly intensified in soybean cultivation when subjected to severe water stress in the reproductive phase (FIOREZE et al., 2013).

As for grain yield, as well as other evaluated characteristics, quadratic behavior was also observed (Figure 5), and soybean plants had higher grain yield averages at concentrations of 15 and 14 kg ha-1, about Of 2935.4 and 2866.6 kg ha-1 for hydrogel 1 and hydrogel 2, respectively, equivalent to 110 and 105.6% more than the control.

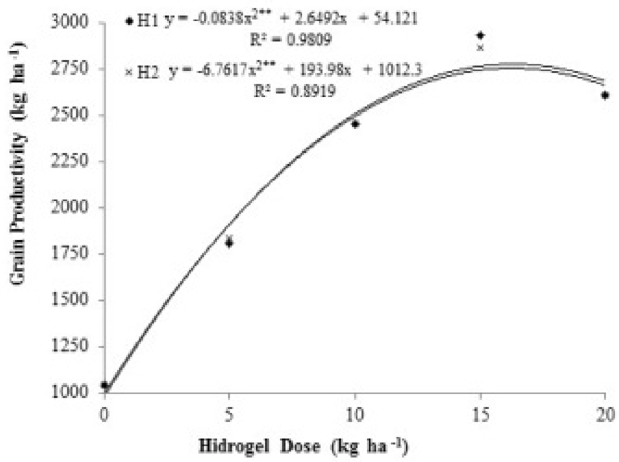

Figure 5. Productivity in kg ha-1 of soybean cultivar MSOY 8644 submitted to different concentrations (0; 5; 10; 15 kg ha-1) and commercial products (H1: Hydrogel; H2: Hydroplan;). Ns not significant; ** significant for $P \leq 0.01$; * Significant for $P \leq 0.05$ for the F test.

The 2015/2016 harvest season in the State of Tocantins, as well as in many other regions of the country, was characterized by extremely adverse climatic conditions, being considered the most severe of the last years, characterized by irregularities and scarcity of rainfall, with three periods Short Droughts and above-average temperatures for the period. Those productions are considered satisfactory and demonstrate the potential of the polymers to be used as soil conditioners, since they provided water to the plants, favoring the increase in productivity in about 52 and 48% for hydrogels 1 and 2, respectively, more than in the average of State that was 1937 kg ha^{-1} in the 2015/2016 harvest. It is worth mentioning that the experiment was conducted in the southern region of the state of Tocantins, where historically there have been lower precipitations.

RESUMO: Dentre os fatores de produção agrícola, o déficit hídrico é um dos principais motivos que mais limita a produção de soja no Brasil. A fim de amenizar os prejuízos por estresse hídrico nas plantas, os hidrogéis surgem como condicionadores de água no solo, já são polímeros capazes de absorver grande quantidade de água e estão sendo utilizados como alternativa viável para melhorar o armazenamento de água em áreas de escassez. Objetivou-se com este trabalho avaliar a eficiência da utilização do hidrogel na retenção e disponibilização de água para o desenvolvimento e produção da cultura da soja quando submetido a estresse hídrico. As concentrações de hidrogéis entre 14 e 18 kg ha^{-1} resultaram em maior altura de plantas, número de vagens, massa de cem grãos e produtividades de grãos.

PALAVRAS-CHAVE: *Glycine max* (L.). Manejo. Condicionador de Solo. Seca. Cerrado. Veranico.

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