WATER ABSORBENT POLYMER IN SUGARCANE CROP

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ABSTRACT: The water absorbent polymer effect on vegetative growth and production of Theoretical Recovery Sugar (TRS) of sugarcane cv. RB 86 7515 was evaluated on two field tests installed in randomized blocks, with four treatments and five repetitions. The polymer doses were 0; 4; 8 and 12 g m^{-1} of furrow (test 1) and 0; 1.4; 2.8 and 4.2 g m^{-1} of furrow (test 2). Test 1 (dec/2007 to may/2009) was implanted in a Distroferric Red Argisol soil in Presidente Prudente - State of São Paulo (SP), Brazil; and the test 2 (Aug/2008 to Aug/2009) was implanted in a Red Yellow Argisol soil in Lucélia - State of São Paulo (SP), Brazil. In test 2, there were no significant differences for any evaluated parameters. In both tests the polymer doses equal to or less than 4 g m^{-1} of furrow showed no significant effect on the evaluated parameters. In test 1, the polymer doses of 8 and 12 g m^{-1} of the conditioning polymer increased the number of tillers in stage II of development and led to the largest amount of straw. The gross income per hectare has positive relation with the polymer doses. The polymer had no significant effect on the sugarcane stems productivity and technological parameters.

KEYWORDS: *Saccharum spp.*, polymer, water retention, polyacrylamide.

POLÍMEROS HIDROABSORVENTES EM CULTURA CANAVIEIRA

RESUMO: Avaliou-se o efeito de um polímero hidroabsorvente no crescimento vegetativo e na produção de açúcares teoricamente recuperáveis (ATR) de cana-de-açúcar cv. RB 86 7515, em dois ensaios de campo instalados em blocos inteiramente casualizados, com quatro tratamentos e cinco repetições. As doses do polímero foram 0; 4; 8 e 12 g m^{-1} sulco (ensaio 1) e 0; 1,4; 2,8 e 4,2 g m^{-1} sulco (ensaio 2). O ensaio 1 (dez/2007 a maio/2009) foi implantado em Argissolo Vermelho Distroférrico, em Presidente Prudente - SP, e o ensaio 2 (ago./2008 a ago./2009) em Argissolo Vermelho-Amarelo, em Lucélia - SP. No ensaio 2, não houve diferenças significativas para nenhum dos parâmetros avaliados. Em ambos os ensaios, doses do polímero iguais ou inferiores a 4 g m^{-1} de sulco não apresentaram efeito significativo sobre os parâmetros avaliados. No ensaio 1, as doses 8 e 12 g m^{-1} do polímero condicionador aumentaram o número de perfilhos no estádio II de desenvolvimento e levaram à maior quantidade de palhiço. A renda bruta por hectare apresentou relação positiva com as doses do polímero. O polímero não teve efeito significativo na produtividade de colmos da cana-de-açúcar nem nos parâmetros tecnológicos.

PALAVRAS-CHAVE: *Saccharum spp.*, polímero, retenção de água, poliacrilamida.

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INTRODUCTION

The sugarcane is one of the most economically important crops in Brazil, presenting prospect for the coming years to expand its cultivated area. Because of the future rising demand for alcohol and sugar, it is necessary to increase agricultural productivity and longevity of sugarcane, increasing the efficiency of use of resources already available in the sugarcane installation and its cultivation (CAMPOS et al., 2008).

The demand for reducing the emission of greenhouse gases (GHG) has found alternative sources in renewable energy, including biofuels. BAKER & ZAHNISER (2006) showed that the conversion rate of corn to ethanol is $3m^3$ h^{-1} and consume $140m^3$ of water for producing 1 GJ of energy. In the United States, the world's largest producer of ethanol, the biofuel comes from corn, which is produced mainly under irrigation, which can create conflicts over the use of sources of surface water and groundwater. The sugarcane in Brazil is more efficient than corn in water use with a consumption of 99 m^3 GJ^{-1} of energy produced, especially in non-irrigated areas. Brazil is an example of production and use of renewable fuels (45.4% of its energy matrix, with 31.5% coming from biomass). Brazil is a world leader in the manufacture of ethanol from sugarcane, which accounts for 16.6% of its energy matrix (MICHELAZZO & BRAUNBECK, 2008). The expansion of sugarcane plantations in the State of São Paulo has occurred primarily in the West of the State, where there is a need for technologies to obtain good biomass production and increase its photosynthetic efficiency (OLIVEIRA et al., 2007).

The water occupies a prominent position in crop production; the low water availability reduces productivity, even in the more fertile soils. In every culture, water is a limiting factor when seeking the maximum expression of productive potential because it affects plant growth, reduces agricultural productivity and results in low efficiency of water use by crops and fertilizers. In sugarcane, water accounts for approximately 71% of its fresh weight (DALRI & CROSS, 2008; GONÇALVES et al., 2010).

Hydric deficit limits the production of sugarcane, especially in areas where there is a prolonged period of drought, as in the Midwest Region of Brazil (SILVA et al., 2008a; SILVA et al., 2008b). The supply of water soon after planting the sugarcane is essential to good bud sprouting and the development of an ideal stand, as well as to the growth of the ratoons after cutting. The availability of water in the soil depends on various factors such as soil type, plant characteristics and atmosphere evaporative power, and PRADO (2005) considered the water retention capacity, which is inherent to the type of soil, as the main factor.

Some types of polymers absorb a mass of water of hundred times their own mass (SANTANA et al., 2007), and PREVEDELLO & LOYOLLA (2007) commented that this increase is up to 100 times their own mass. As the polymer retains water in its molecules, the available water may increase if added to the soil. GERVASIO & FRIZZONE (2004) found that the gain in water retention in the soil, with the addition of the polymer occurred until the matrix potential of -10 kPa and from this point the values have not changed. The authors consider this fact as an indication that the polymer increases water retention in low tensions and releases easily, thereby increasing its availability for plants. The most commonly used polymers are derived from petroleum and called polyacrylamide (PAM) being used in agriculture under different trademarks (GASCUE et al., 2006; SIVAPALAN, 2006; SANTANA et al., 2007).

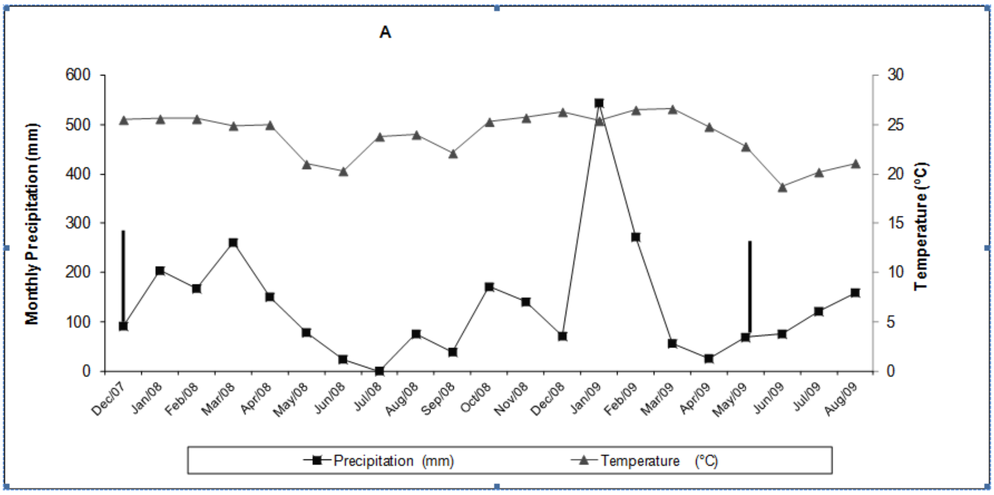
SAAD et al. (2009) reported that the polymers are recommended for use in agriculture as soil conditioners to improve the physicochemical properties of the soils, reducing the number of irrigation, nutrient losses and costs of crop production. Studies with polymers in agriculture (PREVEDELLO & LOYOLA, 2007; SILVA et al., 2008 b) have shown increased water retention in the soil and their availability to plants, reducing irrigation frequency, optimization of growth and increased productivity plants. PREVEDELLO & LOYOLLA (2007) observed that in clay soils polymers promoted a reduction in the rate of water infiltration into the soil. In sandy soil tested, the polymer did not promote the effect. OLIVEIRA et al. (2004a) conducted research with a water absorbent polymer in sugarcane and reported greater water retention, better sprouting and tiller number in the initial phase of field culture.

CENTURION et al. (2007) reported that changes in the structure of the soil are generally verified by changes in the values of soil density, penetration mechanic resistance, aeration porosity, total porosity, storage and availability of water to plants, water dynamic on surface and soil profile, these changes will interfere significantly and directly in the proliferation and penetration of roots and providing higher productivities in agriculture crops. OLIVEIRA et al. (2004b) evaluated the influence of the concentration of a water absorbent polymer in water retention characteristics of two different soil types and found that in matrix potentials exceeding -1000 kPa, the water retention was higher as it increased the concentration of polymer mixture, for both soils. However, for lower matrix potentials, the water retention was not influenced by the concentration of the product. They also observed that improved soil water conditions induced increases in industrial productivity and quality.

This research aim to study the effects of using water absorbent polymer in two Argisols of the West of São Paulo State region on biometric characteristics (height and diameter of the stems, number of tillers per meter and the production of straw) and technology (TRS - Theoretical Recovery Sugar) of the sugarcane culture. The hypothesis is that the use of polymer provides greater vegetative growth, increased production of TRS and gross income by area.

MATERIAL AND METHODS

The experiment was conducted in two areas of cultivation with cultivar 86 RB 7515 and four doses of water absorbent polymer. In both places, the climate is classified by Köeppen as Aw of dry winter and hot summer. The first test was performed from December, 2007 to May, 2009 in the experimental field of the Universidade do Oeste Paulista - UNOESTE (University of the Western São Paulo in Presidente Prudente - State of São Paulo (SP), Brazil), in geographic coordinates 22^{o}07’04”S, 51^{o}22’04”W and altitude of 430 m. The air temperature and precipitation data used in the assay were collected at the weather station located at 30 m from the experimental area (Figure 1A). The second test was performed from August, 2008 to August, 2009, in Ibiúna Farm (Lucélia - State of São Paulo (SP), in Brazil), in geographic coordinates 21^{o}78’63”S, 51^{o}03’31”W and altitude of 416 m. The air temperature and precipitation data used in the assay were collected at the weather station of Faculdades Adamantinenses Integradas - FAI (Integrated Schools of Adamantina, in Adamantina - São Paulo (SP), Brazil), 13.9 km from the test site, in the positions of 21^{o} 66’75”S, 51^{o}07’ 73”W and altitude of 449 m (Fig. 1B).



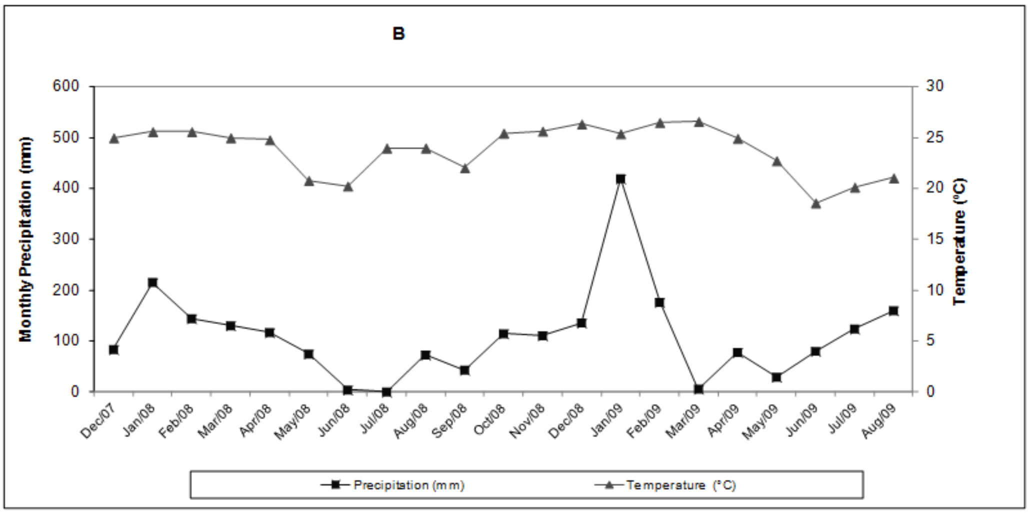


FIGURE 1. Weather histogram for (A) test 1 and (B) test 2. (UNOESTE and FAI).

The soil from test 1 is a Distroferric Red Argisol and from test 2 the soil is a Red Yellow Argisol (EMBRAPA, 1999). These soil samples were taken 60 days before planting (test 1) and 90 days before planting (test 2). The physical-chemical analysis of these soils is given in Table 1. For Test 1 the mineral fertilization was performed according to chemical analysis using 31.5 kg N ha^{-1}, 135 kg P_2O_5 ha^{-1} and 135 kg K_2O ha^{-1}, with 675 kg ha^{-1} of the formulated 00-20-20, and additional application of 70 kg urea ha^{-1} without the need of liming. For Test 2 liming was done with 4.5 t ha^{-1} 60 days before planting and mineral fertilization with 30 kg N ha^{-1}, 180 kg P_2O_5 ha^{-1} and 80 kg K_2O ha^{-1}, with 1,000 kg of the formulated 03-18-08.

TABLE 1. Physical-chemical analysis of the soil of tests 1 and 2.

			Test 1			
pH in CaCl	pH in SMP	Potential Acidity (H+AL)	Al^{+3}	Mg^{+2}	Ca^{+2}	K+
			(mmolc dm^{-3})			
5.5	7.3	11	0	6	11	1.4
SO_4^{-2} (mg dm^{-3})	Phosphorus (mg dm^{-3})	Organic Matter (g dm^{-3})	S.B (mmolc dm^{-3})	(M%)	CTC (mmolc dm^{-3})	V(%)
1.3	21	5	18	0	29	63
Sand		Silt g kg^{-1}	Argil		Textural Class	
795.7		64.3	140.0		Sandy	
			Test 2			
pH in CaCl	pH in SMP	Potential Acidity (H+AL)	Al^{+3}	Mg^{+2}	Ca^{+2}	K+
			(mmolc dm^{-3})			
4.65	ND	18	ND	5	9	1.8
SO_4^{-2} (mg dm^{-3})	Phosphorus (mg dm^{-3})	Organic Matter (g dm^{-3})	S.B (mmolc dm^{-3})	(M%)	CTC (mmolc dm^{-3})	V(%)
ND	5	9	15,8	ND	33.8	47
Sand		Silt g kg^{-1}	Argil		Textural Class	
917.5		49.0	33.5		Sandy	

The tests were conducted in the statistical delineation of complete randomized block with four treatments and five replications. Test 1 was conducted with higher doses than in test 2 to explore the interaction between polymer, soil and plant in order to find the amount of polymer that maximizes the culture results. The polymer used in the tests is a mixture of two products, Hydroplan-EB/HyB-M and Hydroplan-EB/HyC. According to the manufacturer, the components are a mixture of Acrylamide Copolymer and Acrylate Potassium and are used to absorb and retain large quantities of water and nutrients. The particle size ranges from 0.3 to 1 mm and the water absorption into the soil (measured under a pressure of 305.7 kPa) ranges from 100 to 250 grams of water per gram of product, with a pH usable from product to the ground, between 5.0 and 9.0.

The polymer dosages used in Test 1 were as follows: 0; 4; 8 and 12 g m^{-1} of furrow. The test was conducted with two lower doses specified by the manufacturer: 0; 1.4; 2.8 and 4.2 g m^{-1} of furrow. In both tests, the polymer doses were applied according to the treatments, at predetermined precision balance technique and placed in plastic envelopes. Subsequently they were transported to the field and applied as granular powder (original), evenly on the bottom of the furrows and without irrigation. Then the planting and fertilization recommended were performed. The experimental portions consisted of five rows of sugarcane spaced 1.5 m to 10 m of length, with a total area of 75 m^2 and 36 m^2 of useful area (4.5 m x 8 m).

The variables evaluated in this tests and used as parameters were: number of tillers per meter (NTM measured in vegetative growth - stage II); average height and diameter of the stems at the end of the cycle (AHS and ADS, measured at stage IV), in meter and centimeter respectively; biomass at the end of the cycle (BIOMASS = stem + straw, stage IV) in tons; mass of straw at the end of the cycle (STRAW, stage IV) in tons; stem weight at the end of the cycle (STEM, stage IV) in tons; apparent sucrose (POL) in %; fiber (FIBER) in %; reducing sugars (RS) in % and total recovery sugars (TRS) in kg t^{-1}, which were calculated at the final stage (stage IV) using methods described in FERNANDES (2003). The experimental data were statistically processed by the SISVAR software, using the F test for analysis of variance ($p<0.05$) and the Scott-Knott test for comparison of averages ($p<0.05$). The parameters that showed significant statistical differences were analyzed with the program Microcal Origin 6.0® (Microcal Origin Software Inc., Northampton, USA).

The value of TRS_ha was calculated by multiplying the TRS (kg t^{-1} sugarcane) for the production of stems (t ha^{-1}). The gross income per hectare (R$ ha^{-1}) was determined by multiplying the TRS_ha (kg ha^{-1}) by the value of the TRS (R$ kg^{-1}). The value of the TRS used was of R$ kg^{-1} TRS 0,3102, referring to the 2009/2010 harvest (CONSECANA, 2009). These parameters were evaluated by means of polynomial regression, with the aid of the Microcal Origin 6.0® software.

RESULTS AND DISCUSSION

The results of the analysis of variance of tests 1 and 2 are shown in Tables 2 and 3. In test 1 there were significant differences in the number of tillers per meter of furrow (NTM) and production of straw. There were no differences for any of the parameters in test 2.

TABLE 2. F test: coefficient of variation (CV) of the parameters evaluated in test 1.

Parameter	G.L.	F	C.V. (%)
NTM	3	14.0**	14.48
AHS	3	0.66 $^{n.s.}$	3.13
ADS	3	1.84 $^{n.s.}$	5.95
BIOMASS	3	2.45 $^{n.s.}$	17.32
STRAW	3	3.87*	12.11
STEM	3	1.37 $^{n.s.}$	16.34
POL	3	0.30 $^{n.s.}$	6.53
FIBER	3	2.15 $^{n.s.}$	9.11
RS	3	0.11 $^{n.s.}$	35.61
TRS	3	0.35 $^{n.s.}$	6.14

NTM - number of tillers per meter in the vegetative growth (stage II); AHS - average height of the stems at the end of the cycle (stage IV) in meter; ADS - average diameter of the stems at the end of the cycle (stage IV) in centimeter; BIOMASS - biomass (stem + straw) at the end of the cycle (stage IV) in tons; STRAW - straw mass at the end of the cycle (stage IV) in tons; STEM - stem mass at the end of the cycle (stage IV) in tons; POL - apparent sucrose in %; FIBER - industrial fiber in %; RS – reducing sugars in % and TRS - total recovery sugar in kg per tons.

TABLE 3. F test: coefficient of variation (CV) of the parameters evaluated in test 2.

Parameter	G.L.	F	C.V. (%)
NTM	3	0.68 $^{n.s.}$	17.42
AHS	3	1.66 $^{n.s.}$	8.05
ADS	3	2.32 $^{n.s.}$	11.44
BIOMASS	3	0.82 $^{n.s.}$	14.47
STRAW	3	0.73 $^{n.s.}$	12.11
STEM	3	0.85 $^{n.s.}$	15.43
POL	3	0.84 $^{n.s.}$	5.61
FIBER	3	0.05 $^{n.s.}$	6.33
RS	3	0.17 $^{n.s.}$	17.12
TRS	3	0.84 $^{n.s.}$	5.19

NTM - number of tillers per meter in the vegetative growth (stage II); AHS - average height of the stems at the end of the cycle (stage IV) in meter; ADS - average diameter of the stems at the end of the cycle (stage IV) in centimeter; BIOMASS - biomass (stem + straw) at the end of the cycle (stage IV) in tons; STRAW - straw mass at the end of the cycle (stage IV) in tons; STEM - stem mass at the end of the cycle (stage IV) in tons; POL - apparent sucrose in %; FIBER - industrial fiber in %; RS – reducing sugars in % and TRS - total recovery sugar in kg per tons.

At the beginning of development (stage II) of test 1, the use of the polymer provided significant differences in the number of tillers m^{-1} (NTM - Figure 2A), and the treatments 8 to 12 g m^{-1} of furrow are the higher values, and the control treatments (0g) and 4g of polymer had the lowest averages. At the final stage (stage IV), the conditioner polymer caused no significant effect on the average of stems diameter (ADS) and stems height (AHS).

According to the results obtained in test 2, polymer doses of 4.2 g m^{-1} of furrow did not promote significant changes in any of the variables (Table 2). In both tests, the dose of 4g m^{-1} is considered equal to the control (0g m^{-1}). In test 1 (Figure 2A), the polynomial regression showed statistical significance ($p>0.01$) for the NTM. The results are in agreement with OLIVEIRA et al. (2004a), who reported higher water retention with the use of a water absorbent polymer and higher number of tiller m^{-1}.

Regarding the technological analysis, there were no significant statistical differences between treatments for any variable (POL%, FIBER%, RS% and TRS). However, COSTA et al. (2009) reported the importance of the production of TRS per area, since the payment of sugarcane occurs by the ratio of the amount of TRS, and profitability is a function of net return per hectare. The regression analysis for the values of TRS per hectare obtained in test 1 (Figure 2C) shows a linear tendency statistically significant between doses of polymer used and values of TRS per hectare, which led to a statistically significant regression between the polymer dose and gross income (Figure 2D). This fact is interesting for the productive sector of sugarcane and is in agreement with the studies of various authors (SIVAPALAN, 2006; SILVA et al., 2007; GONÇALVES et al., 2010), who reported the importance of water availability in the use of production factors.

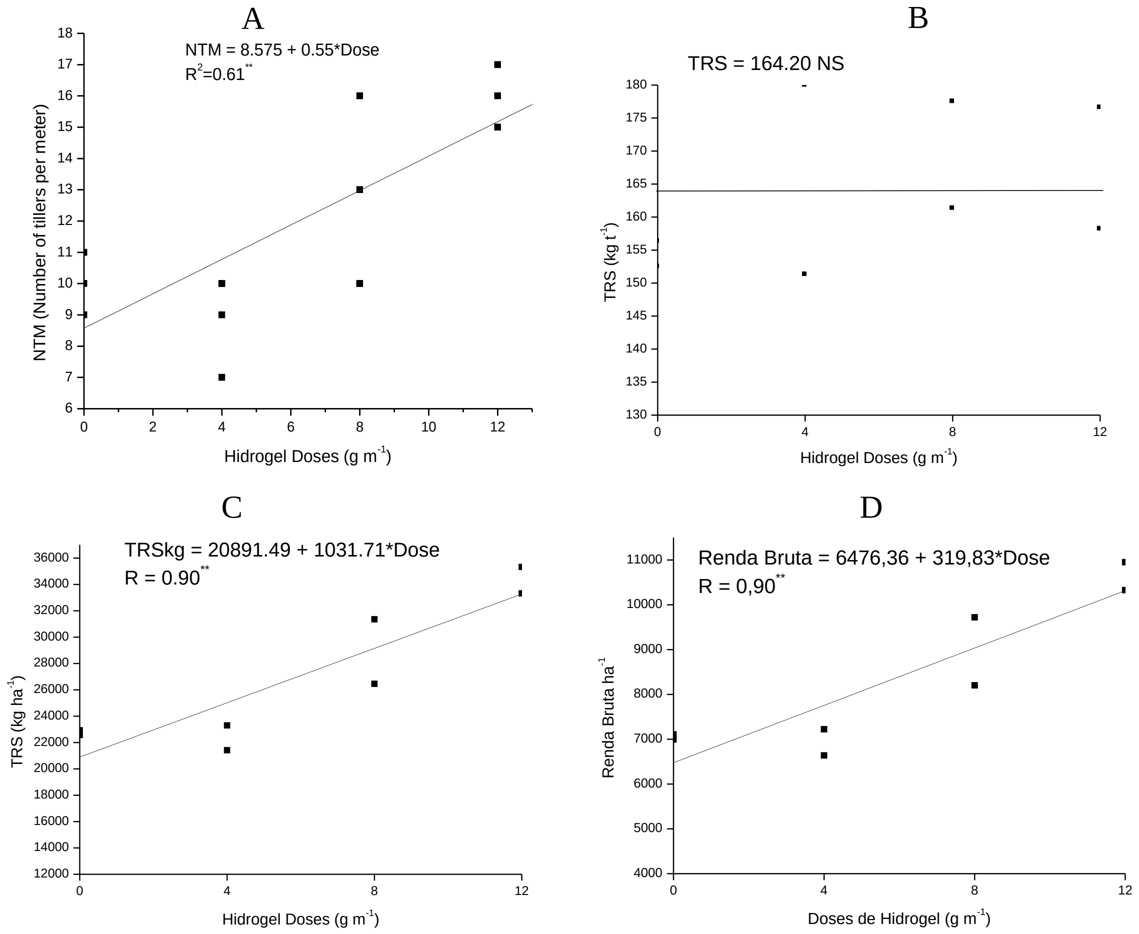


FIGURE 2. Linear regressions for the test 1: (A) Number of tillers per meter of furrow (NTM), (B) TRS in kg ton^{-1} sugarcane, (C) TRS in kg ha^{-1} and (D) Gross Income in R$ ha^{-1}.

The use of water absorbent polymers increases water availability due to reduced percolation of water into the soil, with greater water retention and increased water availability to plants (PREVEDELLO & LOYOLA, 2007; SANTANA et al., 2007; SILVA et al. 2008 b). As a result, provides increased productivity and profitability.

In tests 1 and 2, the values of biomass (stem + straw) showed no significant differences between the polymer doses (average of 213.88 t ha^{-1} and 159.47 t ha^{-1}, respectively). For the stems productivity we observed the same result with an average of 158.40 t ha^{-1} for test 1 and 123.77 t ha^{-1} for test 2. The highest number of tillers observed in stage II in test 1 (Figure 2A) was not sufficient to provide changes in stem productivity. However, the first test showed statistical differences in the amount of straw (Figure 3A), whereas the highest values were obtained in treatments with 8 and 12 g m^{-1}, and the lowest, in treatments with 0 and 4 g m^{-1}. This explains the lack of significant results in test 2, in which the highest dose of polymer was 4.2 g m^{-1}.

ALLEONI et al. (1995) reported a strong correlation between biometric parameters and agricultural productivity, used in the industrial units to forecast productivities in different portions. However, in this test this correlation reflected only in higher production of straw, composed by pointer, green and dry leaves of sugarcane. These parts are defined by physiologists as producers of photoassimilates, which result in greater synthesis of sucrose in the leaf, which is translocated by the phloem and taken to the stem, where it accumulates from base to apex and elevates the level of TRS. This physiological effect is seen in Figure 2C, where the concentration of TRS (TRS t^{-1}) remained the same for the treatments, but the return (TRS ha^{-1}) increased with doses of polymer.

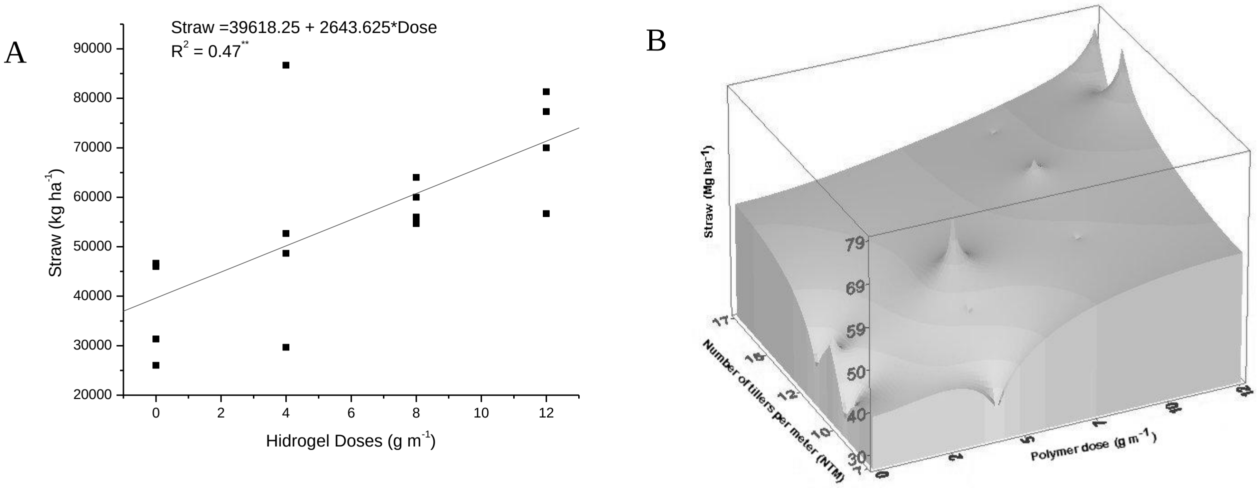


FIGURE 3. (A) Quadratic Regression between straw and polymer doses (B). Response surface for the variables NTM and Straw in function of polymer doses of the test 1.

According to FARIAS et al. (2008) the model containing two independent variables facilitates the visualization of the culture behavior in a wider way, favoring an estimate closer to reality. Thus, it was performed the regression of the independent variable (polymer doses) with relation to the variables NTM and Straw, obtaining a surface response of the first test (Figure 3B). We observe a strong correlation between dose, number of tillers m^{-1} (NTM) and Straw mass. The surface is visibly inclined, showing that higher doses of the polymer led to higher values of NTM and higher formation of straw. It is possible to note the interaction between the polymer doses and plant physiology, showing an increase of sprouting and vegetative growth at higher doses of the polymer, in agreement with the literature on the importance of water on plant growth (SILVA et al., 2007; GONÇALVES et al., 2010) and on the action of polymers (SANTANA et al., 2007; SAAD et al., 2009).

CONCLUSIONS

The polymer doses less than or equal to 4 g m^{-1} of furrow had no significant effect on the evaluated parameters;

Doses of 8 and 12 g m^{-1} of the conditioner polymer increased the number of tillers at stage II and of development and led to the larger amount of straw;

Gross income per hectare showed positive relation with the polymer doses;

The polymer had no significant effect on the productivity of stems of sugarcane and on technological parameters.

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