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Nitrogen efficiency in wheat yield through the biopolymer hydrogel

Ângela T. W De Mamann[1], José A. G. da Silva[2], Osmar B. Scremin[1], Rubia D. Mantai[1], Ari H. Scremin[1] & Eldair F. Dornelles[1]

[1] Universidade Regional do Noroeste do Estado do Rio Grande do Sul/Departamento de Ciências Exatas e Engenharias. Ijuí, RS. E-mail: angelademamann@hotmail.com; osmarscremin@hotmail.com; rdmantai@yahoo.com.br (Corresponding author); ahscremin@hotmail.com; eldair.dornelles@gmail.com

[2] Universidade Regional do Noroeste do Estado do Rio Grande do Sul/Departamento de Estudos Agrários. Ijuí, RS. E-mail: jagsfaem@yahoo.com.br

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Triticum aestivum
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ABSTRACT

Nitrogen use efficiency in wheat biomass and grain yields can be favored by the biopolymer hydrogel. The objective of the study was to analyze the use of the biopolymer hydrogel applied to the seed in the optimization of fertilizer-N on wheat biomass and grain yields, under different conditions of agricultural year and succession systems of high and reduced release of residual-N. In the study, two experiments were conducted, with different farming systems, soybean/wheat and maize/wheat, one to quantify the biomass yield rate and the other to determine grain yield. The experiments were conducted in the years 2014 and 2015, in a randomized block design with four replicates in a 4 x 4 factorial scheme, corresponding to hydrogel doses (0, 30, 60 and 120 kg ha^{-1}) added in the groove along with the seed and N fertilizer rates (0, 30, 60 and 120 kg ha^{-1}), applied as top-dressing. It is possible to improve the fertilizer-N efficiency by wheat using the biopolymer hydrogel for the production of biomass and grains. The highest wheat yield per kilogram of N supplied is obtained with 30 and 60 kg ha^{-1} of hydrogel, regardless of the year and succession system.

Palavras-chave:
Triticum aestivum
simulação
sistemas de cultivo
estresse hídrico

Eficiência do nitrogênio na produtividade do trigo pelo biopolímero hidrogel

RESUMO

A eficiência de uso do nitrogênio na produtividade do trigo, pode ser favorecida pelo biopolímero hidrogel. O objetivo do estudo foi analisar o uso do biopolímero hidrogel aplicado junto à semente na otimização do N-fertilizante sobre a produtividade de biomassa e grãos de trigo, em distintas condições de ano agrícola e sistemas de sucessão de alta e reduzida liberação de N-residual. No estudo dois experimentos foram conduzidos nos anos de 2014 e 2015, um para quantificar a taxa de produtividade de biomassa e biomassa total e o outro para determinação da produtividade de grãos. O delineamento experimental foi o de blocos casualizados com quatro repetições, em fatorial 4 x 4 para doses de hidrogel (0, 30, 60 e 120 kg ha^{-1}) adicionado junto à semente e doses de N-fertilizante (0, 30, 60 e 120 kg ha^{-1}) aplicadas em cobertura, respectivamente, no sistema de sucessão soja/trigo e milho/trigo. É possível melhorar a eficiência de N-fertilizante pelo trigo com o uso do biopolímero hidrogel à produção de biomassa e grãos. A maior produtividade de trigo por quilograma de nitrogênio fornecido é obtida com 30 e 60 kg ha^{-1} de hidrogel, independente do ano e do sistema de sucessão.

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Introduction

Wheat is one of the most produced cereals in the world (Arenhardt et al., 2015; Brezolin et al., 2017). Nitrogen (N) is essential to guarantee high yield of the wheat crop (Teixeira Filho et al., 2010; Prando et al., 2013), but is easily leached in rainy years (Teixeira Filho et al., 2010; Mantai et al., 2015) or volatilized in dry years (Rojas et al., 2012; Arenhardt et al., 2015). Thus, N use efficiency by wheat is eventually compromised, decreasing the yield and increasing the losses to the environment (Prando et al., 2013, Silva et al., 2015). Technologies that allow to improve yield with greater sustainability are necessary, especially in the increase of N use efficiency in the agricultural processes (Pinnow et al., 2013; Mantai et al., 2015).

One of the ways to improve N absorption by plants is the maintenance of soil moisture, since the N supply depends, among other factors, on moisture, aeration and temperature, which interact in the cultivation systems (Rocha et al., 2008; Silva et al., 2015). The use of the biopolymer hydrogel may represent a technology to regulate soil water availability to crops, which would favor the efficiency of absorption of nutrients and improve the yield (Azevedo et al., 2008; Mendonça et al., 2013). Hydrogels are biodegradable three-dimensional polymeric networks that retain water in their structure, forming a gel, which is capable of hydrating and releasing water over time (Kaewpirom & Boonsang, 2006; Venturoli & Venturoli, 2011).

The objective of the study was to analyze the use of the biopolymer hydrogel applied along with the seed in the optimization of fertilizer-N on wheat biomass and grain yields, under different conditions of agricultural year and succession systems of high and reduced residual-N release.

Material and Methods

The experiment was conducted in the years 2014 and 2015 in Augusto Pestana, RS, Brazil. The soil is classified as typic dystroferric Red Latosol and the climate of the region, according to Köppen's classification, is Cfa, with hot summer and without dry season. Ten days before sowing, soil analysis was made and the following characteristics were identified (Tedesco et al., 1995): i) maize/wheat system (pH = 6.5, P = 34.4 mg dm^{-3}, K = 262 mg dm^{-3}, OM = 3.0%, Al = 0 $cmol_c$ dm^{-3}, Ca = 6.6 $cmol_c$ dm^{-3} and Mg = 3.4 $cmol_c$ dm^{-3}) and; ii) soybean/wheat system (pH = 6.2, P = 33.9 mg dm^{-3}, K = 200 mg dm^{-3}, OM = 2.9%, Al = 0 $cmol_c$ dm^{-3}, Ca = 6.5 $cmol_c$ dm^{-3} and Mg = 2.5 $cmol_c$ dm^{-3}). Sowing was performed in the third week of June, as recommended for the crop, on a residual cover of high and reduced C/N ratio, maize/wheat and soybean/wheat systems, respectively. A seeder-fertilizer machine was used for sowing, to compose the plot with 5-m-long rows at spacing of 0.20 m between rows, to form the experimental unit of 5 m^2. Planting density was equal to 400 viable seeds m^{-2}. Along the experiment, the fungicide Tebuconazole was applied at the dose of 0.75 L ha^{-1} and weeds were controlled using the herbicide Metsulfuron-methyl at dose of 4 g ha^{-1}. At sowing, 45 and 30 kg ha^{-1} of P_2O_5 and K_2O were applied based on the contents of P and K in the soil, for an expected grain yield of 3 t ha^{-1}, respectively, and 10 kg ha^{-1} of N as basal fertilization (except the standard experimental unit), with the rest for the proposed doses in the phenological stage of third expanded leaf. The hydrogel was applied along with the seed, at the same depth and along the wheat row.

In each cultivation condition (soybean/wheat and maize/wheat systems), two experiments were conducted, one to quantify total biomass yield by the cuts performed every 30 days until physiological maturation, and the other to estimate grain yield (GY, kg ha^{-1}). The four experiments were set in randomized blocks with four replicates, in 4 x 4 factorial scheme, for the sources of variation hydrogel doses (0, 30, 60 and 120 kg ha^{-1}) and fertilizer-N doses (urea) (0, 30, 60 and 120 kg ha^{-1}), using the wheat cultivar TEC 10, totaling 128 experimental units per cultivation system. Grain yield was obtained by cutting three central rows of each plot at the harvest maturation point, with grain moisture close to 22%. The grains were threshed using a stationary threshing machine and taken to the laboratory to correct the moisture content to 13% and estimate grain yield (GY, kg ha^{-1}). In the experiments to quantify biomass yield, the plant material was harvested close to the soil, by collecting one linear meter of the three central rows of each plot at 30, 60, 90 and 120 days after emergence, totaling four cuts. The samples were taken to a forced-air oven at 65 °C and dried until constant weight, to estimate the biomass yield rate (Y, kg ha^{-1} d^{-1}) and total biomass yield (BY, kg ha^{-1}).

After the assumptions of homogeneity and normality which were met through the Bartlett's test, analysis of variance was made to detect the main effects and interaction effects. The linear equation ($Y = b_0 \pm b_1x$) was fitted in the estimation of biomass yield and the means of total biomass yield and grain yield were compared using the test of Scott & Knott (1974). Subsequently, a quadratic equation ($Y = b_0 \pm b_1x \pm b_2x^2$) was fitted in the estimation of the ideal dose of the fertilizer-N ($N_{ideal} = - b_1/2b_2$) for grain yield, with simulation of the total biomass yield through the ideal N dose for grain production.

Results and Discussion

The rainfalls along the crop cycle were 952 mm in 2014 and 817 mm in 2015, which are similar to the historic average of 20 years, 900 mm, but with different distribution between the years (Figure 1). In 2014, the greatest volume of rains occurred from half cycle to close to maturation (Figure 1A), favoring long periods of lower insolation with reduction in photosynthetic efficiency, except the excess of rains close to maturation. In 2015, the greatest volume of rains occurred from emergence to close to 36 days of crop development, followed by regular rainfalls of lower intensity and better distribution from the reproductive stage to maturation (Figure 1B). These facts justify the higher grain yield in 2015, compared with 2014. Rainfall is the main meteorological variable affecting the yield of agricultural crops (Battisti et al., 2013). The condition of cultivation year in wheat is predominantly defined by the distribution and volume of rains during the development (Arenhardt et al., 2015).

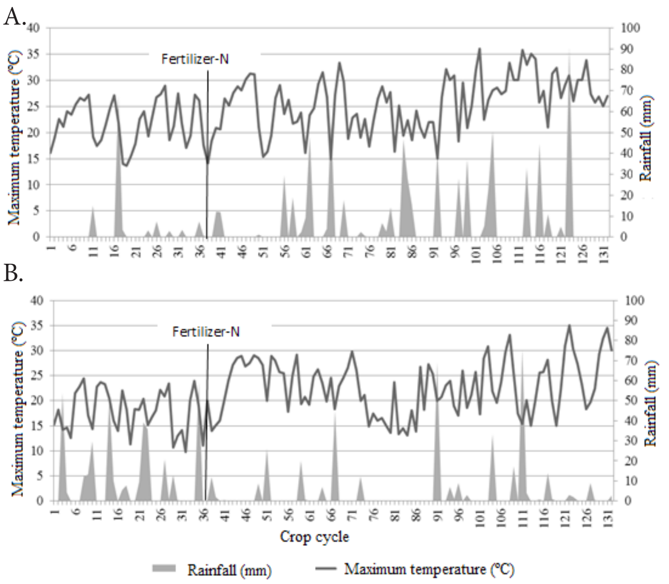

Figure 1. Rainfall and maximum temperature along the wheat cycle, (A) year 2014 and (B) year 2015

Significant differences between the main effects and interaction effects were obtained between years, hydrogel doses and N doses. Therefore, the presented results are relative to the follow-up analysis of the effects of this interaction. In Table 1, for the soybean/wheat system, regardless of year and hydrogel dose, the increment in fertilizer-N increased linearly the biomass yield rate day^{-1} (b_i), total biomass yield and grain yield. In 2014 (Table 1), the fertilizer-N doses of 60 and 120 kg ha^{-1} promoted higher biomass yield rate with 30 kg ha^{-1} of hydrogel. This hydrogel dose led to the highest mean value of grain yield, but the effects on total biomass did not show alteration, except at the highest dose of the biopolymer, reducing the yield. In 2015 (Table 1), the fertilizer-N doses of 60 and 120 kg ha^{-1} with the hydrogel doses of 60 and 120 kg ha^{-1} led to the highest biomass yield rate, with more expressive mean values of total biomass yield and grain yield.

In Table 2, in the maize/wheat system, regardless of the hydrogel dose and agricultural year, biomass yield rates day^{-1}, total biomass yield and grain yield were increased by the increment in the fertilizer-N dose. In 2014 (Table 2), the highest biomass yield rate was observed at the fertilizer-N doses of 60 and 120 kg ha^{-1} with 30 and 60 kg ha^{-1} of hydrogel. Regardless of the use of N-fertilizer, there was no alteration in grain yield and total biomass yield under the conditions of use of the biopolymer. In 2015 (Table 2), the N dose of 120 kg ha^{-1} with 30 kg ha^{-1} of hydrogel led to the highest biomass

Table 1. Regression of biomass yield rate day^{-1}, total biomass yield and grain yield at doses of hydrogel and nitrogen in the soybean/wheat system

Hydrogel	Nitrogen	$Y = b_0 \pm b_i x$	R^2	P	GY	$\bar{X}_{GY}$	BY	$\bar{X}_{BY}$
(kg ha^{-1})				($b_i x$)	(kg ha^{-1})			
		Year 2014						
0	0	-655 + 65.69x	0.92	*	1350 d	1921 B	6765 d	8471 A
	30	-847 + 76.84x	0.90	*	1831 c		7785 c	
	60	-954 + 81.21x	0.92	*	2128 b		8474 b	
	120	-1302 + 101.09x	0.94	*	2373 a		10860 a	
30	0	-1045 + 67.5x	0.92	*	1630 d	2124 A	8119 b	9199 A
	30	-1046 + 82.7x	0.91	*	1972 c		8597 b	
	60	-1116 + 91.34x	0.87	*	2334 b		9134 b	
	120	-1382 + 108x	0.88	*	2558 a		10945 a	
60	0	-912 + 65.35x	0.90	*	1366 d	1947 B	6951 d	8653 A
	30	-1084 + 82.2x	0.83	*	1783 c		8157 c	
	60	-1027 + 85.28x	0.92	*	2175 b		8952 b	
	120	-1372 + 101.93x	0.90	*	2462 a		10550 a	
120	0	-664 + 58.11x	0.92	*	1292 c	1756 C	6100 c	7380 B
	30	-702 + 62.92x	0.93	*	1618 b		6652 c	
	60	-832 + 74.24x	0.91	*	2007 a		7645 b	
	120	-854 + 87.6x	0.93	*	2107 a		9124 a	
		Year 2015						
0	0	-1032 + 60.14x	0.85	*	1413 c	2472 B	6339 d	8389 B
	30	-1156 + 77.48x	0.84	*	2505 b		7838 c	
	60	-1331 + 83.15x	0.89	*	2887 a		8844 b	
	120	-1665 + 99.94x	0.87	*	3084 a		10533 a	
30	0	-929 + 60.68x	0.87	*	1405 c	2517 B	5949 c	8669 B
	30	-1314 + 77.5x	0.90	*	2697 b		8628 b	
	60	-1279 + 81.33x	0.93	*	2709 b		9121 b	
	120	-1629 + 108.21	0.85	*	3258 a		10976 a	
60	0	-1101 + 75x	0.91	*	1995 c	2748 A	8010 c	9360 A
	30	-1157 + 78.8x	0.91	*	2803 b		8423 c	
	60	-1307 + 92.66x	0.87	*	2904 b		9413 b	
	120	-1670 + 113.39x	0.87	*	3290 a		11595 a	
120	0	-1193 + 71.96x	0.91	*	1940 b	2682 A	8173 d	10146 A
	30	-1446 + 82.53x	0.90	*	2808 a		9535 c	
	60	-15.88 + 92.93x	0.90	*	2981 a		10357 b	
	120	-1835 + 117.44x	0.90	*	2998 a		12517 a	

Y - Estimate of biomass yield; GY - Grain yield; BY - Total biomass yield; $\bar{X}_{GY}$ - Mean value of grain yield under the conditions of use of hydrogel; $\bar{X}_{BY}$ - Mean value of total biomass yield under the conditions of use of hydrogel; R^2 - Coefficient of determination; ; P ($b_i x$) - Probability of the line slope parameter; *Significant at 0.05 probability level by t-test; Means followed by the same lowercase letters for each hydrogel dose compare nitrogen doses and by uppercase letters compare hydrogel doses, constituting a statistically homogeneous group by Scott-Knott test at 0.05 probability level

Table 2. Regression of biomass yield rate day^{-1}, total biomass yield and grain yield at doses of hydrogel and nitrogen in the maize/wheat system

Hydrogel	Nitrogen (kg ha^{-1})	$Y = b_0 \pm b_i x$	R^2	P ($b_i x$)	GY (kg ha^{-1})	$\bar{X}_{GY}$	BY (kg ha^{-1})	$\bar{X}_{BY}$
Year 2014								
0	0	-664 + 42.5x	0.89	*	559 d	1191 A	4651 c	5911 A
	30	-829 + 51.57x	0.87	*	1190 c		5666 b	
	60	-702 + 56.52x	0.88	*	1412 b		5808 b	
	120	-1013 + 73.72x	0.87	*	1602 a		7519 a	
30	0	-751 + 45.90x	0.90	*	678 d	1304 A	5129 b	6168 A
	30	-768 + 53.54x	0.88	*	1201 c		5586 b	
	60	-604 + 57.93x	0.84	*	1353 b		5514 b	
	120	-1190 + 80.52x	0.89	*	1985 a		8442 a	
60	0	-687 + 46.16x	0.89	*	664 c	1247 A	4930 c	6135 A
	30	-614 + 52.37x	0.85	*	1228 b		5068 c	
	60	-615 + 58.08x	0.86	*	1244 b		5709 b	
	120	-1090 + 81.64x	0.91	*	1852 a		8831 a	
120	0	-637 + 43.83x	0.87	*	710 d	1138 A	4564 c	5910 A
	30	-617 + 50.48x	0.87	*	1029 c		5332 b	
	60	-586 + 56.07x	0.86	*	1192 b		5675 b	
	120	-885 + 79.77x	0.89	*	1622 a		8067 a	
Year 2015								
0	0	-917 + 45.1x	0.84	*	1201 d	1882 A	5402 d	8164 B
	30	-1320 + 63.26x	0.84	*	1746 c		7534 c	
	60	-1444 + 78.78x	0.88	*	2090 b		8685 b	
	120	-1859 + 99.02x	0.88	*	2492 a		11033 a	
30	0	-1057 + 54.94x	0.87	*	1313 d	1920 A	6336 d	8670 B
	30	-1193 + 68.44x	0.87	*	1670 c		7352 c	
	60	-1455 + 85.71x	0.84	*	2032 b		8831 b	
	120	-1966 + 112.19x	0.88	*	2663 a		12161 a	
60	0	-1342 + 71.48x	0.88	*	1424 c	2000 A	8202 c	9929 A
	30	-1625 + 84.26x	0.87	*	1940 b		9799 b	
	60	-1551 + 89.48x	0.88	*	2185 b		9670 b	
	120	-1924 + 104.69x	0.89	*	2449 a		12043 a	
120	0	-1222 + 67.56x	0.89	*	1377 b	1851 A	7985 b	9267 A
	30	-1109 + 64.96x	0.91	*	1583 b		7427 b	
	60	-1707 + 89.63x	0.88	*	2178 a		10485 a	
	120	-1887 + 105.31x	0.85	*	2267 a		11170 a	

Y - Estimate of biomass yield; GY - Grain yield; BY - Total biomass yield; $\bar{X}_{GY}$ - Mean value of grain yield under the conditions of use of hydrogel; $\bar{X}_{BY}$ - Mean value of total biomass yield under the conditions of use of hydrogel; R^2 - Coefficient of determination; ; P ($b_i x$) - Probability of the line slope parameter; *Significant at 0.05 probability level by t-test; Means followed by the same lowercase letters for each hydrogel dose compare nitrogen doses and by uppercase letters compare hydrogel doses, constituting a statistically homogeneous group by Scott-Knott test at 0.05 probability level

yield. Regardless of the use of fertilizer-N, grain yield was not altered, except for the increment in biomass yield with 60 and 120 kg ha^{-1} of hydrogel. It should be pointed out that, regardless of the agricultural year, there were no effects of using hydrogel on grain yield in the maize/wheat system, differently from the soybean/wheat system. These facts raise the hypothesis that the large biomass accumulation combined with the lower capacity of straw decomposition in the residual cover of maize promoted better soil cover with maintenance of moisture, compromising the direct action of the hydrogel.

Nitrogen fertilization is decisive for wheat yield, but there are multiple processes interfering with the N use efficiency, such as the characteristics of soil and climate (Prando et al., 2013). The reduced soil moisture decreases N use efficiency, limiting the yield (Mantai et al., 2015). The use of hydrogel in agriculture can be a technology to absorb and supply water to plants during the entire development cycle (Mews et al., 2015). Studies conducted with coffee demonstrate that the water-absorbing polymer showed significant water retention in the soil, increasing the mass of roots (Castro et al., 2014). In jatropha plants, the hydrogel applied directly in the hole favored growth and survival in the first months after planting, due to the methods of application and formulations of the product (Dranski et al., 2013).

In Table 3, in the soybean/wheat system, regardless of the cultivation year, the equations evidenced a quadratic response in the absence and at highest dose of the biopolymer; however, regardless of the year, 30 and 60 kg ha^{-1} of hydrogel promoted a linear behavior in grain yield, which raises the hypothesis that the biopolymer under these conditions favors N use. In 2014, for every kg of N applied, there were increments of 7.65 and 8.97 kg ha^{-1} in grain yield, for 30 and 60 kg ha^{-1} of hydrogel, respectively. In 2015, these same doses led to increments of 13.43 and 10.35 kg ha^{-1} of grains per kg of N.

In Table 3, for the soybean/wheat system in 2014, the analysis of biomass yield through the fertilizer-N with the use of hydrogel evidenced a linear behavior, regardless of the biopolymer dose. This result qualifies the condition of 60 kg ha^{-1} of hydrogel in the highest N use efficiency for biomass production, with 29.31 kg ha^{-1} produced per kg of N. In 2015, the same behavior was observed in all conditions of use of hydrogel. In this cultivation year, the hydrogel dose of 30 kg ha^{-1} promoted higher N use efficiency for biomass production, with 38.45 kg kg^{-1} of fertilizer-N. The maximum expression of biomass in the

Table 3. Regression in the estimation of ideal nitrogen dose for grain production and expected yield, in the use of hydrogel in the soybean/wheat and maize/wheat systems

Hydrogel (kg ha^{-1})	$Y = b_0 \pm b_1x \pm b_2x^n$	R^2	P (b_ix^n)	N_{ideal} (kg ha^{-1})	Y_E (kg ha^{-1})
	Soybean/wheat system - Year 2014				
0	GY =1355 + 17.64x - 0.08x^2	0.99	*	110	2327
	BY = 6695 + 23.82x	0.99	*		10415
30	GY = 1722 + 7.65x	0.92	*	-	-
	BY = 7948 + 23.83x	0.97	*		-
60	GY = 1475 + 8.97x	0.93	*	-	-
	BY = 7114 + 29.31x	0.99	*		-
120	GY = 1268 + 15.99x - 0.07x^2	0.98	*	114	2181
	BY = 6025 + 25.81x	0.99	*		8967
	Soybean/wheat system - Year 2015				
0	GY = 1456 + 37.06x - 0.2x^2	0.98	*	93	3173
	BY = 6601 + 34x	0.98	*		9856
30	GY = 1812 + 13.43x	0.77	*	-	-
	BY = 6650 + 38.45x	0.90	*		-
60	GY = 2145 + 10.35x	0.93	*	-	-
	BY = 7739 + 30.89x	0.97	*		-
120	GY = 1984 + 28.59x - 0.17x^2	0.97	*	84	3186
	BY = 8286 + 35.42x	0.99	*		11261
	Maize/wheat system - Year 2014				
0	GY = 773 + 7.95 x	0.81	*	-	-
	BY = 4715 + 22.79x	0.96	*		-
30	GY = 761 + 10.35x	0.97	*	-	-
	BY = 4726 + 27.46x	0.84	*		-
60	GY = 768 + 9.13x	0.93	*	-	-
	BY = 4361 + 33.78x	0.89	*		-
120	GY = 752 + 7.36x	0.99	*	-	-
	BY = 4473 + 28.32x	0.95	*		-
	Maize/wheat system - Year 2015				
0	GY = 1338 + 10.36x	0.94	*	-	-
	BY = 5786 + 45.29x	0.98	*		-
30	GY = 1330 + 11.23x	0.99	*	-	-
	BY = 6076 + 49.4x	0.99	*		-
60	GY = 1576 + 8.05x	0.89	*	-	-
	BY = 8366 + 39.76x	0.92	*		-
120	GY = 1442 + 7.79x	0.83	*	-	-
	BY = 7625 + 31.28x	0.76	*		-

GY - Grain yield (kg ha^{-1}); BY - Biomass yield (kg ha^{-1}); R^2 - Coefficient of determination; P(b_ix^n) – Probability of the line slope parameter; *Significant at 0.05 probability level by t-test; N_{ideal} -Ideal nitrogen dose estimated by the grain yield regression equation; Y_E - Estimated values of biomass yield and grain yield based on the ideal nitrogen dose

year 2015 is due to the large volume of rainfall in the vegetative stage (Figure 1), the phase of highest contribution to biomass production.

In Table 3, in the maize/wheat system, regardless of the cultivation year, the equations evidenced a linear behavior for wheat grain yield in all conditions of use of hydrogel. In 2014, the hydrogel doses of 30 and 60 kg ha^{-1} promoted higher N use efficiency for grain production, with 10.35 and 9.13 kg ha^{-1}, respectively, per kg of N supplied. In 2015, the hydrogel dose of 30 kg ha^{-1} led to the highest fertilizer-N use efficiency, with 11.23 kg ha^{-1} of grains per kg of N. The condition of larger rainfall volume in 2015 in the vegetative stage promoted adequate soil moisture, limiting the action of the biopolymer. Additionally, higher values of hydrogel led to reduction in grain yield. In the maize/wheat system in 2014 (Table 3), the analysis of biomass yield through the use of fertilizer-N and hydrogel also evidenced a linear behavior, regardless of the biopolymer doses, as obtained in the soybean/wheat system. In 2014, the hydrogel dose of 60 kg ha^{-1} led to higher N use efficiency for biomass production, with 33.78 kg ha^{-1} per kg of the fertilizer. In 2015, 30 kg ha^{-1} of hydrogel promoted higher efficiency, with 49.4 kg of production per kg of N.

The results in Table 3, regardless of the year and succession system, indicate that the highest yield rates were obtained at the hydrogel doses of 30 and 60 kg ha^{-1}. The product hydrogel costs R$ 18.00 kg^{-1}; considering a dose of 30 kg ha^{-1} of the polymer, the cost is R$ 540.00 ha^{-1}. Although the cost may seem high, the product has a water-retention action in the soil of 3 to 4 years; therefore, the cost is diluted along the crop seasons.

Various studies confirm the efficiency of the hydrogel in agriculture. Marques & Bastos (2010) found beneficial effects of hydrogel incorporation in the substrate for the production of bell pepper seedlings. Mews et al. (2015), in the production of 'Ipê' seedlings, observed that the utilization of the biopolymer increased the use of N fertilization. Albuquerque Filho et al. (2009) observed that the hydrogel allowed higher use efficiency of irrigation depths, increasing the green matter of coriander. Therefore, it is a condition that points to the use of the biopolymer in cereal species such as wheat, which requires soil moisture for better N use.

Conclusions

1. It is possible to improve fertilizer-N efficiency by wheat using the biopolymer hydrogel for biomass and grain yields.

2. Highest wheat yield per kilogram of N is obtained with 30 and 60 kg ha^{-1} of hydrogel, regardless of year and succession system.

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