TIMING OF NITROGEN FERTILIZER APPLICATION IN NO-TILLAGE COTTON IN BRAZIL

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Abstract

This study aimed at evaluating the agronomic efficiency of nitrogen (N) fertilizers blended with urease inhibitor, nitrification inhibitor, and a slow-release polymer applied at different times in a no-till cotton crop as well as the possibility of reducing the number of broadcast applications using conventional and alternative N sources. The experiment was carried out in a complete randomized block design with four replications, in a (6x4)+1 factorial arrangement: six N sources (ammonium nitrate; urea; 50% urea + 50% ammonium sulfate; urea + urease inhibitor - NBPT; urea + slow-release polymer; and ammonium sulfonitrate + nitrification inhibitor - dimetil pirazol phosphate), four times of broadcast application (100% right after emergence; 50% right after emergence + 50% in phase B1 - first floral bud; 100% in phase B1; and 50% in phase B1 + 50% in phase F1 - first flower), and one control. None of the alternative N sources tested resulted in yields higher than the conventional sources (urea, ammonium nitrate, and ammonium sulfate). The highest yield was achieved when the N was applied earlier and split into two applications (50% right after emergence + 50% in phase B1). Single N application was more efficient only when using urea + slow-release polymer.

INTRODUCTION

Nitrogen (N) is one of the nutrients applied in large amounts in cotton crops in Brazil. Since this crop needs 60 to 70 kg/ha N to produce 1 ton of cotton seed, it is necessary to fertilize the soil in order to complement the amount of this nutrient provided by it. Low plant N uptake efficiency is widely known, which is a consequence of several processes of transformation and losses of N in the soil, such as immobilization, denitrification, leaching, and volatilization. NH_3 volatilization is one of the mechanisms of transformation of N applied to the soil that contributes the most to the low N recovery by crops, mainly when the source is urea and it is applied to the mulch in a no-till system [1]. Besides using suitable management practices, there is technology available to enhance plant nutrient uptake, such as slow-release or controlled-release fertilizers, urease inhibitors, and nitrification inhibitors. The use of these products in value-added crops such as cotton may be an interesting option, especially to reduce N loss, as it has been observed in the United States [2].

This study aimed at evaluating: 1) the agronomic efficiency of N fertilizers blended with urease inhibitor, nitrification inhibitor, and slow-release polymer applied at different times in no-till cotton crop; 2) the possibility of reducing the number of broadcast applications using conventional and alternative sources of N fertilizers.

MATERIAL AND METHOD

The experiment was carried out under field conditions during the 2007/2008 growing season, on Vargem Grande Farm, municipality of Montividiu (51º27'16" W, 17º 22' 53" S), state of Goiás, in the Midwestern Region of Brazil, in a no-till area with agriculture-animal husbandry integration, where the preceding crops were corn intercropped with *Brachiaria brizantha* . The soil of this area, classified as clayey Typic Haplustox, contained 43 g/dm^3 organic matter in the 0-20 cm layer.

The experiment was carried out in a complete randomized block design with four replications, in a (6x4)+1 factorial arrangement: six N sources (ammonium nitrate; urea; 50% urea + 50% ammonium sulfate; urea + urease inhibitor – NBPT (Agrotain®); urea + slow-release polymer; and ammonium sulfonitrate + nitrification inhibitor - dimetil pirazol phosphate), four times of broadcast application (100% right after emergence; 50% right after emergence + 50% in phase B1; 100% in phase B1; and 50% in phase B1 + 50% in phase F1), and one control treatment (no N fertilizer). For these treatments, we considered 90 kg/ha N as the dose used in the broadcast application, although all the treatments also received the equivalent to 20 kg/ha N placed in the seed row (basic formulation). The plots consisted of six rows of 5 m each, 0.81 m between rows, and we planted the seeds at the four central rows.

We planted 8 seeds of cv. Fibermax 977 per m of row using a seed-cum-fertilizer-drill on December 8, 2007. Fertilization at planting time was performed using 400 kg/ha 5-30-00 fertilizer, which corresponds to 20 kg/ha N and 120 kg/ha P_2O_5. Fertilization after emergence was carried out in December 19, 2007, 6 days after emergence (DAE), according to the treatments. At 35 DAE, in phase B1, the first broadcast N fertilization was performed, according to the treatments, together with K fertilization to supply the equivalent to 75 kg/ha K_2O. The second broadcast fertilization was applied using only N, according to the treatments, before the first flower opening. All the broadcast applications were carried out manually. Total precipitation in the period from October/2007 to May/2008 was 1730 mm, well distributed along the months of high water use by the crop.

We evaluated: leaf macronutrient content, plant height, cotton seed and fiber yield, fiber percentage, average boll weight, number of bolls per plant. The agronomic efficiency (AE) of N sources tested, at each time of application, was calculated using the yield recorded (kg/ha) and the dose of N applied (90 kg/ha), using the formula: AE = (yield with N fertilizer – yield of control treatment)/90. The results were evaluated using variance analysis (F test, $P < 0.05$). When significant, the means were compared using the Tukey's test ($P < 0.05$), and when we compared groups of treatments, the means were contrasted using the F test ($P < 0.05$).

RESULTS AND DISCUSSION

Treatments that received broadcast application of 90 kg/ha N produced 38.8% more cotton seed and 40.5 % more fiber than the control treatment, which received only 20 kg/ha N placed in the seed row (Table 1). Plants that received broadcast application also developed better, were 15 cm taller, presented higher average boll weight, and higher leaf N content (Table 1). The variance analysis indicated the effect of N sources, time of application, and interaction of these factors on cotton yield. We also detected isolated effect of N sources and time of application on leaf N content. Regardless of the time of application, urea, ammonium nitrate, and urea + slow-release polymer resulted in higher yields, with no statistical differences among them (Tables 1 and 2). The same N sources also resulted in the highest AE (Table 3).

For most N sources tested, the highest yields were achieved when N was applied earlier and split into two applications (50% right after emergence + 50% in phase B1). This may be related to the reduction of the effect of a possible soil N immobilization by microorganisms due to the anticipation of N fertilization as well as the decrease in probable losses caused by leaching, volatilization, or denitrification as a consequence of splitting. Nevertheless, it seems that the neutralization of the effect of soil N immobilization played a more important role, since N fertilizer splitting from phase B1 on (50% in phase B1 + 50% in phase F1) did not influence yield compared to a single application in phase B1 (100% in phase B1). These results indicate that N broadcast applications should be carried out earlier (i.p. until the beginning of the reproductive phase – first flower buds) in no-till systems in the presence of *B. brizantha* mulch. The treatment with urea + slow-release polymer showed the best performance with a single application right after emergence (Table 2), which suggests that polymer-coated fertilizers to obtain slow N release may be used as an early, single broadcast application.

Table 1 **– Results of cotton production variables, Soil Plant Analysis Development (SPAD) index, and leaf nitrogen content, according to nitrogen sources and times of application, Montividiu, GO, 2007/2008 growing season.**

Treatment	**Plant height (cm)**	**Boll (no.)**	**Boll weight (g)**	**Cotton seed (kg/ha)**	**Fiber (%)**	**Fiber (kg/ha)**	**SPAD**	**N (g/kg)**
				Control vs. Factorial				
Control	97 b(1)	14.5 a	4.34 b	3096 b	41.7 a	1290 b	46.4 a	40.0 b
Factorial 6x4 (sources x times)	112 a	14.6 a	4.87 a	4297 a	42.2 a	1812 a	47.2 a	42.7 a
				Effects of N sources				
Ammonium nitrate	113 a(2)	14.8 a	4.93 a	4437 a	42.0 a	1861 a	47.0 a	43.4 ab
Urea	112 a	14.9 a	4.91 a	4633 a	42.3 a	1958 a	47.1 a	44.0 a
Urea + ammonium sulfate	113 a	14.4 a	4.77 a	4070 b	42.4 a	1725 c	47.9 a	41.5 b
Urea + NBPT	110 a	13.9 a	4.87 a	4128 b	42.2 a	1741 bc	47.6 a	41.6 b
Urea + polymer	113 a	14.9 a	4.90 a	4391 a	42.2 a	1852 ab	46.8 a	42.4 ab
Ammonium sulfonitrate + nitrification inhibitor	113 a	14.8 a	4.86 a	4121 b	42.1 a	1736 bc	46.9 a	43.0 ab
				Effect of times of application				
100% after emergence	112 a(2)	14.8 a	4.78 a	4374 b	42.1 a	1841 b	46.0 b	41.0 b
50% after emergence + 50% phase B1	114 a	15.1 a	4.89 a	4623 a	42.1 a	1947 a	47.2 a	42.2 ab
100% phase B1	113 a	14.6 a	4.91 a	4139 c	42.2 a	1747 c	47.9 a	43.4 c
50% phase B1 + 50% phase F1	111 a	14.0 a	4.91 a	4055 c	42.3 a	1715 c	47.8 a	44.2 c
C.V. (%)	7.8	18.7	5.8	6.8	1.5	7.1	2.8	6.7

B1 = first floral bud; Boll (no.) = average number of bolls per plant; Boll weight (g) = average weight of bolls. Values followed by the same letters do not differ among each other: (1) contrasting the means using the F test ($P < 0.05$); (2) using the Tukey's test ($P < 0.05$).

Table 2 – **Cotton seed yield according to nitrogen sources and times of application, Montividiu, GO, 2007/2008 growing season.**

N source	Cotton seed yield (kg/ha)				
	Time of N application				Average
	100% after emergence	50% after emergence + 50% phase B1	100% phase B1	50% phase B1 + 50% phase F1	
Ammonium nitrate	4688 aA[(1)]	4716 abA	4118 abB	4224 abB	4437 a
Urea	4546 abB	5052 aA	4524 aB	4410 aB	4633 a
Urea + ammonium sulfate	4010 bB	4516 abA	3885 B	3868 abB	4070 b
Urea + NBPT	4303 abAB	4406 abA	3803 bB	4000 abAB	4128 b
Urea + polymer	4710 aA	4327 bB	4330 aB	4196 abB	4391 a
Ammonium sulfonitrate + nitrification inhibitor	3984 bBC	4717 abA	4152 abB	3630 bC	4121 b
Average	4374 B	4623 A	4135 C	4055 c	

[(1)] Values followed by the same small letters for time of application and capital letters for each N source do not differ among each other using the Tukey's test ($P < 0.05$). B1 = first floral bud

Table 3 – **Agronomic efficiency of nitrogen sources according to times of application, Montividiu, GO, 2007/2008 growing season.**

N source	Agronomic efficiency				
	Time of N application				Average
	100% after emergence	50% after emergence + 50% phase B1	100% phase B1	50% phase B1 + 50% phase F1	
Ammonium nitrate	17.7	18.0	11.4	12.5	14.9
Urea	16.1	21.7	15.9	14.6	17.1
Urea + ammonium sulfate	10.2	15.8	8.8	8.6	10.8
Urea + NBPT	13.4	14.6	7.9	10.0	11.5
Urea + polymer	17.9	13.7	13.7	12.2	14.4
Ammonium sulfonitrate + nitrification inhibitor	9.9	18.0	11.7	5.9	11.4
Average	14.2	17.0	11.5	10.7	

B1 = first floral bud

CONCLUSIONS

1. None of the of the alternative N sources tested, including polymer-coated fertilizer, urease inhibitor, and nitrification inhibitor, resulted in yields higher than the conventional sources (urea, ammonium nitrate, and urea + ammonium sulfate).
2. For most N sources tested, the highest yield was achieved when N was applied earlier and split into two applications (50% right after emergence + 50% in phase B1).
3. A single N application right after emergence was more efficient only when using urea + slow-release polymer.

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