ECONOMIC STUDY OF NITROGEN DOSAGE FOR COTTON CROPS

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SUMMARY

*Cotton (*Gossypium hirsutum *L.) is one of the main crops grown in Brazil. Rational and efficient fertilization occupies a prominent place in the set of factors that directly influence agricultural productivity. The aim of this study was to calculate the most economic nitrogen dose for cotton crop. The experiment was conducted in a Red-Yellow Argisol (Oxisols). The experimental design was a randomized complete block. The treatments resulted in increasing levels of nitrogen, 0, 40, 80, 120 and 160kg·N·ha^{-1} applied in coverage in two phases. The response curve to the increasing doses of nitrogen fertilization was fitted by a quadratic expression. The most economical N fertilizer dose obtained for cotton production was 88.3kg·N·ha^{-1}, where a yield of 3555.5kg ha^{-1} cotton was estimated.*

ESTUDIO ECONÓMICO DEL MANEJO DE NITRÓGENO EN CULTIVOS DE ALGODÓN

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RESUMEN

*El algodón (*Gossypium hirsutum *L.) es uno de los cultivos más importantes en Brasil. La fertilización racional y eficiente ocupa un lugar prominente en el conjunto de factores que influyen de manera directa en la productividad agrícola. El objetivo de este estudio fue calcular la dosis más económica de nitrógeno para el cultivo de algodón. El experimento fue conducido en un Argisol Rojo-Amarillo (Oxisol). El diseño experimental fue en bloque completo aleatorio. Los tratamientos resultaron en dosis ascendentes de nitrógeno de 0, 40, 80, 120 y 160kg·N·ha^{-1} aplicados en superficie en dos fases. La curva de respuesta a los niveles ascendentes de fertilización nitrogenada fue ajustada por una expresión cuadrática. La dosis más económica de fertilizante para la producción de algodón resultó ser de 88,3kg·N·ha^{-1}, con la cual se estimó un rendimiento de 3555.5kg·ha^{-1}*

Introduction

Cotton (*Gossypium hirsutum* L.) is one of the main crops grown in Brazil, currently occupying 1400300ha. The cotton yield estimated for the 20011/12 harvest is of 3297800ton. The Midwest region accounted for 61.4% of cropland in the country. The current average productivity of cotton in the country is 3700-3800kg·ha^{-1} (CONAB, 2010).

Obtaining high yields at an economically viable cost is the starting point for making cotton cultivation more competitive in the market. The recovery of Brazilian cotton production can benefit directly from this increased competitiveness, thus favoring the opening of internal and external markets.

Rational and efficient fertilization occupies a prominent place among the factors that directly influence agricultural productivity, allowing gains in quantitative and qualitative aspects. Because they represent a considerable share of production costs, fertilizers and their more efficient and rational use deserves greater attention from farmers.

In the case of cotton crop, nitrogen is among the most responsive factors for production increase (Teixeira *et al*., 2008). Nitrogen fertilization deserves some attention when accounting for a proper crop management. Such practice allows not only an increase in production, but also increases the farmer's net revenue and profit, also allowing to achieve production stability, proper balance of nutrients and environmental preservation.

When performed properly, nitrogen fertilization of cotton crops provides the stimulation of growth and flowering, regulates the plant cycle, increases productivity and improves the characteristics of the fiber (Beltrão, 1999). Incorrectly applied, when in shortage, it leads to reduced growth, stems with short internodes, fall of flowers and fruit buds, causing a significant decrease in final yield. When applied in excess, nitrogen fertilization can favor an exagerated vegetative growth (Furlani Junior *et al*., 2003), resulting in reduced formation of reproductive structures and low productivity (Beltrão, 1999).

Currently, the recommendation of nitrogen fertilization is among the most discussed issues regarding cotton cultivation. The present recommendation is based on the aimed productivity and the history of the area, mainly due to the lack of a careful study, based

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ESTUDO ECONÔMICO DO MANEJO DE NITROGÊNIO EM CULTIVOS DE ALGODÃO

Nericlenes Chaves Marcante e Marcos Antonio Camacho

RESUMO

*O algodão (*Gossypium hirsutum *L.) é um dos cultivos mais importantes no Brasil. A fertilização racional e eficiente ocupa um lugar proeminente no conjunto de fatores que influem de maneira direta na produtividade agrícola. O objetivo deste estudo foi calcular a dose mais econômica de nitrogênio para o cultivo de algodão. O experimento foi conduzido em um Argissolo Vermelho-Amarelo (Oxissolo). O desenho experimental foi em bloco completo ao acaso. Os tratamentos resultaram em doses ascendentes de nitrogênio de 0, 40, 80, 120 e 160kg·N·ha^{-1} aplicados em superfície em duas fases. A curva de resposta aos níveis ascendentes de fertilização nitrogenada foi ajustada por uma expressão quadrática. A dose mais econômica de fertilizante para a produção de algodão resultou ser de 88,3kg·N·ha^{-1}, com a qual se estimou um rendimento de 3555.5kg·ha^{-1}*

on soil chemical analysis, which could allow the best recommendation to the farmer (Carvalho *et al.*, 2006). It is recommended that the amount to be applied at sowing be split into two periods, applying it on the surface, especially in areas with low levels of soil organic matter (Carvalho *et al.*, 2006).

The nitrogen uptake by cotton plants is directly influenced by climatic conditions, cultivar and soil type, complicating the determination of nutritional requirements of malvaceae plants. In the Brazilian Cerrado region, the lack of studies on which to base the recommendations for nitrogen fertilization of cotton crops makes it impossible to achieve an economically viable production.

The aim of this study was to evaluate the effects of nitrogen on cotton production through the calculation of the most economical nitrogen dose for the crop.

TABLE I
CHEMICAL ANALYSIS OF THE RED-YELLOW ARGISOL (OXISOLS)

Layers cm	pH $CaCl_2$	M.O. g·dm^{-3}	P (Melihch-3) mg·dm^{-3}	K	Ca	Mg	(H+AL)	SB	T	Al	V
				cmol·dm^{-3}							%
0-20	5.5	18	42.4	0.3	4	1.1	3.7	5.4	9.1	0.1	59
20-40	5.6	11	19	0.1	3.2	0.6	3.3	3.92	7.2	0.1	54

Materials and Methods

The study was carried out in Aquidauana City, Mato Grosso do Sul State, located at 20°28’S and 55°40’W, at an average altitude of 207m. The climate, according to Köppen classification, belongs to the type Aw (tropical wet), with rainy summers, dry winters and annual rainfall of ~1200mm, concentrated from November to February, and maximum and minimum temperatures of 33°C and 19.6°C, respectively. The soil was classified as Red-Yellow Argisol (Oxisols) according to Embrapa (1999).

Soil sampling was performed throughout the experimental field before the culture setting, at 0-20 and 20-40cm in depth, collecting 20 subsamples for fertility analysis, as recommended by Raij *et al.* (2001). The results of chemical analysis are shown in Table I.

The experimental design was a randomized complete block with five treatments and five replications. The treatments consisted of nitrogen applied on the surface at doses of 0, 40, 80, 120 and 160kg of N ha^{-1}.

Soil preparation was carried out with conventional methods, disc harrow followed by a leveling harrow. After preparing the soil, millet (*Pennisetum glaucum*) was sowed in order to form a ground cover for no-tillage cotton crops. Sowing was performed manually, maintaining an average density of 14 plants/m. At sowing, fertilization consisted in the application of 10, 35 and 40kg·ha^{-1} of N, K_2O and P_2O_5, respectively, as urea, potassium chloride and superphosphate (Souza and Lobato, 2004). Each experimental block measured 35×5.4m. Each block was divided into five parts, measuring 7×5.4m each, and each of them received a different dose of N.

The cotton (*Gossyppium hirsutum* L.) variety used was NuOpal®, using supervised seeds, delinted and chemically treated. Weed, pests and pathogens control, and the application of growth regulators, followed specifications from Embrapa (2003) recommendations.

Nitrogen fertilization, as urea, was carried out in two phases: one half of the total dose was applied at the flower buds appearance (B1 and B3), 42 days after sowing, and the other half dose was applied with the appearance of first flower (F1), 57 days after sowing,. The nitrogen fertilizer was applied at the side of the sowing row.

Leaf samples were collected as indicated by Oliveira (2004), collecting the limbo of the fifth leaf from the apex on the main stem, at the beginning of blooming. These samples were analyzed for nitrogen using the method described by Malavolta *et al.* (1997).

For each plot a floor area comprised of three central rows was assigned. Bolls were collected from plants found within 2m of these central ranks. The production was estimated after the boll collection, depending on the weight of the fibers and seeds (equivalent to commercial cotton). The data were transformed into kg·ha^{-1}.

The amount of nitrogen resulting more economical for the cultivation of cotton was calculated as recommended by Raij (1991) and Zebarth *et al.* (1991).

To perform the calculation of the most economic dose, the market price paid by the industry per ton of cotton in 2010, of R$270.00, was used. The cost per ton of urea was R$650.00. But, assuming that for large scale production other costs are also associated to that of the fertilizer, such as time of the machine used to apply it and the cost of the machine operator, a total cost of the fertilizer + application costs of R$905.00 was used.

Considering the problem of a variable exchange rate and the large variation in prices paid per ton of cotton, it was chosen to use the exchange ratio in place of currency, as used by Natale *et al.* (2010). Thus, cotton was used as currency in the calculations, using the ratio of ton of N applied/ ton of cotton paid by industry in 2010. However, as only 40% of urea consists of nitrogen, a conversion to know the value of one ton of pure N is needed, obtaining R$1625.00.

After that conversion is made, a ratio of ton of N applied/ton of cotton can be calculated, giving R$1,625/R$270= 6.02. Through the derivation of the regression equation between the cotton production and increasing levels of nitrogen it is possible to calculate the most economical dose. Taking into account the exchange ratio, consider $dy/dx= a_1+2a_2x=$ exchange ratio (Natale *et al.*, 2010). The most economical dose (x') is, then, calculated as

$$x'=\frac{a_1 \text{ - echange ratio}}{2.(-a_2)} \qquad (1)$$

Results and Discussion

The average cotton yields obtained as a result of the application of different doses of nitrogen are shown in Figure 1. It can be seen that the response slope to nitrogen fertilization follows a quadratic expression, as occurred with increasing levels of nitrogen doses.

The most economical dose is defined as the quantity of fertilizer or nutrient applied to obtain the maximum prescription by growing area (Raij, 1991), showing the maximum distance between the line of input cost and the culture cost-response curve to the application of the input (Natale *et al.*, 1996).

Using the regression equation provided in Figure 1 and applying the derivation of Eq. 1, as demonstrated by Raij (1991), it was possible to calculate the most economical dose of nitrogen fertilizer for cotton production (x') as

$$x'= \frac{70.298 - 6.02}{2.(0.634)}$$

which amounts to 88.3kg·ha^{-1} of N or 220.75kg·ha^{-1} of urea.

From the most economical dose, it is possible to calculate the increase in productivity caused by N fertilization in cotton crops by replacing the x from the equation given by the most economical dose.

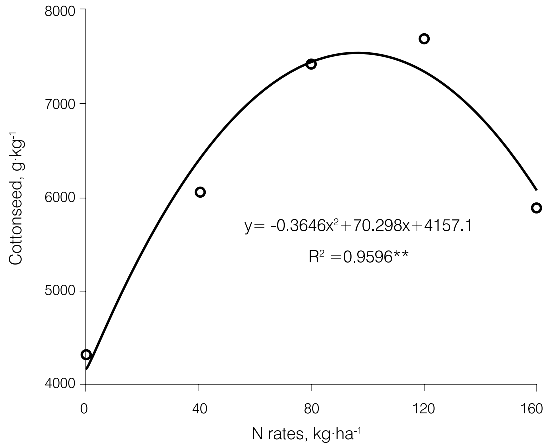

Figure 1. Effect of increasing doses of nitrogen on the yield of cotton.

In the equation in Figure 1 it can be appreciated that productivity without the use of nitrogen fertilizer (control) was 4157.1kg·ha^{-1} of cotton. Applying the most economical dose to the equation an increase in productivity caused by N fertilization is obtained, reaching 7521.7kg·ha^{-1}. Subtracting from this value the value of productivity without the use of nitrogen fertilizer shows an increase of 3364.57kg·ha^{-1} (80.9%) in productivity of the cotton crop by surface application of nitrogen fertilizer in two applications.

In studies of the influence of increasing levels of nitrogen on cotton yield using the same system, it was possible to calculate the most economical dose. Analyzing the cotton growth and yield, Teixeira *et al.* (2008) obtained a quadratic equation in the regression performed for the yield as a function of increasing doses of nitrogen. By using the same exchange ratio obtained in this study it was possible to calculate the most economical dose for that work, which was 61.05kg N ha^{-1}, reaching a cotton yield of 3555.5kg·ha^{-1}. Comparing these values with the present study, it is found that the economic dose of 88.3kg·ha^{-1} gave a yield 47.2% higher than the one found by Teixeira *et al.*, (2008), but it is noteworthy that different cultivars were used in the two studies.

Evaluating irrigation management and the influence of different doses of nitrogen, Guerra *et al.* (2002) found that under a water system at 500kPa, nitrogen fertilization produced significant yield increases, up to 120kg·ha^{-1}, whereas higher doses caused an excessive vegetative growth of plants, leading to a decrease in productivity. The most economical dose calculated for the study performed by Guerra *et al.* (2002) was 127.12kg of N ha^{-1}, and gave a yield of 5114kg·ha^{-1}, comparable to the present study. It was observed that the most economic dose was 43.96% higher, and yet the yield was 47.1% lower. This happened due to excess water applied by irrigation. With too much water nitrogen may have been leached into a region of soil poor on roots, impairing the use of the applied nitrogen fertilizer (Rosolem, 2001).

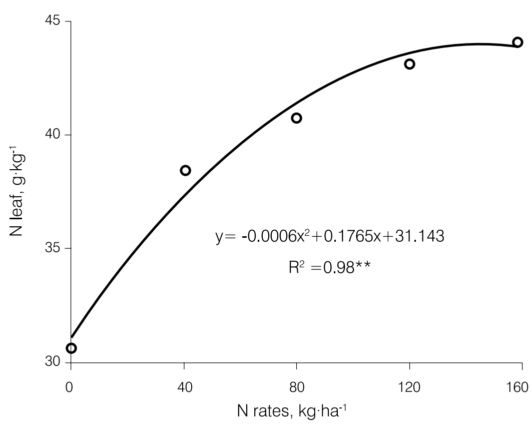

Figure 2. Content of leaf nitrogen in cotton plants as a function of nitrogen fertilization in covering.

Figure 2 shows the leaf nitrogen content in cotton as a function of nitrogen in surface fertilization. It can be noted that the regression equation behaved in a quadratic way, according to the equation productivity (Figure 1) showing that upon increasing the amount of nitrogen fertilizer applied, the nitrogen gain in cotton leaves is not linear. Therefore, it is clear that the increase in cotton productivity is directly correlated with leaf nitrogen content present in the plant (Figure 3). The decline in productivity occurs due to an increase in the plant vegetative cycle, directly interfering the allocation of assimilates to the formation of reproductive structures, that is, formation of clubs (Furlani Junior *et al.*, 2003), resulting in a reduced productivity.

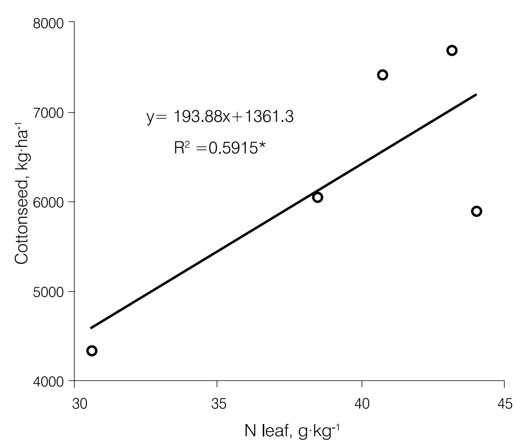

Figure 3. Cottonseed as a function of N leaf content.

The recommended leaf N content in cotton, according to Malavolta (1992), is between 35 and 40g·kg^{-1}. Analyzing Figure 2, it is observed that for the most economical dose (88.3kg·ha^{-1}), the leaf content was 42g·kg^{-1}, close to that recommended.

In terms of cost of nitrogen fertilizer for cotton production, it is observed that it represented only 1.18% of the revenue from the application of the input, which clearly reflects the compensatory use of surface nitrogen application for the cotton crop, noting that it was used as currency exchange ratio for the calculation.

The maximum technical efficiency of nitrogen fertilizer obtained in this study was 96.4kg·ha^{-1}, having an average productivity of 7545kg·ha^{-1}. It is noted that the most economical dose equivalent to 99.0% of the values of maximum productivity achieved by a cotton plant and 9% less ion terms of expenses, demonstrating the benefits achieved with the use of nitrogen fertilizer.

Some studies have reported that applied surface nitrogen promoted a linear increase in cotton productivity, other than that obtained in this study, not reaching the dose that gave maximum crop productivity and making it impossible to calculate the most economical dose. Lima *et al.* (2006) observed that the production of BRS green cotton cultivar behaved linearly when surface nitrogen was applied up to 240kg·ha^{-1}. Carvalho *et al.* (2006), in a study conducted in four cities in Goiás State, reported nitrogen doses were increased up to 162kg·ha^{-1}, showing increases in cotton yield.

Conclusion

The cotton crop responded positively to nitrogen application, with the most economic level of 88.3kg N ha^{-1}, which promoted a profit of 3555.5kg·ha^{-1} of cotton.

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