academicJournals

Vol. 12(9), pp. 716-722, 2 March, 2017
DOI: 10.5897/AJAR2016.11338
Article Number: DA210BA62995
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Economic viability of the canola crop with nitrogen applied in coverage in no-tillage system in Corbélia-PR, Brazil

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Received 21 June, 2016; Accepted 26 July, 2016

It is essential for the farmer, to have information of cultural costs when deploying a new crop or new technology. The cost of the study allows decision making for new technologies and use of viable inputs in production (Richetti, 2011; Souza et al., 2012). Zimmermann (2005), when studying technical and economic viability of canola crops, stated that canola is economically viable. The aim of this work was to assess the economic viability of different quantities of nitrogenous fertilizers applied in coverage of canola (Hyola 61) crop. The experiment was conducted in a eutrophic Red Latosol, with geographic location of 24°49'06" south latitude and 53°16'44" west longitude, altitude of 682 m and presents subtropical (Cfa) climate, in the Agrícola Andreis experimental farm, in Corbélia, Paraná. The experimental design consisted of randomized blocks with four replications and seven treatments, totaling 28 plots with an area of 31.5 m^2 each. Quantities used to verify canola response were: T1 to 0 kg ha^{-1} N (control); T2 to 25 kg ha^{-1} N; T3 to 50 kg ha^{-1} N; T4 to 75 kg ha^{-1} N; T5 to 25 kg ha^{-1} N + 27 kg ha^{-1} S; T6 to 50 kg ha^{-1} N + 54 kg ha^{-1} S (both in solid form) and T7 to Micro Xisto HF (liquid form) foliar fertilizer. An F-test (Analysis of Variance) was used in order to verify statistical difference among treatments, followed by Tukey's means comparison test, at 5% significance. Grain yield presented a statistically non-significant tendency to increase. Nitrogen top dressing did not provide economic return for the climatic conditions observed in this harvest.

Key words: *Brassica napus* L. var. oleifera, fertilizer, production.

INTRODUCTION

The first canola crops were cultivated in 1974 by Cooperativa Regional Tritícola Serrana Ltda – Cotrijuí, in Rio Grande do Sul, as an alternative for fallow lands and in rotation with wheat crops during winter. In Paraná, crops started being cultivated in the beginning of 1980, whereas expansion of cropped areas only happened after 2001. According to the Brazilian Department of Agriculture and Supply (Seab, 2012), in 2011/2012, Paraná harvested

12,454 hectares of canola, amounting to a grain yield of 20,683 tons and average yield of 1,661 kg ha^{-1}.

Canola cultivation is a viable economical alternative for winter crops in rotation with wheat and winter maize, besides being an option for agro-energetic purposes (Tomm 2006). It is important to mention that crop rotation systems maximize sustainability and decrease phytosanitary issues that lower yield and increase production costs on commercial crops due to diversity of crops of different plant species. Another factor that might influence in canola crop yield is the availability of nutrients in the soil, mainly nitrogen and sulfur. Normally, there is a deficiency of these two compounds in acid soils with low levels of organic matter, as stated by Tomm (2007). Nitrogen is the most requested nutrient and the one that most influences crop production whenever the remaining nutrients are found in satisfactory levels (Freitas et al., 2010; Melo et al., 2011).

Rheinheimer et al. (2007) observed that the areas with the largest canola crops in Brazil presented a deficiency of sulfur, mainly due to intense use of concentrated fertilizers without sulfur in their formulation and continuous extraction caused by harvesting. The reduction in organic matter quantity due to lack of crop rotation and increase of mineralization is another factor that contributes to sulfur decrease in the soil. Even with the incentive given by the state of Paraná to canola cultivation, it is important to assess the economic viability of this oilseed when setting up a new business. In the opinion of Richetti (2011) and Souza et al. (2012) the study of costs for implementing a crop aims to assist decision making, as well as adopting technologies and using inputs to obtain the best results in agricultural production.

Zimmermann (2005), when studying technical and economic viability of canola crops, stated that canola is economically viable and, in addition to being another option in winter crop rotation, it also makes possible to break pest and disease cycles. According to Souza et al. (2012), the gross revenue of a business is obtained by multiplying the total yield by the product unit value. Total business cost is given by the sum of all factors involving production cost, such as: applied agricultural inputs; performed agricultural operations; business administration; depreciation of improvements, machinery and equipments; cost, capital and land remuneration. Net earnings correspond to the difference between gross revenue and total cost. The business is only economically viable when the return is positive. This work aimed to assess productivity behavior and production cost of a canola crop under no tillage in function of nitrogen and sulfur top treatments.

MATERIALS AND METHODS

The experiment was carried out at Agrícola Andreis experimental farm in Corbélia, Paraná, in a typical Eutrophic Oxisol according to the Brazilian System of Soil Classification SiBCS (2009), with clay content superior to 65% according to laboratorial analyzes from Solanálise (2010). The farm is located at south latitude 24°49’06” and west longitude 53°16’44”, altitude of 682 m and presents subtropical (Cfa) climate, as specified by Köppen’s classification Iapar (2012).

The seeder/fertilizer set was used in the experiment, model PST3, with 7 rows, intra-row spacing of 45 cm and 10 m of length, loaded with canola Hybrid Hyola 61, covering an area of 31.5 m^2 for each plot of the treatment, with two border lines, as suggested by Tomm (2007) for the no tillage. The dose of 280 kg ka^{-1} of 10-18-18 NPK fertilizer, corresponding to 28 kg ha^{-1} N, 50 kg ha^{-1} P_2O_5 and 50 kg ha^{-1} K_2O, was used in the base fertilization. The sowing depths used consisted of 2 to 3 cm, with density of 25 seeds per meter, to provide a final density of at least 40 plants per square meter (Tomm et al., 2009).

Nitrogen and sulfur were top dressed manually 5 cm away from the canola row and foliar fertilizer application was done with an electric knapsack sprayer with 80 L ha^{-1} mixture, 45 days after emergence with damp soil (Tomm et al., 2009). The experiment design consisted of randomized blocks with four replications and seven treatments, totaling 28 plots, with an area of 31.5 m^2 each (Gomes, 1987). Treatments were conducted with seven different quantities of nitrogen and sulfur: T1: 0 kg ha^{-1} N (control); T2: 25 kg ha^{-1} N; T3: 50 kg ha^{-1} N, T4: 75 kg ha^{-1} N; T5: 25 kg ha^{-1} N + 27 kg ha^{-1} S; T6: 50 kg ha^{-1} N + 54 kg ha^{-1} S (both in solid form) and T7: 0.45 L ha^{-1} N + 0.1L ha^{-1} S (liquid form). The commercial fertilizers employed were: CO $(NH_2)_2$ (urea), as source of N; $(NH_4)_2$ $S0_4$ (ammonium sulfate), as source of N + S, and Micro Xisto HF foliar fertilizer, as source of N + S.

To keep the standard of the desired plants, pesticides had to be used to control pests. Therefore, *Diabrotica speciosa* (Germar) and *Elasmopalpus lignosellus* (Zeller) were controlled by means of spraying with a sprayer bar, employing pesticides Novalurom 15 g i.a ha^{-1} + Esfenvalerate 10 g i.a ha^{-1} with a mixture of 130 L ha^{-1} at the beginning of pest attack, 11 days after canola emergence (Domiciano and Santos, 1996; Zimmermann, 2005; Tomm et al., 2009).

The assessment of productivity was given by the total manual harvest of each treatment sample and converted into kg ha^{-1} according to Krüger et al. (2011). The economic return of each treatment was achieved by verifying variable costs (employed inputs and labor) added to the capital cost (depreciation of improvements, machinery, equipment and land remuneration), subtracted from the gross revenue, which is obtained by means of grain revenue (Carvalho 2011; Souza et al. 2012). An F-test (Analysis of Variance) was used in order to verify statistical difference among treatments, followed by Tukey’s means comparison test, both at 5% significance (Gomes, 1987). Model presumptions were verified by applying Hartley's Fmax test for homogeneity of variances and Shapiro-Wilk’s test for normality. Software ASSISTAT 7.6 beta was used for data analysis (Silva and Azevedo, 2009). Production variables as well as costs generated by

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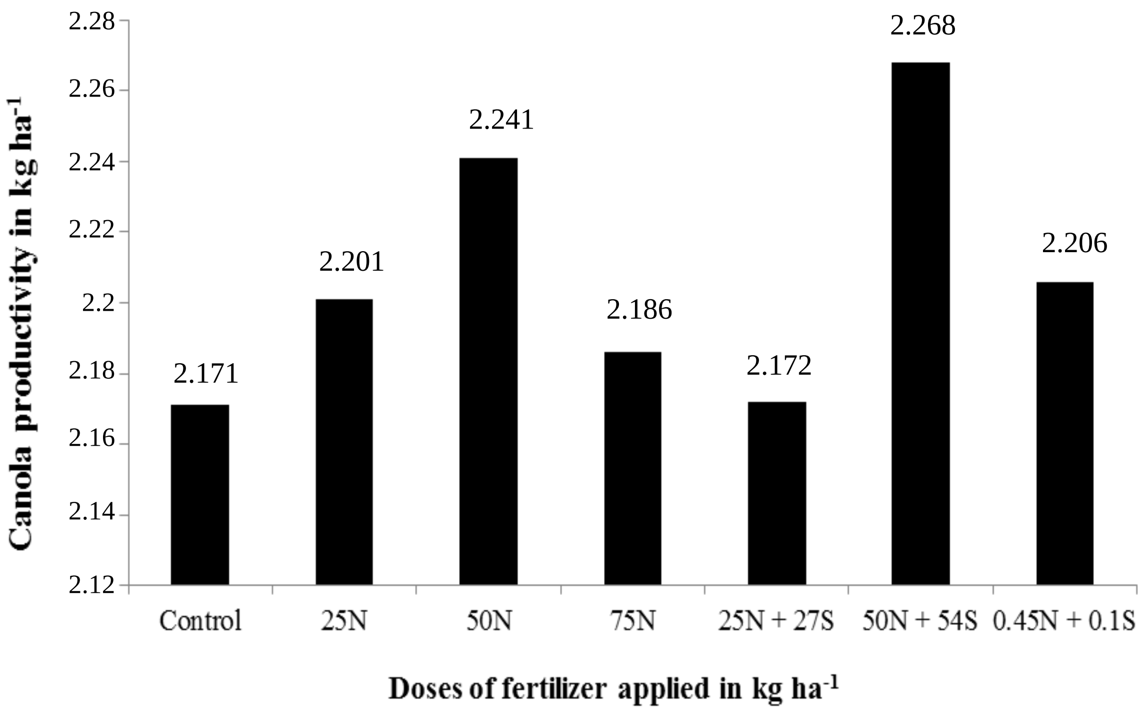

Figure 1. Canola production in kg ha^{-1} as a function of the different amounts of fertilizer applied.

each treatment were considered when determining the most indicated and economically viable treatment to obtain higher yield in oil production.

RESULTS AND DISCUSSION

Figure 1 shows the average values in canola productivity in kg ha^{-1} as a function of nitrogen (N) and sulfur (S) doses as top treatments (control = 0 kg ha^{-1} N; 25 N = 25 kg ha^{-1} N; 50 N = 50 kg ha^{-1} N; 75 N = 75 kg ha^{-1} N; 25 N + 27 S = 25 kg ha^{-1} N+ 27 kg ha^{-1} S; 50 N + 54 S = 50 kg ha^{-1} N + 54 kg ha^{-1} S and 0.45 N + 0.1 S = 0.45 L ha^{-1} N + 0.1 L ha^{-1} S (foliar fertilizer). Canola productivity in kg ha^{-1} as a function of the doses of nitrogen applied as top dressings in the treatment of 50 kg ha^{-1} N presented an increase of 70 kg ha^{-1} in comparison to the control, whereas, in the treatment with 75 kg ha^{-1} the yield increase was only 15 kg ha^{-1}. As for treatments with nitrogen + sulfur, there was a grain yield increase of 97 kg ha^{-1} in the treatment with 50 N + 54 S kg ha^{-1} in comparison to the control. The treatment with liquid nitrogen showed a yield increase of 35 kg ha^{-1} when compared to the control. Even though all treatments presented an increase in canola grain yield, such productivity was not statistically significant at a level of 5%.

According to Osório Filho et al. (2007), the lack of response to the sulfur added to the soil, may be related to the intake of atmospheric sulfur by rainwater, even in demanding crops. Jackson (2000) obtained results that differed from the ones found in this study in a research on canola productivity with five different experimental conditions and observed spring canola responses to different amounts of nitrogen and sulfur. In a study with nitrogen doses ranging from 50 to 200 kg ha^{-1}, Öztürk (2010) obtained a 47% increase in grain yield with a treatment that received 150 kg ha^{-1} N.

Borsoi et al. (2010) studied the effect of nitrogen and sulfur on Hybrid Hyola 43 and obtained statistically significant differences compared to the control with treatments with 38 kg ha^{-1} (urea) and 17 N + 18 S kg ha^{-1} (ammonium sulfate). The treatment with sulfur + nitrogen increased the yield in 20.9%. Karamanos et al. (2007) obtained an increase of 23.7% in canola yield with the use of nitrogen and sulfur in soils lacking these nutrients. Gao et al. (2010) in a study on canola yield with the application of 84 and 168 kg ha^{-1} N in two locations did not obtain any increase in grain yield. The same was observed by Rigon et al. (2010) when assessing canola response to sulfur and nitrogen applied to the cover in plots. The behavior of fenometric variables depending on fertilization of nitrogen applied to the coverage (Figure 2) shows regression curves obtained for the average values of the number of siliquas per plant, mass of a thousand grains, Canola production in kg ha^{-1}, and Canola oil content. It can be seen in Figure 2a that the number of

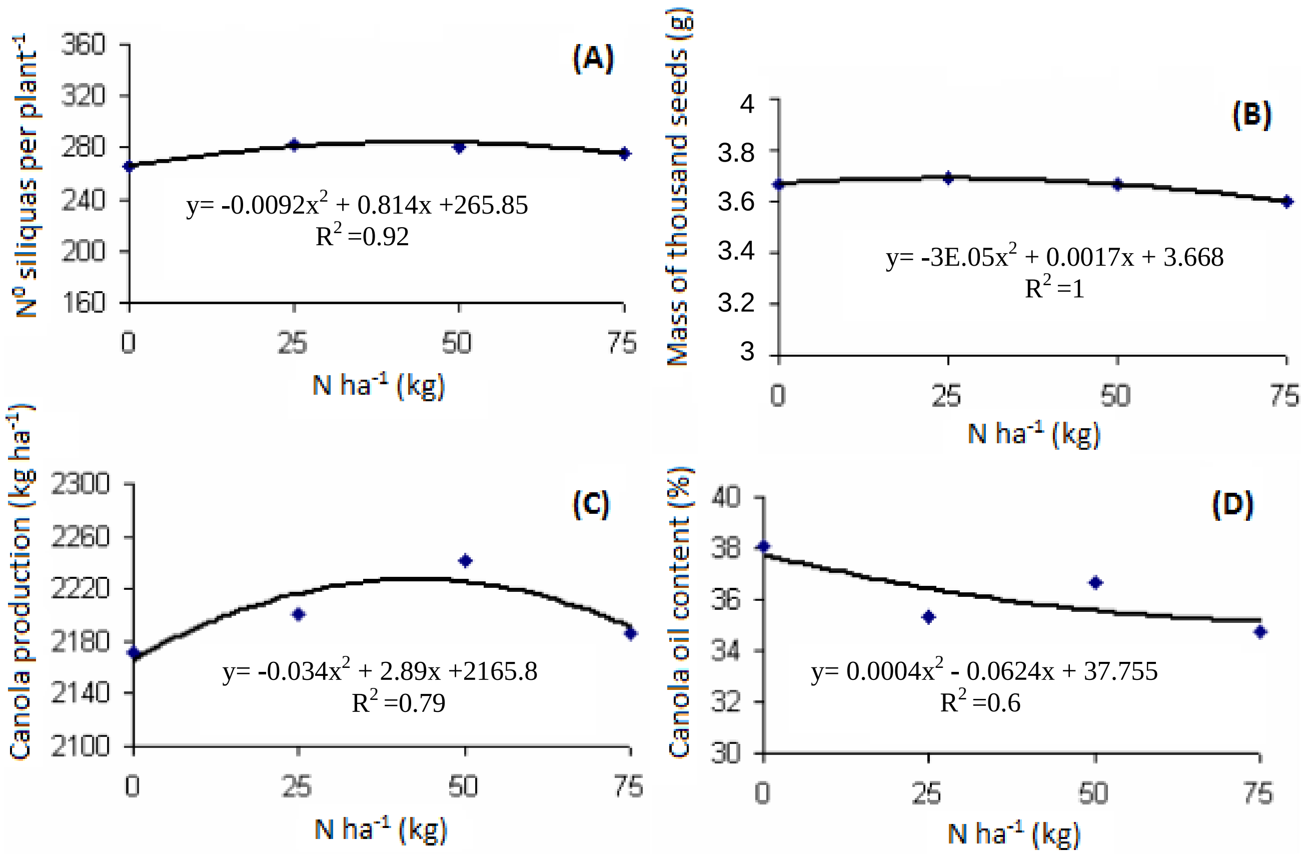

Figure 2. Curves obtained for average values of number of siliquas per plant (A), mass of a thousand seeds (B), Canola production in kg ha^{-1} (C), and Canola oil content (D) according to the fertilization of N applied to the coverage.

Table 1. Canola economic return according to the amounts of nitrogen and sulfur applied as top treatments in one hectare in 2011.

Variables	T1	T2	T3	T4	T5	T6	T7
				R\$ ha^{-1}			
Gross revenue	1,519.76	1,540.94	1,569.33	1,530.36	1,520.18	1,587.63	1,544.77
Total cost	890.82	977.37	1,048.92	1,120.47	1,005.11	1,104.39	932.40
Net earnings	628.94	563.57	520.41	409.89	515.07	483.24	612.37

T1 = 0 kg ha^{-1} N (control); T2 = 25 kg ha^{-1} N; T3 = 50 kg ha^{-1} N; T4 = 75 kg ha^{-1} N; T5 = 25 kg ha^{-1} N + 27 kg ha^{-1} S; T6 = 50 kg ha^{-1} N + 54 kg ha^{-1} S and T7 = 0.45 L ha^{-1} N + 0.1 L ha^{-1} S (foliar fertilizer).

siliquas per plant follows a quadratic relationship, reaching the maximum point between 25 and 50 kg of N ha^{-1} (in the amount of 44.24 kg N ha^{-1}). The Figure 2b presents the regression curve for the mass of thousand grains according to the doses of nitrogen applied coverage; it is observed that the maximum mass point is obtained between 25 and 50 kg N ha^{-1} (in the value 28.33 kg of N ha^{-1}). In Figure 2c, the productivity kg ha-1 follows a quadratic relation, reaching the maximum point between 25 and 50 kg N ha^{-1} (in the value 42.50 kg of N ha^{-1}). It is observed that the grains in oil content in Figure 2d, decreases as the coverage fertilization with nitrogen increases. Similar results were obtained by Ahmad et al. (2007) when studying Canola´s response to nitrogen fertilization. Jackson (2000) stated that canola decreases seed oil content when larger quantities of nitrogen are applied, possibly due to the delay in the crop´s maturation. Another probable cause of this reduction in oil content is the fact that such nutrient is one of the main components of proteins that leads to an increase in

Table 2. Canola total cost (R$ ha^{-1}) and relative cost in one hectare according to the amounts of nitrogen and sulfur applied to the cover in 2011.

Treatments	Variables	
Kg (ha^{-1}) of N and S	**Total cost in R$ (ha^{-1})**	**Relative cost**
T1	890.82	100
T2	977.37	109.7
T3	1,048.92	117.7
T4	1,120.47	125.8
T5	1,005.11	112.8
T6	1,104.39	124.0
T7	932.40	104.7

T1 = 0 kg ha^{-1} N (control); T2 = 25 kg ha^{-1} N; T3 = 50 kg ha^{-1} N; T4 = 75 kg ha^{-1} N; T5 = 25 kg ha^{-1} N + 27 kg ha^{-1} S; T6 = 50 kg ha^{-1} N + 54 kg ha^{-1} S and T7 = 0.45 L ha^{-1} N + 0.1 L ha^{-1} S (foliar fertilizer).

protein percentage and a decrease in oil content (Öztürk, 2010). Table 1 shows the economic return of the canola crop according to the amounts of nitrogen and sulfur applied as top treatments.

The experiment showed that the highest net earnings were obtained with T1, which did not receive any nitrogen or sulfur to its cover, whereas, the lowest net earnings were verified in the treatment that received 75 kg ha^{-1} nitrogen to its cover. Such results are similar to those obtained by Souza et al. (2012), in a study on maize response to nitrogen and sulfur fertilization, this was applied as top treatments in doses of 100, 150 and 200 kg ha^{-1}, in harvests 2008 and 2009. Canola production cost was higher with the addition of nitrogen sources applied to the cover, which ranged from R$ 890.82 to R$ 1,120.47 ha^{-1} for treatments without N and with 75 kg ha^{-1} N, respectively (Table 1). Relative costs in one canola hectare, according to the applications of nitrogen and sulfur to the cover, are described in Table 2. The treatment which received 75 kg ha^{-1} N had an increase of 25.8% in production cost when compared to the control treatment, which did not receive N to its cover. The production cost with applications of 50 N + 54 S kg ha^{-1} was 1.8% lower with the application of 75 kg ha^{-1} N to the cover. The treatment that received foliar fertilizer application had the lowest relative cost increase in relation to the control treatment. The participation of variables that constitute the production cost of a canola hectare is shown in Table 3.

The total canola cost in one hectare was 21.21 sacks for the treatment without nitrogen as top dressing and 26.68 sacks for the treatment that received 75 kg ha^{-1} N. For this treatment, the cost increase was 5.47 sacks ha^{-1} and the canola production increase was 15 kg ha^{-1} (0.25 sacks ha^{-1}). The treatment with 50 kg ha^{-1} N provided an increase of 70 kg ha^{-1} (1.17 sacks) in production and the cost increase was 3.76 canola sacks ha^{-1}. The treatment with 50 N + 54 S kg ha^{-1} presented a production increase of 97 kg ha^{-1} (1.62 sacks) and the cost increase was 5.08 canola sacks ha^{-1}. The treatment with foliar fertilizer had a cost increase of 2.06 sacks ha^{-1} and a canola production increase of 35 kg ha^{-1} (0.58 sacks). The cost with nitrogen fertilizers applied to the cover was higher than the addition to the canola production cost in all treatments. By considering the participation of nitrogen fertilizers applied as top treatments in one hectare in the total canola cost, one can verify that the variation ranges from 0% (for the treatment that did not receive cover fertilization) to 19.19% (for the treatment that received 75 kg ha^{-1} de N).

Conclusion

Canola productivity did not present significant statistical difference in all treatments with cover fertilization. The gross income obtained with canola decreased with the applications of nitrogen to the cover. Nitrogen fertilization applied as top dressing did not provide economic return in this harvest under the climatic conditions observed. It concludes also that it is important to perform technology diffusion activities to increase canola yield. The environmental education, agricultural and vocational education for rethinking management proposals is for new farmers of canola cultivation. The internationalization of small and medium enterprises (SMEs) is towards canola exporting at a wider marketplace. The social acceptability or competitive land use of other prosperous and prolific cultivation species, were applicable. The governmental policies and political initiatives helped in strengthening the perspectives of the canola future.

Conflict of interest

The authors have not declared any conflict of interest.

Table 3. Variables of production cost of one hectare of canola under no tillage in the city of Corbélia, Paraná, harvest 2011 for family farming.

Cost components	T1	T2	T3	T4	T5	T6	T7
		--%--					
1. Inputs							
Canola seeds	12.80	11.66	10.87	10.17	11.34	10.32	12.23
Maintenance fertilizer	40.92	37.30	34.76	32.54	36.27	33.01	39.1
Herbicides	1.71	1.56	1.45	1.36	1.51	1.38	1.63
Cover fertilizer	0.00	7.32	13.64	19.16	9.89	17.98	3.22
Insecticides	2.05	1.87	1.74	1.63	1.82	1.65	1.96
2. Agricultural operations							
Sowing	4.37	3.98	3.71	3.47	3.87	3.52	4.17
Herbicide application	1.30	1.19	1.10	1.03	1.15	1.05	1.24
Insecticide application	1.30	1.19	1.10	1.03	1.15	1.05	1.24
Fertilizer application	0.00	1.54	1.43	1.34	1.49	1.36	1.24
Mechanical harvest	10.10	9.21	8.58	8.03	8.95	8.15	9.65
3. Other costs							
Manpower	4.58	4.17	3.89	3.64	4.06	3.69	4.38
Technical assistance	1.75	1.59	1.49	1.39	1.55	1.41	1.67
Agricultural insurance (Proagro)	1.75	1.59	1.49	1.39	1.55	1.41	1.67
4. Depreciations							
Improvement depreciation	2.37	2.16	2.01	1.88	2.10	1.91	2.26
Machinery depreciation	7.10	6.47	6.03	5.65	6.30	5.73	6.79
Equipment depreciation	4.99	4.55	4.24	3.97	4.42	4.03	4.77
5. Remuneration of factors							
Land remuneration (3% land value)	2.91	2.65	2.47	2.32	2.58	2.35	2.78
Total	100	100	100	100	100	100	100
		----------------------------------**Sacks (ha^{-1})**----------------------------------					
Cost in 60-kg sacks	21.21	23.27	24.97	26.68	23.93	26.29	22.20

T1 = 0 kg ha^{-1} N (control); T2 = 25 kg ha^{-1} N; T3 = 50 kg ha^{-1} N; T4 = 75 kg ha^{-1} N; T5 = 25 kg ha^{-1} N + 27 kg ha^{-1} S; T6 = 50 kg ha^{-1} N + 54 kg ha^{-1} S and T7 = 0.45 L ha^{-1} N + 0.1 L ha^{-1} S (foliar fertilizer).

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