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Nitrogen and sulfur applied to the coverage of a canola crop in no-tillage system

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Canola (*Brassica napus* L. var. oleifera) is an oilseed that belongs to the *Brassicaceae* family and has in its grains a content of 38% oil and 27% protein. The aim of this work was to evaluate the interference of different quantities of nitrogen fertilizer applied to the coverage of the Canola crop on direct and indirect components of the production of grains and oil. In that sense, an experiment with the Canola culture was implemented, in succession to the culture of soybean, with hybrid Hyola 61, under no-tillage system, in a soil classified as Eutrophic Red Latosol, located at 24°49'06" S and 53°16'44" W, in the experimental area of Andreis Agricultural Farm, in the municipality of Corbélia, Paraná State – Brazil. The experimental design used consisted of random blocks with 4 replications and 7 treatments, summing up to 28 plots, in an area of 882 m². For base fertilization, 28 kg ha^{-1} of N, 50 kg ha^{-1} of P_2O_5, and 50 kg ha^{-1} of K_2O were applied. Treatments consisted of control, 25 kg ha^{-1} of N, 50 kg ha^{-1} of N, 75 kg ha^{-1} of N, 25 kg ha^{-1} of N + 27 kg ha^{-1} of S, 50 kg ha^{-1} of N_2 + 54 kg ha^{-1} of S and 0.45 L ha^{-1} of N + 0.1 L ha^{-1} of S (foliar fertilizer Micro Xisto HF), applied to the coverage 42 days after the emergence of Canola seedlings. No significant statistical differences were observed among treatments on production components, except for oil content.

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

INTRODUCTION

The search for alternative and economically feasible plants for oil production is a constant matter in the Brazilian agriculture, mainly after the decision of using vegetal oils to produce biodiesel. In that sense, Canola culture, which has in its grains an average content of 38% oil, may represent an agronomically sustainable choice (Tomm et al., 2010). Canola is responsible for 15% of the total oil produced in the world. Its oil with low content of erucic acid and glucosinolates, and high content of omega 3 and vitamin E is also considered one of the healthier oils for human consumption, being recognized by medicine as a functional food (Brown et al., 2008). Such oilseed was already known in India 3000 years ago. In Europe, during the 13th century, its oil was

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Table 1. Chemical soil analysis, at depths 0 to 10 cm and 10 to 20 cm from the experimental area at Andreis Agricultural Farm. Corbélia – PR. 2011.

Depth	pH	H + Al	Ca	Mg	K	CTC	P	S	M.O	V
(cm)	$CaCl_2$	--------------------$Cmol_c dm^{-3}$--------------------					----$mg\ dm^{-3}$----		----------%--------	
0 - 10	5.4	4.96	6.79	2.08	0.23	14.06	10.80	1.50	4.66	64.72
10 - 20	5.0	6.21	4.88	1.85	0.20	13.14	3.80	3.90	3.58	52.74

Source: Solanálise Soil Analysis Laboratory, report no 11158 (2011).

used as a fuel to light cities and to lubricate ships. Its cultivation had world projection during the Second World War, due to its efficiency in lubricating ships, for being more resistant to water steam and high temperatures (Shahidi, 1990). Canola cultivation, according to Zonin et al. (2010), began in Brazil in the year of 1974 by a union called Tritícola Serrana Ltda - Contrijuí (RS), as an alternative for cultivation in fallow areas and in crop rotation with wheat during winter; at that time it was called Colza. In Paraná, the first crops occurred in the beginning of the 1980's. The expansion of the cultivated area started in 2001, already with the name Canola, which stands for "Canadian Oil Low Acid", for having less than 2% of erucic acid and less than 30 micromoles of glucosinolate. With the constant innovations that happen in agriculture, in the search for sustainable solutions, food production for humans and animals, and renewable sources of energy, Canola is one more option to the producer. It is a winter culture, which, due to its agronomic characteristics and climatic demands, meets the conditions to be incorporated in the system of grain production in the cold period of the year in Brazil (Casão Junior et al., 2012).

The development of the no-tillage system, as well as the need to keep the soil covered with straw during the whole year and to apply crop rotation, introduces Canola as a feasible option in periods and areas in which wheat production is economically unfeasible, such as fallow areas. Canola cultivation is efficient in the suppression of weed, pest and disease control, and also in the recycling of nutrients for increasing crop rotation and the sustainable production of grains (Franchini et al., 2011).

White mold, caused by fungus *Sclerotinia sclerotiorum* (Lib.) de Bary, has aroused wide concern by the productive sectors regarding research, mainly in the coldest Brazilian areas in which soybean, beans and Canola are produced. Fungus *S. sclerotiorum* (Lib.) de Bary is a cosmopolitan pathogen; it occurs both in temperate zones and in subtropical and tropical regions; apart from being a polyphagous fungus, it is characterized for infecting and being host for 408 species and 278 kinds of plants (Henneberg et al., 2012). In order to fully develop and produce grains, Canola requires climatic conditions, favorable soils and both macro and micronutrients in the soil solution for assimilation. Canola responds positively to nitrogen (N) and sulfur (S) when applied to the coverage during sowing (Öztürk, 2010). The present work aimed to verify the effect of different quantities of nitrogen fertilizers applied to the coverage under no-tillage system, on the direct and indirect components of grain and oil productivity of the Canola culture.

MATERIALS AND METHODS

The experiment was carried out at the research property of Andreis Agricultural Farm, in the municipality of Corbélia, Paraná State, Brazil, in a soil classified as typical Eutrophic Red Latosol according to SiBCS (2009), located at latitude: 24°49'06"S, longitude: 53°16'44" W, and altitude: 682 m above sea level. The climate is classified, according to Köppen's classification, as Cfa – sub-tropical (IAPAR, 2012). Soil fertility was verified at the study area with the collection of 2 compound samples of soil, collected at 0 to 10 cm and 10 to 20 cm depth, according to Gao et al. (2010) and analyzed at Solanálise Soil Analysis Laboratory. Soil analysis results based on the samples are shown in Table 1.

The experiment was implemented with plots of 7 lines, with distance of 45 cm between lines and 10 m long, with Canola hybrid Hyola 61, totalizing an area of 882 m² in no-tillage system (April,19) in the year of 2011. As for base fertilization, 280 kg ka^{-1} of chemical manure NPK were used, in the formula of 10.18.18, which corresponds to 28 kg ha^{-1} of N, 50 kg ha^{-1} of P_2O_5 and 50 kg ha^{-1} of K_2O (Tomm et al., 2010).

In order to keep the standards of desired plants, pests *Diabrotica speciosa* (Germar) and *Elasmopalpus lignosellus* (Zeller) were controlled by ground pulverization with a bar sprayer using pesticides Novalurom 15 g i.a ha^{-1} + Esfenvalerate 10 g i.a ha^{-1}, in a 130 liters ha^{-1} syrup at the beginning of pest attack, 11 days after the emergence (May, 07) of canola, in principal growth Stage 1, with the first leaf unfolded (Meier, 2001; Tomm et al., 2009).

Nitrogen and sulfur were manually applied to the coverage to the line at 5 cm from the Canola plants; foliar fertilizer was also applied with the use of an electric backpack sprayer in syrup of 80 L ha^{-1}, 42 days after the emergence of seedlings with damp soil, on the 07 June, when the plants was in principal growth Stage 1, with the fourth leaf unfolded (Meier, 2001; Tomm et al., 2009). Treatments consisted of 7 different quantities of nitrogen fertilizers: T1: Control; T2: 25 kg ha^{-1} of N; T3: 50 kg ha^{-1} of N; T4: 75 kg ha^{-1} of N; T5: 25 kg ha^{-1} of N + 27 kg ha^{-1} of S; T6: 50 kg ha^{-1} of N + 54 kg ha^{-1} of S (both solid); T7: 0.45 L ha^{-1} of N + 0.1 L ha^{-1} of S (liquid). Commercial fertilizers used in the experiment were the following: Urea $CO(NH_2)_2$, as source of N; Ammonium sulfate $(NH_4)_2\ S0_4$, as source of N + S; and foliar fertilizer Micro Xisto HF, as source of liquid N + S.

The experimental design used in this study consisted of random blocks with four replications and 7 treatments, totalizing 28 plots, each one with 31.5 m² (Gomes, 2009). The variables evaluated were: productivity, in kg ha^{-1} (PDH), obtained by the total manual

Table 2. Pluviometric precipitation (mm) occurred during the experiment, at the meteorological station of Cascavel, PR 2011.

10-day period	Months						
	March	April	May	June	July	August	September
1st	10.8	7.0	1.8	27.0	66.0	6.4	39.8
2nd	2.4	17.8	11.4	0.0	36.8	187.4	15.6
3rd	53.6	29.8	0.0	18.8	24.0	36.4	22.2
Total	66.8	54.6	13.2	45.8	126.8	230.2	77.6

Source: Simepar 2012.

harvest of the plot and converted into kg ha^{-1}; mass of a thousand grains (MTG), by the weighing of two samples with 125 grains randomly collected from the volume gathered from the plot and multiplied by four; grain oil content (GOC), obtained by the extraction of oil by direct extractor Soxhlet of each sample randomly collected from the gathered volume; plants with symptoms of sclerotinia (SCL) by the counting of all plants in the plots with symptoms and wounds caused by fungus *Sclerotinia sclerotiorum* (Lib.) de Bary. In order to evaluate individual plant yield and its components' estimate, 8 plants were randomly collected from each plot to compose the averages for the following determinations: a) number of siliquas per plant (NSP), by the counting of siliquas in each plant; b) grain mass per plant (GMP), obtained by the track of each individual plant, measured on an analytical scale.

In order to verify the statistical difference among treatments, the F test (analysis of variance) was applied, as well as a posterior test (Tukey's), that aimed to compare averages, considering the level of 5% significance for both tests (Gomes, 2009). The model's presuppositions were verified by the application of Hartley's maximum F test for homogeneity of variance, and Shapiro-Wilk's test for normality. In order to analyze data, software ASSISTAT 7.6 beta was used (Silva and Azevedo, 2009).

RESULTS AND DISCUSSION

One can observe that the sum of pluviometric precipitations in the periods of 10 days from March to September 2011 in the experiment area (Table 2), showed higher concentration in the filling stage of the Canola grains. Results obtained by the analysis of variance for the variables: number of siliquas per plant (NSP), grain mass per plant (GMP), MTG, GOC, productivity in kg ha^{-1} (PDH), and plants with sclerotinia symptoms (SCL) (Table 3), presented a significant effect only for oil content at 5% of significance which indicates that there was no response to nitrogen and sulfur applied to the coverage for the other variables. The variation coefficients obtained ranged from 1.27% for grain oil content to 26.13% for plants with sclerotinia symptoms. Such results are similar to those found by Rigon et al. (2010), who studied Canola's response to nitrogen and sulfur applied to coverage plots and did not obtain any improvement in productivity at 5% significance.

According to Osório Filho et al. (2007), Canola's absence of response to the sulfur added to the soil may be related to the intake of atmospheric sulfur by rainwater. The results found in the present study differ from those obtained by Rigon et al. (2010), who observed statistical response at 5% significance for the interaction of 60 kg ha^{-1} of N + 16 kg ha^{-1} of S according to the number of siliquas. Öztürk (2010) verified an increase of 45% in the production of siliquas, and 22% in grain mass per plant. Also Veromann et al. (2013) found that fertilization with N significantly increased the number of siliques and yield.

Results obtained in this experiment differ from those obtained by Johnston et al. (2000), who performed a study in five different experimental conditions aiming to verify Spring Canola's response to different quantities of N and S, and obtained significant statistical differences. Öztürk (2010), in an experiment with quantities of N ranging from 50 to 200 kg ha^{-1}, obtained 47% of increase in grain production for the treatment which received 150 kg ha^{-1} of Borsoi et al. (2010) verified the effect of the application of N and S on the hybrid Hyola 43, and obtained significant statistical differences from the witness in relation to the treatments with 38 kg ha^{-1} of N (urea) and 17 N + 18 S kg ha^{-1} (Ammonium sulfate); the treatment with N + S presented productivity increase of 20.9%.

Karamanos et al. (2007) obtained 23.7% increase in the production of Canola grains with the usage of N and S in soils with deficit of these nutrients. In soils with good amounts of N and S, there were no significant statistical responses. Gao et al. (2010), when studying Canola's yield with applications of 84 and 168 kg ha^{-1} of N in two places in the years of 2007 and 2008, did not obtain any increase in Canola's grain production. By verifying the plants infected with sclerotinia (Table 3), one can observe that the treatments did not present any statistically significant effect. Results differ from those obtained by Kutcher et al. (2005), who observed statistically significant response in the interaction between nitrogen and the incidence of sclerotinia disease, in the quantities of 80 and 120 kg ha^{-1}.

The regression curves obtained for the average values of number of siliquas per plant, mass of a thousand grains, Canola production in kg ha^{-1}, and Canola oil content according to the fertilization of N applied to the coverage can be observed in Figure 1. One may observe that the number of siliquas per plant follows a quadratic relation, reaching the maximum point between 25 and 50 kg of N ha^{-1} (in the value 44.24 kg of N ha^{-1}), as shown in Figure 1a. Figure 1b presents the regression curve for

Table 3. Phenotypic average values for Canola productivity and *S. sclerotiorum* (Lib.) de Bary symptoms according to different dosages of nitrogen and sulfur applied to the coverage in 2011.

Treatments	Variables					
	NSP	GMP	MTG	GOC	PDH	SCL
kg ha^{-1} N and S	n $plant^{-1}$	g $plant^{-1}$	g	%	kg ha^{-1}	Pl. w/ symp.
Control	264.75	10.65	3.67	38.12[a]	2.171	1.45
25 N	283.50	11.27	3.69	35.32[d]	2.201	1.05
50 N	281.50	10.95	3.66	36.65[bc]	2.241	1.11
75 N	276.25	10.87	3.60	34.77[d]	2.186	1.67
25 N + 27 S	258.25	11.20	3.74	37.17[ab]	2.172	1.59
50 N + 54 S	273.00	10.74	3.68	35.60[cd]	2.268	1.44
0.45 N +0.1 S[1]	257.25	10.27	3.70	37.00[b]	2.206	1.45
F value	0.31[ns]	0.45[ns]	0.33[ns]	26.33*	0.41[ns]	1.60[ns]
P - value	0.9230	0.8387	0.9116	<0.001	0.8647	0.2032
C.V.	14.19	9.46	4.10	1.27	5.17	26.13
MSD	89.69	2.40	0.35	1.08	266.35	0.85

Averages followed by the same letter in the column do not differ significantly from each other by Tukey's test at 5% significance. * = significant at the level of 5% probability; [1] = foliar fertilizer; ns = non-significant; CV = coefficient of variation; MSD = minimum significant difference; NSP = number of siliquas per plant; GMP = grain mass per plant; MTG = mass of a thousand grains; GOC = grain oil content; PDH = productivity in kg ha^{-1}; SCL = Sclerotinia.

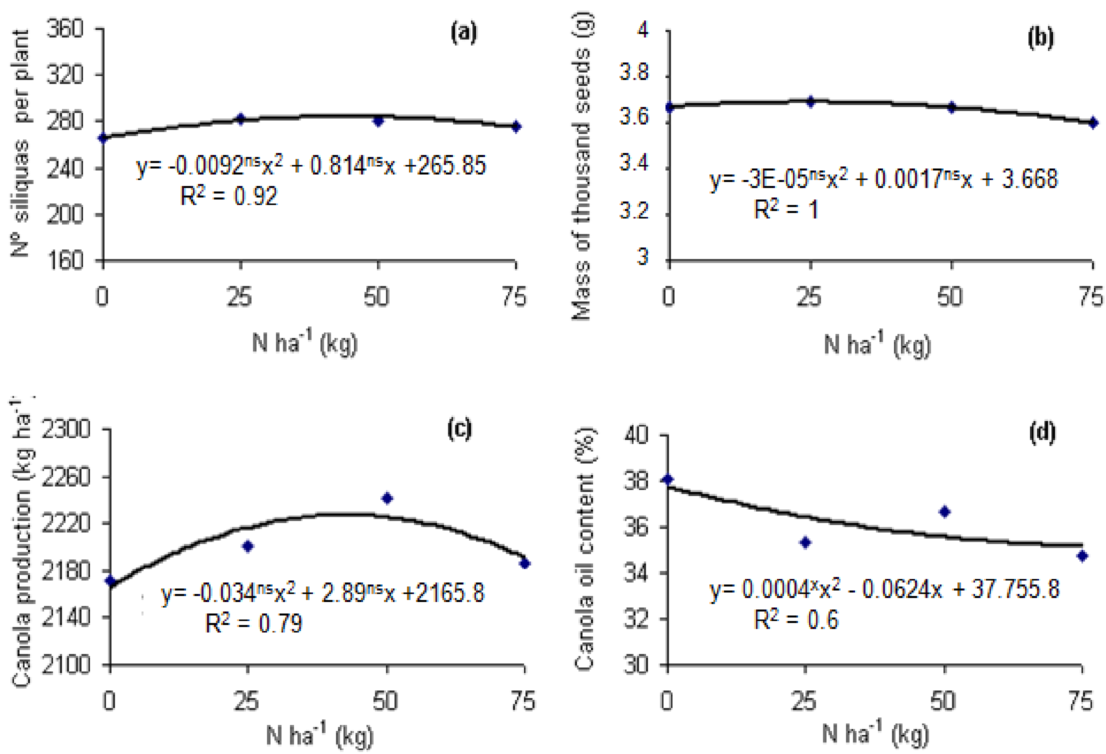

Figure 1. Curves obtained for average values of number of siliquas per plant (a), mass of a thousand seeds (b), Canola production in kg ha^{-1} (c), and Canola oil content (d) according to the fertilization of N applied to the coverage. * = significant at the level of 5% probability; [1] = foliar fertilizer; ns = non-significant.

the mass of a thousand grains according to the doses of nitrogen applied to the coverage; one may notice that the maximum mass point is obtained between 25 and 50 kg of N ha^{-1} (in the value 28.33 kg of N ha^{-1}). One may observe in Figure 1c that the productivity kg ha^{-1} follows a quadratic relation, reaching the maximum point between

25 and 50 kg of N ha^{-1} (in the value 42.50 kg of N ha^{-1}). One may also notice that the grain oil content Figure 1d, decreases as the coverage fertilization with N increases. Similar results were obtained by Ahmad et al. (2007), when studying Canola's response to nitrogen fertilization. Johnston et al. (2000) stated that Canola decreases seed oil content when larger quantities of N are applied, possibly due to the delay in the crop's maturation. Another probable cause of this reduction in oil content, according to Öztürk (2010), is the fact that such nutrient is one of the main components of proteins, what leads to an increase in protein percentage and a decrease in oil content.

Conclusion

In all treatments with nitrogen and sulfur fertilization applied to the coverage there was no statistical difference regarding Canola's productivity in relation to the treatment which did not receive nitrogen fertilization to the coverage. Canola's grain oil content decreased with the application of nitrogen to the coverage in all treatments when compared to the witness, except for the treatment that received 25 kg ha^{-1} of N + 27 kg ha^{-1} of S. In this experiment, no statistical difference was observed between treatments concerning to the incidence of symptoms and damages caused by fungus Sclerotinea sclerotiorum (Lib.) de Bary.

REFERENCES

Ahmad G, Jan A, Arif M, Jan MT, Khattak RA (2007). Influence of nitrogen and sulfur fertilization on quality of canola (*Brassica napus* L.) under rainfed conditions. J. Zhejiang Univ. Sci. B 8(10):731-737.

Borsoi A, Cereda CC, Santos RF, Secco D, Souza SNM (2010). Efeito da aplicação de enxofre e nitrogênio no cultivo da canola (canola L. var. oleifera). In: 5º Congresso Internacional de Bioenergia. Curitiba.

Brown J, Davis JB, Lauver M, Wysocki D (2008). USCA Canola Growers' Manual. Oregon. P. 71.

Casão Junior R, Araújo AG, Llanillo RF (2012). Plantio direto no Sul Brasil: Fatores que facilitaram a evolução do sistema e o desenvolvimento da mecanização conservacionista. IAPAR. Londrina. P. 77.

Franchini JC, Costa JM, Debiasi H, Torres E (2011). Importância da rotação de culturas para a produção agrícola sustentável no Paraná. Embrapa Soja, Londrina. P. 29.

Gao J, Thelen KD, Min DH, Smith S, Hao X, Gehl R (2010). Effects of manure and fertilizer applications on canola oil content and fatty acid composition. Agron. J. 102(2):790-797.

Gomes FP (2009). Curso de Estatística Experimental. 15. ed. Piracicaba, FEALQ. P. 451.

Henneberg L, Grabicoski EMG, Jaccoud-Filho DS, Panobianco M (2012). Incidência de *Sclerotinia sclerotiorum* em sementes de soja e sensibilidade dos testes de detecção. Pesquisa Agropecuária Brasileira 47(6):763-768.

IAPAR (2012). Cartas Climáticas do Paraná. Classificação Climática - Segundo Köppen. Instituto Agronômico do Paraná. Londrina. Disponível em: <http://www.iapar.br/modules/conteudo/conteudo.php?conteudo=597>. Acesso em: 20 ago. 2012.

Johnston AM, Lafond GP, Hultgreen GE, Hnatowich GL (2000). Spring wheat and canola response to nitrogen placement with no-till side band openers. Canadian J. Plant Sci. 81:191–198.

Karamanos RE, Goh TB, Flaten DN (2007). Nitrogen and sulphur fertilizer management for growing canola on sulphur sufficient soils. Canadian J. Plant Sci. 87(2):201-210.

Kutcher HR, Malhi SS, Gill KS (2005). Topography and Management of Nitrogen and Fungicide Affects Diseases and Productivity of Canola. Agron. J. Madison 97:533-541.

Meier U (2001) Growth stages of mono and dicotyledonous plants. 2.ed. Berlin: Federal Biological Research Cent. Agric. Forest. P. 158 (BBCH Monograph).

Osório Filho BD, Rheinheimer DS, Silva LS, Kaminski J, Dias GF (2007). Deposição do enxofre atmosférico no solo pelas precipitações pluviais e respostas de culturas à adubação sulfatada em sistema plantio direto. Ciência Rural 37(3):712-719.

Öztürk Ö (2010). Effects of source and rate of nitrogen fertilizer on yield, yield components and quality of winter rapeseed (*Brassica napus* L.). Chilean J. Agric. 70(1):132-141.

Rigon JPG, Cherubin MR, Capuani S, Moraes MT, Conterato RB, Wastowski AD, Rosa GM (2010). Efeito de doses de enxofre e parcelamento do nitrogênio em cobertura na cultura da canola, In: IV Congresso Brasileiro de Mamona e I Simpósio Internacional de Oleaginosas Energéticas, João Pessoa. Anais. pp. 1333-1338.

Shahidi F (1990). Canola and Rapeseed: Production, Chemistry, Nutrition, and Processing Technology. New York: AVI, Chap. 1:3-14.

SiBCS (2009). Sistema brasileiro de classificação dos solos - Embrapa Solos. Rio de Janeiro. P. 397.

Silva FAS, Azevedo CAV (2009). Principal Components Analysis in the Software Assistat-Statistical Attendance. In: World congress on computers in agriculture, 7, Reno-NV-USA: American Society of Agricultural and Biological Engineers.

Simepar (2012). Instituto Tecnológico do SIMEPAR, Curitiba, Laudo 335/12.

Tomm GO, Wiethölter S, Dalmago GA, Santos HP (2009). Tecnologia para produção de canola no Rio Grande do Sul. Embrapa Trigo, Passo Fundo. P. 39.

Tomm GO, Ferreira PEP, Aguiar JLP, Castro AMG, Lima SMV, Mori C (2010). Panorama atual e indicações para aumento de eficiência da produção de canola no Brasil. Embrapa Trigo, Passo fundo. P. 82.

Veromann E, Toome M, Kännaste A, Kaasik R, Copolovici L, Flink J, Kovacs G, Narits L, Luik A, Niinemets Ü (2013). Effects of nitrogen fertilization on insect pests, their parasitoids, plant diseases and volatile compounds in Brassica napus. Crop Protection 43:79-88.

Zonin VJ, Winck CA, Scarton LM, Silva TN (2010). Utilização da canola como alternativa na cadeia de suprimentos do biodiesel: estudo de caso em duas empresas do RS, In: 48º Congresso SOBER, Campo Grande. P. 20.