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Effects of nutritional arrangements of NPK on the yield of grains and Crambe oil cultivation

Igor Eduardo Lunelli[1], Deonir Secco[1], Araceli Ciotti de Marins[2], Helton Aparecido Rosa[1]*, Reginaldo Ferreira Santos[1], Augustinho Borsoi[1], Gustavo Veloso[1], Reinaldo Aparecido Bariccatti[1], Samuel Nelson Melegari de Souza[1] and Tiago Roque Benetoli da Silva[3]

[1]UNIOESTE – Western Paraná State University – Postgraduation Program, Master Course of Energy in Agriculture, RuaUniversitária, 2069, CEP: 85.819-130 Faculdade, Cascavel, Paraná, Brazil.
[2]UTFPR – Federal Technological University of Paraná, Brazil.
[3]Department of Agricultural Sciences, UEM - Maringá State University, Maringá, Brazil.

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The objective of this study is to evaluate the yield of grains and oil from the crops of the *Crambe abyssinica Hochst* under nutritional arrangements based on NPK. This experiment was carried out in the city of Cascavel-PR, on a typical dystrophic hapludox, clayey to very clayey texture, with a smooth undulated relief, with average altitude of about 680 m. The treatment consisted of nutritional arrangements based on NPK, which are: NPK; T2:N; T3:P; T4:K; T5:NP; T6:NK; T7:PK; T8: witness (without applying fertilizer). The experimental delimitation used for the experience was not fixed but occasional in which 8 treatments and 3 repetitions were applied. The measurement of the grain production was accomplished over a 1.0 m² area located on the central part of the experimental unities. The oil production itself was accomplished utilizing the Soxhlet method. The statistical data provided was based on the analysis of the variance; the treatment means were compared by Tukey test, on 5% of significance. No nutrients alone or in combination promoted a significant difference for grain yield. For oil yield, the arrangement consisting of NPK promoted significant difference from other treatments except for treatments NK and P.

Key words: Oilseeds, nutrients, energy potential.

INTRODUCTION

The environmental impacts caused by the conventional energy sources have been forcing men to pursue other renewable energy alternatives, which are economically viable and with reduced pollution rates. Many are the benefits in our country for the implantation of bioenergy cultures. Among them, the prospect of incorporating of new areas, given that it is possible to achieve success with oilseed cultivation without competing with the agriculture designated for food production, and with environmental impacts limited to the socially accepted ones, and also the possibility of multiple cultivations within the agricultural calendar. Among the bioenergy available for cultivation, is Crambe (*Crambe abyssinica* Hochst), a plant with great potential for the production of raw material for biodiesel. Crambe is a cruciferous originally from the Mediterranean region, which is very tolerant to drought, mainly because of its vegetative development, once it does not tolerate the rainy seasons or high relative air humidity along it (Muller, 2008; Viana et al., 2012).

*Corresponding author. E-mail: helton.rosa@hotmail.com. Tel: (55) 45 -99473145.

The main factors that allow this cultivation to be well accepted are: The good performance presented in the experimental fields, the low cost of production, rusticity, easy adaptability to low fertility soils and drought resistance, the non-imposition for new machinery and equipment for cultivation and the facility of extracting its oil by presses (Neves et al., 2007).

Its blossoming occurs 35 days after plantation; the flowers are white, numerous and small (Erickson and Bassin, 1990). It is very tolerant to the cold weather, except after its germination when it tolerates temperatures of up to 3°C negative, and in its blossoming when the occurrence of frosts causes abortion of flowers. Due to its climatic requirements, in Brazil, it behaves as a sort of autumn/winter cultivation. The central-southern region of MatoGrosso do Sul, north/northeast of Paraná and south of São Paulo are considered the best places to its adaptation with viability for commercial cultivation.

With approximately 38% of oil on dry basis, the oilseed produces an average of between 1.000 and 1.200 kg ha^{-1} of grains, or close to 400 kg ha^{-1} of oil (Roscoe and Delmontes, 2008).

In the context of biofuels, Brazil stands out due its great potential in producing raw material, as it is the country which has the largest arable green area in the world and available hand craft (Bilich and Silva, 2006).

The obtained biodiesel from Crambe oil can be produced within the specifications required by the legislation of ANP – National Petroleum Agency (Resolution nº. 7 2008). Even though some of its parameters, such as viscosity and content of calcium and magnesium, are close to the allowed limits (Silva et al., 2009).

Crambe requires good levels of moisture in the soil only during germination and cultivation establishment, and it requires a maximum of 150 to 200 mm of water until its full blossoming. After this period the ideal condition for its best development is the absence of rain, once that excessive rain, associated to high humidity, favors the occurrence of diseases (Pitol, 2008).

The shortage of information regarding nutritional requirements may restrict the attainment of high productivity and interfere directly in the quantity, quality and oil content of the seeds produced. It is known that the plant absorbs large amounts of N, which can be inferred due to its high protein content in the grain (Souza et al., 2009). Initial studies about the nutrition of “crambe FMS Brilhante” were conducted by the MS Fundation (Fundação MS), presenting a low response to NPK formulations in remediated soils (Broch et al., 2010). The same work, however, obtained evidence that the increased availability of N in the soil can generate significant responses in grain production. According to Carlsson (2009), for the improvement of the cultivation of crambe as a producer of oil to biodiesel production, additional studies are needed, aiming a productive chain improvement.

This work aimed to evaluate the production of grain and crop Crambe oil under arrangements of soil fertilizers based on some extreme important macronutrients to the cultivation development and, more specifically, verifying if there was an increase of the production with the application of some isolated nutrient.

MATERIALS AND METHODS

The experiment was carried out on the Farm School which belongs to FAG – FaculdadeAssisGurcgacz, located in the city of Cascavel – Paraná, in 2010. The farm has a total area of 90 ha, and it is approximately located on 680 m altitude, which coordinates are: 24° 56'23 "latitude and 53° 30'27" longitude.

The soil of the region is classified as Hapludox, clayey to very clayey (EMBRAPA – EmpresaBrasileira de PesquisaAgropecuária, 2006). To perform the experiment, a soil analysis was realized before the crops of Crambe for eventual correction of fertility and acidity which presented the following data as shown in Table 1.

The hybrid seed used was ‘FMS Brilhante’, with a cycle that varies between 90 and 115 days, depending on the duration of the rainy season in each region. For seeding the selected type a seeding planter trawl equipped with an out of phase double disk mechanism furrowers, rotor typed seed metering (of continuous flowing) regulated for plantation with 0.03 m depth, 0.30 m spacing between rows was used. This way a population of around 150 plants per m² was obtained.

The experimental design used was not fixed but occasional in which eight treatments and three replications were applied on a total area of 883 m². In eachcropping strip the used treatment were randomly selected with a combination of NPK. The experimental units consisted of 4.8 m wide by 6 m long, with a total area of 28.8 m². The treatments consisted of fertilizing the soil through arrangements with NPK, which were distributed as follows: T1: NPK; T2: N; T3: P; T4: K; T5: NP; T6: NK; T7: PK and a witness (without applying fertilizer). Fertilization and crop management were performed according to technical recommendations for the region, according to Pitol (2008). Therefore the dosage used was of 90 kg ha^{-1} N, 68 $kgha^{-1}$ P and19 $kgha^{-1}$ K, and the N inthe form of urea (21%N), P as very simple phosphate (60% P), and K in the form of potassium chloride (45% K).

The harvest of Crambe was performed in the central areas of each plot with the aid of a metal frame of 1 m² in each treatment. After harvesting the crop material, each treatment was separated into plastic bags still with impurities such as small leaves, branches and roots. All material was threshed in a small mixer using grain pull tractor. After the cleaning process, the samples were weighed with a semi-analytical precision scale with accuracy to two decimal places. Then, for the extraction of vegetable oil, with the aid of an analytical precision scale up to four decimal places, a 100 ml beaker and a tweezers, the procedure of weighing samples of 10 g each was started, which was done by Soxhlet system, described in the road map of practical classes of the UTFPR, 2009. This method was described by Franzin Von Soxhlet 1879.It is one of the most used methods due to its convenience of implementation and operation, and also because it requires just a few material sex tractors.

The statistical analyzes for grain and oil yield consisted of the analysis of variance (ANOVA). To compare the means of treatment, we used the Tukey test at 5% probability that ran through the "free software" Sisvar version 5.3 was used.

RESULTS AND DISCUSSION

The yield of Crambe grains showed no significant

Table 1. Chemical attributes of the experimental area.

Elements	$Cmol_c$ dm^3	Interpretation
Calcium (Ca)	9.54	High
Magnesium (Mg)	5.61	High
Potassium (K)	1.03	High
Aluminum (Al)	0.00	Low
H + Aluminum (H + Al)	6.21	High
CTC	22.39	High
	g dm^3	
Carbon (C)	24.31	High
Organic matter (MO)	41.81	High
	%	
Basis saturation (V)	72.26	High
	mg dm^3	
Phosforum (P)	2.20	Low
pH $CaCl_2$	5.30	

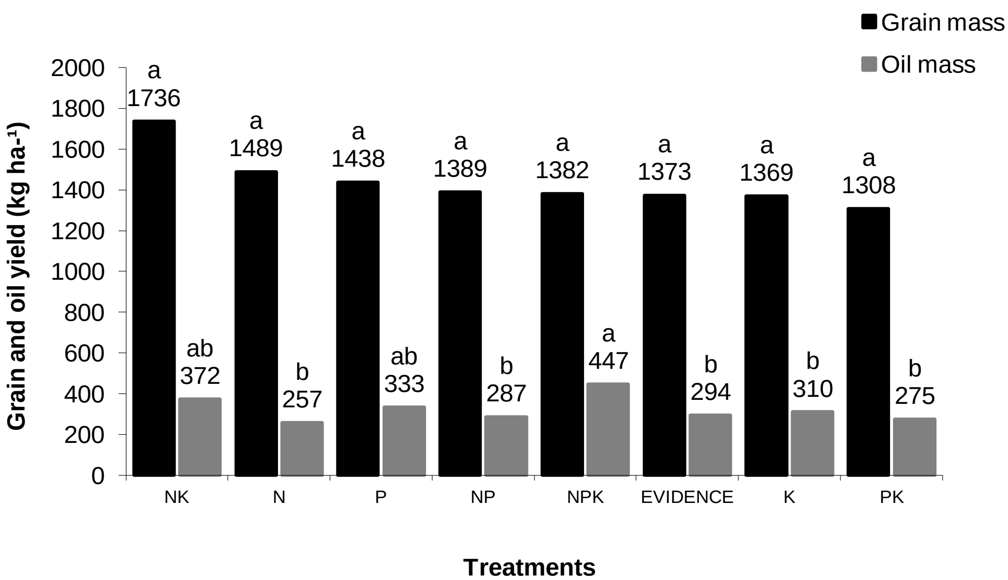

Figure 1. Yield of grains and crambe cultivation oil (kg.ha^{-1}) under arrangements of fertilization based on NPK.

differences regarding the fertilization arrangements. Although there was nosignificant difference between treatments (C.V = 18.67%), the arrangement between Nitrogen and Potassium was the treatment which contributed to increased productivity, being 18.15% higher than the control, as shown in Figure 1. The treatment that less contributed to the increase in grain yield was the arrangement with Potassium, Phosphate and Potassium individually.

When working with different levels of Potassium fertilization, Rossetto et al. (1998) observed that there was no favoritism of Potassium on seed yield of canola. Moreira et al. (2010), evaluating the yield of Crambe cultivation in response to variations in saturation of bases and mineral fertilization with NPK, observed a significant effect of mineral fertilization (NPK) and an interaction between mineral fertilization and saturation of bases on the productivity of Crambe, however it was not verified any significant influence by saturation of bases. The authors observed an increased productivity of about 12% by adding N, with the dose of 20 kg ha^{-1} and an increase of about 28% with the dose of 40 kg ha^{-1} when compared to the control. To the oil yield, it was observed that there were significant differences between the possible

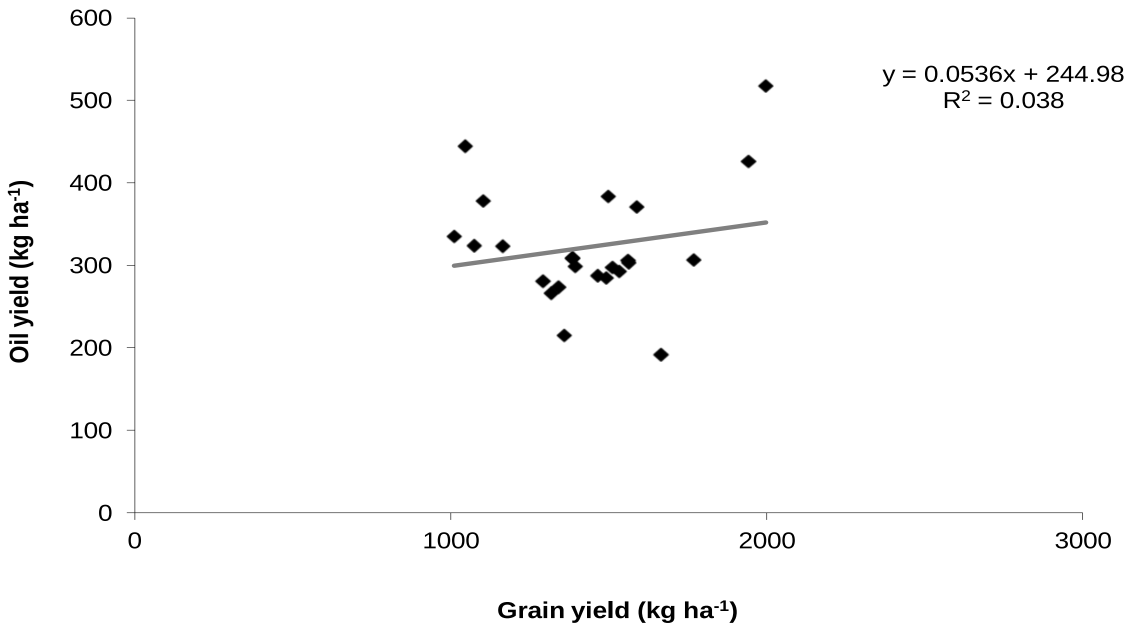

Figure 2. Linear regression analysis of oil yield according to the yield of crambe grains cultivation.

treatments. One can see that the arrangement made by NPK, NK and Palone were the treatments that conditioned improved yields of oil (Figure 1). In contrast, the other treatments did not differ from each other significantly and presented lower values compared to the arrangement with NPK, except for NK and P alone.

That may be explained by Wright et al. (1988) who, working with Colza, defined that the treatment with N extends the lifespan of the leaves, improves the blossoming and increases the cultivation assimilation in general, thus contributing to the grain yield.

The treatment done with Potassium (K) showed no significant difference by the probable reason that it already has a high value in the soil (Laranjeira et al., 2010). According to the Table 1, the area had 1.03 $Cmol_{c.}dm^3$ content, high value for clayey soils, thereby maintaining the high productivity of other arrangements, as shown in Figure 1, which shows yield of1369 $kg.ha^{-1}$ for K.

According to Ozer (2003), in two simultaneous experiments a reduction in the concentration of oil in colza seeds was shown, which was caused by the application of N. That may explain the fact that the treatment with isolated N presented low performance compared to the treatments with P, NK and NPK. For Cheema et al. (2001), the occurred fact was not unexpected, because similar effects were reported by Stoker and Carter (1984), who concluded that increasing the dosage of N in the fertilization of colza, in order to evaluate the oil yield, observed such negative results.

This reduction in the oil content of Crambe seed when it comes to isolated Nitrogen fertilization may still have another explanation. As the Canola and the Colza grain – which belong to the same family of grains as the Crambe – the seed in study is also composed mainly by protein and oil. According to the studies of Ahmad et al. (1999), Brennan et al. (2000), Brennan and Bolland (2007), and Malhi and Gill (2007), this effect is caused because the N increases the protein content in the seed and this fact results in reduction of oil content. The treatment with NPK was the one that presented best yield of seed oil, differing significantly from other treatments, except for the arrangement NK and P alone. This result is similar with the experiment conducted by Lavagnolli and Silva (2008), who studying fertilizations based in P and K, observed significant effects on the oil content due the treatments. They observed an increase of approximately 28 and 30% in the oil content, when applied doses of P_2O_5 and K_20, respectively.

From the Figure 2, one can observe that the yield of oil is linear explained by the yield of Crambe oil in just 3.8% (R^2 = 0.038). Thus, one can interpret that the non-occurrence of any significant difference for the grain yield among the different treatments is not associated with the existing difference between treatments for oil yield. So the nutrients here analyzed, that may potentially alter the oil yield, not necessarily affect the oil yield.

Conclusions

1. No nutrient either isolated or in association, promoted any significant difference for the grain yield.
2. For the oil yield, the arrangement composed by NPK promoted a significant difference from the other treatments, except for the NK and P treatments.

3. The oil yield is more associated with the quality than with the quantity of crambe grains cultivation.

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