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Crambe performance depending on the potassium doses and cultivation in red latosol

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Nowadays, the society is seeking renewable energy sources that will replace in a sustainable way, fossil fuels. A source of energy that has stood out with great energetic potential showing itself to be promising in the world is biodiesel. Among several alternatives, the crop, Crambe (*Crambe abyssinica* Hochst) stands out as an oilseed species plant that belongs to the *Brassicaceae* family. This culture as a source of feedstock for biodiesel production was studied for its high yield of oil production, with about 38% of its grains. In order to get more information on the development of the crop in west of Paraná, it is necessary to develop studies on the response of this crop to fertilization. This study aimed to evaluate the crambe response to doses of potassium (K) grown in Oxisol in west of Paraná. The experimental design was of randomized blocks and the treatments consisted of doses of K (0, 40, 80, 120 and 160 kg ha^{-1} of K_2O), with four replicates. For the assessments, a week preceding the harvest, five plants were collected per plot to measure the morphological features and yield components: plant height, average number of racemes per plant, average length of racemes per plant, number of fruits per plant, and fruit number per raceme and productivity. The results indicate that the soil Oxisol of Toledo has good availability of K. Because of this, significant increments in K_2O doses on morphological characteristics and yield components have not been verified. The K_2O doses did not promote increments on crambe production components.

Key words: Biodiesel, development, *Crambe abyssinica* Hochst, feedstock.

INTRODUCTION

Crambe crop (*Crambe abyssinica* Hochst) is an oleaginous plant that belongs to the *Brassicaceae* family, having its place of origin in the Mediterranean region and with occurrence reports of some species in Ethiopia (Weiss, 2000). It is considered as a winter oilseed, having good resistance to drought and short cycle, ranging from

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Table 1. Chemical and texture attributes of latosol collected in case depth of 0 to 0.2 m Toledo- PR, 2015.

$^{(1)}$pH	C	P	Ca^{2+}	Mg^{2+}	K^{+}	Al	H+Al
	g dm^{-3}	mg dm^{-3}	--------------$cmol_c dm^{-3}$-------------------				
5.80	19.09	19.09	5.95	2.06	0.54	0.08	6.21
	SB	**CTC**	**V**	**Silt**	**Clay**	**Sand**	
	$cmol_c dm^{-3}$		**%**	**------------g kg^{-1}------------**			
	8.55	14.76	57.92	180	720	100	

P, K^+ – Mehlich-1; Ca^{2+}, Mg^{2+} e Al^{3+} – KCl; C – Walkey Black; pH – Calcium chloride; H + Al – buffer SMP (Lana et al., 2010).

90 to 100 days. Crambe is a very resistant crop to pests and diseases, with 26-38% of oil content in dry mass (Machado et al., 2007).

As it is a suitable crop for cultivation in the autumn/winter period, crambe can be a good option for the off-season harvest, due to its tolerance to low temperatures, with high oil content, low production cost, besides its oil been inedible, which makes it a crop with good characteristics for the biodiesel production (EMBRAPA, 2006). Biodiesel has as its main sources of oil, peanut oil, cotton, canola, palm oil, jatropha, crambe, castor bean and soybean, in addition to beef tallow, chicken fat and frying oils already used (Epstein, 2004; Mourad, 2006).

For Rudolf and Wang (2012), there are three reasons why the crambe is a unique oilseed crop: between the brassicas, this species is the one that contains the highest quantity of erucic acid, which is of great industrial interest. It has the highest yield, as compared to rapeseed, requiring however less cultivation efforts; besides not spontaneously hybridized with other brassicas.

Crambe's productivity in Brazil reaches 1000-1500 kg ha^{-1} (Baez 2007; Pitol et al., 2008), reaching in the fields of Assis Gurgacz University and Mato Grosso do Sul Foundation 2300 kg ha^{-1} (Mai Neto, 2009). In Europe and in the United States, there have been productivities higher than 3000 kg ha^{-1} (Pitol et al., 2008).

Regarding the nutritional needs of the crop, the root system of crambe is deep and, bearing this in mind, it becomes very sensitive to toxicity of aluminum, requiring a very well corrected soil profile. The production of crambe is impaired by the presence of exchangeable aluminum in the soil and also by low contents of calcium and magnesium. The correction of the soil should be carried out so that the pH is high, considering ideal range of pH for crambe crop to be between 5.8 and 6.2 (Broch and Roscoe, 2010).

Despite having good rusticity, this plant requires sowing in fertile, deep and corrected soils. Crambe is a crop that considered a recycler of soil nutrients, and with great potential for the exploitation of waste-fertilization of the preceding crops. In experiments implemented by the MS foundation, crambe had no significant responses to NPK fertilization at planting when the soil was corrected and with good levels of P and K (Pitol et al., 2008).

According to Carlsson (2009), for the improvement of crambe culture and oil producer, studies related to proper planting time in different states, fertilization, density, and loss of yield at harvest are of utmost importance.

In southern Brazil, this culture is beginning to be cultivated, but little is known about the conditions that may limit its production. This study aims to evaluate the production of crambe on different doses of potassium, seeking a better specification of the fertilizer thereof.

MATERIALS AND METHODS

This study was conducted in the experimental area of the Catholic University of Paraná, *campus* Toledo, located in the following geographic coordinates: latitude 24° 43' 70,35"S and longitude 53° 46' 04,16"W, 551 m altitude. The soil in the area is classified as Oxisoil, clayey in texture (EMBRAPA, 2006), and the particle size composition of the soil is shown in Table 1.

The experimental design adopted was randomized blocks with four replicate, with chemical analysis are showing the treatments constituted by the K doses (0, 40, 80, 120 and 160 kg ha^{-1} of K_2O). Potassium chloride, 60% K_2O as was used as K source and crambe cultivar FMS Brilhante, with plant density was adjusted by thinning for 100 plants m^2, distance between rows was 0.17 m within 24 m^2 plots (4 x 6 m).

The base fertilization was 40 kg ha^{-1} of N and 100 kg ha^{-1} of P_2O_5. For coverage, it was added in the form of sulphate of ammonia 160 kg ha^{-1} of N, totaling 200 kg $ha^{-1}$of N. The base fertilization of crambe was done on April 26, 2015. This fertilization of plots was carried out with different doses of KCl held by haul, then the sowing of cultivar Brilhante FMS was done with spacing of 0.17 (m) between rows and the germination.

With crambe plants in stage V4 (four leaves expanded), weeding was carried out and after twenty days after emergence, cover fertilization with ammonium sulfate was also done in the amount of 160 kg ha^{-1}.

Variables analyzed were plant height (PH), average length of racemes per plant (ALRP), number of racemes per plant (NRP), number of fruits per raceme (NFR), fruit number per plant (FNP) and productivity.

To quantify the productivity, in kg ha^{-1}, on each plot, were we eliminated the first and the last line, totalizing 18 m^2. Data were submitted for analysis of variance and when significant, polynomial regression analysis was carried out using the software SISVAR (Ferreira, 2011).

RESULTS AND DISCUSSION

Doses of K did not increase ($p > 0.05$) the morphological components and production of cultivated crambe in the 2015 harvest, as shown in Table 2. To determine the dry matter production and accumulation of macronutrients in the of crambe plants at different stages of growth and development, Mauad et al. (2013) conducted an experiment assessing mineral absorption of nutrients, collecting air samples of the plants at 14, 28, 42, 56, 70

Table 2. Analysis of variance for plant height (PH), number of racemes per plant (NRP), average length of racemes per plant (ALRP), number of fruits per raceme (NFR), fruit number per plant (FNP) and productivity in relation to K doses evaluated for the crambe crop grown in Oxisol of Toledo, Paraná.

V.S	D.F.	M.S.					
		PH	NRP	ALRP	NFR	FNP	Productivity
Block	3	0.032*	1.232*	0.0002*	424.39*	122907.5*	92626.9*
Dose	4	0.005^{ns}	1.307^{ns}	0.0004^{ns}	143.58^{ns}	36749.5^{ns}	30859.5^{ns}
Error	12	0.008	1.560	0.0011	82.23	27040.1	48983.5
V.C.		7.02	7.93	8.53	15.19	17.57	20.54
Average		124.9	15.76	0.39	59	936.1	1077.8

*Significant at 5% of probability (0.01 = < p < 0.05); ^{ns} non-significant (p >= 0.05).

and 84 days after emergence. The authors showed that the K builds up leaves, stems and branches rapidly, with the beginning of flowering; there is considerable drop in the accumulated K and K have high mobility in plants at any concentration level, either within the cell, in plant tissue, the xylem or phloem.

Therefore, it is noted that the K increase in the fertilization had no influence on the crambe production components. On the other hand, there was a reduction of pH in function of K doses (Figure 1A). The mean value observed was 1.25 m. In results obtained by Pitol et al. (2010), crambe plants in a seed production field reached an average height of 0.80 m. In addition, Freitas (2010) in an experiment carried out in Dourados in Mato Grosso do Sul State, Brazil, obtained 1.02 m of plant height in the 2008 harvest.

Although not fertilized with nitrogen culture, the area where the experiment was performed had a content of 19.09 of C (Table 1) which provides N mineralization to the crop, and, this nutrient has high mobility in the plant (Marschner, 1995), which is reflected in vegetative growth.

With regard to the NRP, no significant differences (p> 0.05) were found between doses of K (Figure 1B). According to Mauad et al. (2013), evaluation of racemes should be performed at 75 DAE depending on the later gains of dry matter, the maximum accumulation of nutrients in these structures due to translocation of nutrients for the formation of grains after flowering and early senescence of plants.

In this research work, the crambe changes were made in one crambe crop, to simulate production performance parameters achieved in the west of Paraná State, Brazil, where producers use soybean crop rotation system in summer and corn second crop in winter, with rare species for crop rotation (Alves Neto et al., 2016). As for ALRP, no significant differences were observed (p> 0.05) between the dose of K, the mean value was 38.25 cm (Figure 2A).

However, it is noteworthy that in the field, there was greater stem diameter for plants that received fertilization with K. This stem thickening reflects the higher photosynthetic efficiency of crambe plants; however, the size of the plants did not increase. Pitol et al. (2010), when assessing the doses of 0, 100, 200, 300 kg ha^{-1} of NPK 07-24-24 applied at sowing of crambe in Maracaju in Mato Grosso do Sul, found no statistical differences between the results. On the contrary, Bertozzo et al. (2011) noted an increase in crambe plant growth and the same was linear.

As for the NFR, no significant differences (p>0.05) were found; however, the highest values were found in the dose 160 kg ha^{-1} K_2O, as shown in Figure 2B. In the culture of canola, Degenhardt and Kondra (1981) found that the distribution of plants in an area can transform its vegetative and reproductive development.

According to Silva et al. (1983), these changes are related to competition between individuals, as a result of the variation of spacing between rows and the sowing density which can reduce the number and weight of siliques per plant.

Regarding the NFP (Figure 3A), a better result was observed with the dose of 80 kg ha K_2O. A justification for these results would be lower translocation of K from plants to grains. Cordeiro et al. (1999) found that the culture of canola, removes good amount of K but translocates very little to the seeds, requiring less potassium fertilizer than other crops.

Another finding can be attributed to phosphorus and potassium contents from soil of this research that are at very high levels, and so, the number of siliques per plant did not respond to doses of K. For productivity, although some treatments showed good production, significant interferences of the K_2O doses were not observed (p> 0.05) (Figure 3B). In this study, it was observed that the average yield was 934 kg ha^{-1}. Pitol (2008) reported that culture has the potential to produce between 1,000 and 1,500 kg ha^{-1}.

In one of the few studies that address the issue in Brazilian conditions, Freitas (2010) found that the K_2O doses ranging from 0 to 60 kg ha^{-1} in an Clayey Red Latosol, savanna phase, with content above 250 mg dm^-

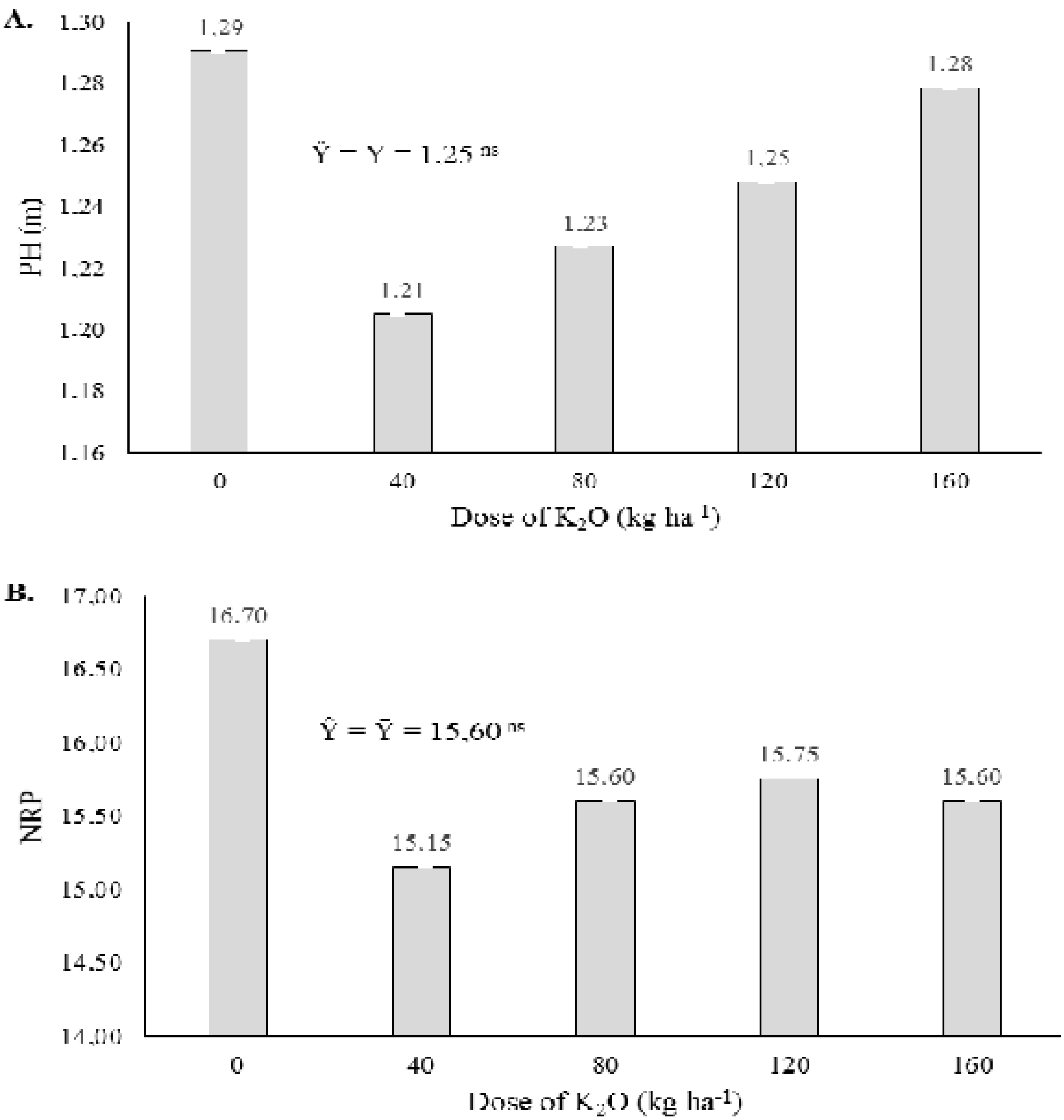

Figure 1. Average results for plant height (A) and number of racemes per plant (B) under different doses of K_2O applied in the crambe crop cultivated in Oxisol typical of Toledo, PR.

^{3}de K, did not show increases in grain yield in the harvests of 2008 and 2009, attributing this result to the high availability of K in the soil.

However, in crops similar to crambeas canola, Avila et al. (2004) found that the application of doses between 50 and 70 kg ha^{-1} of K_2O made canola productivity to remain at appropriate levels. Significant increases in productivity of canola grains and/or grapes with potassium fertilization have been narrated in many countries like Pakistan (Khan, 2004). Rossetto et al. (1998) in soil with 35 mg dm^{-3} of K, highlighted that potassium fertilization did not favor the growth of plants and canola productivity, but resulted in higher retention of siliques in late harvests.

With regard to the harvest of the crop, it was found that crambe has a specific mass that is very low, which requires attention during harvest so that there is no waste, causing loss of production.

Conclusion

The oxisol from this paper shows a good availability of K

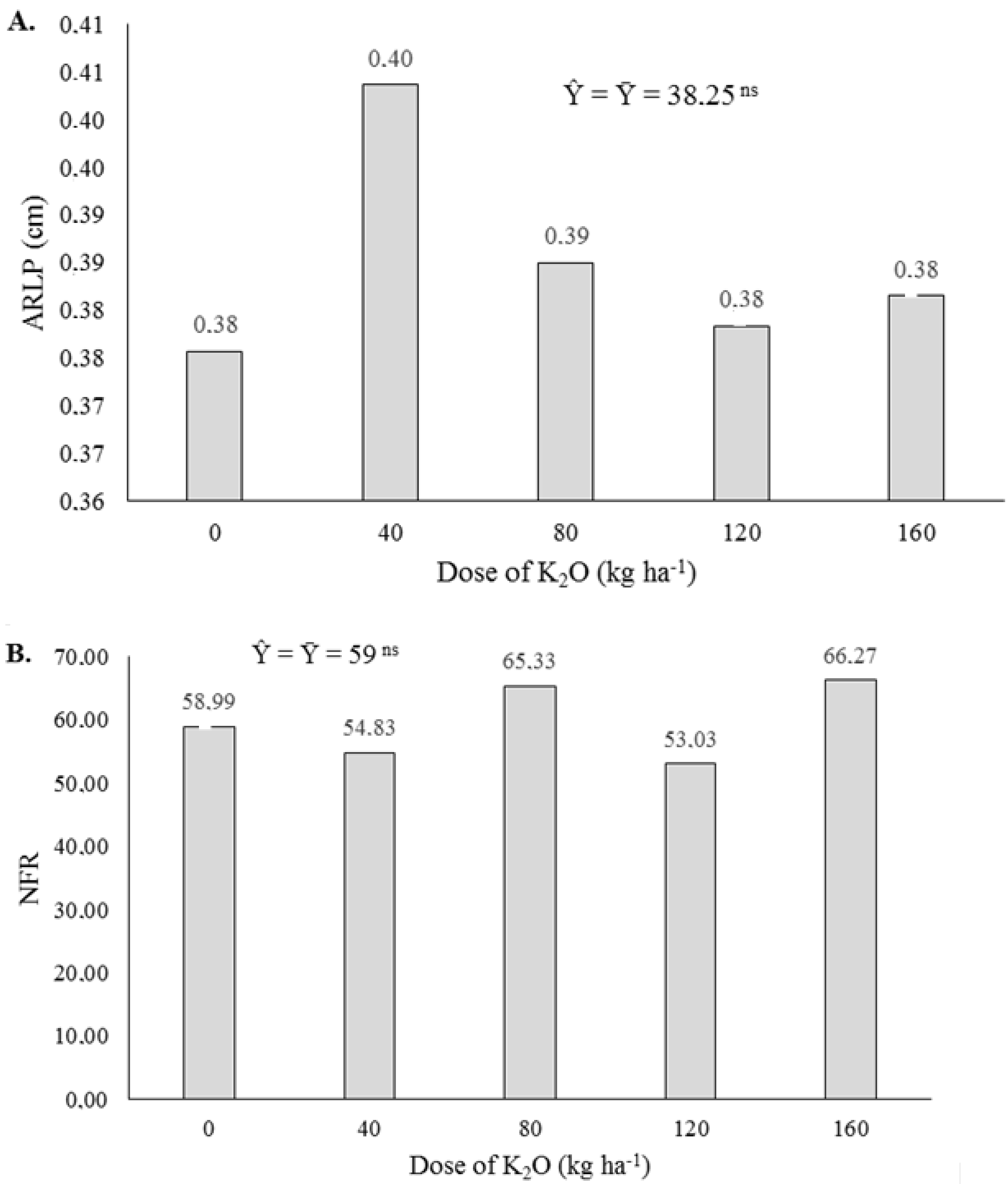

Figure 2. Average results for average length of racemes per plant (A) and number of racemes per plant (B) depending on the K_2O doses applied in the crambe culture cultivated in Oxisol typical of Toledo, PR.

and, because of this, significant increments of the K_2O doses on the morphological characteristics and in the crambe production components was not found.

Besides this, the cultivar FMS Brilhante showed great adaptability and development in the soil of Toledo, in the west of Paraná.

Conflict of interests

The authors have not declared any conflict of interest

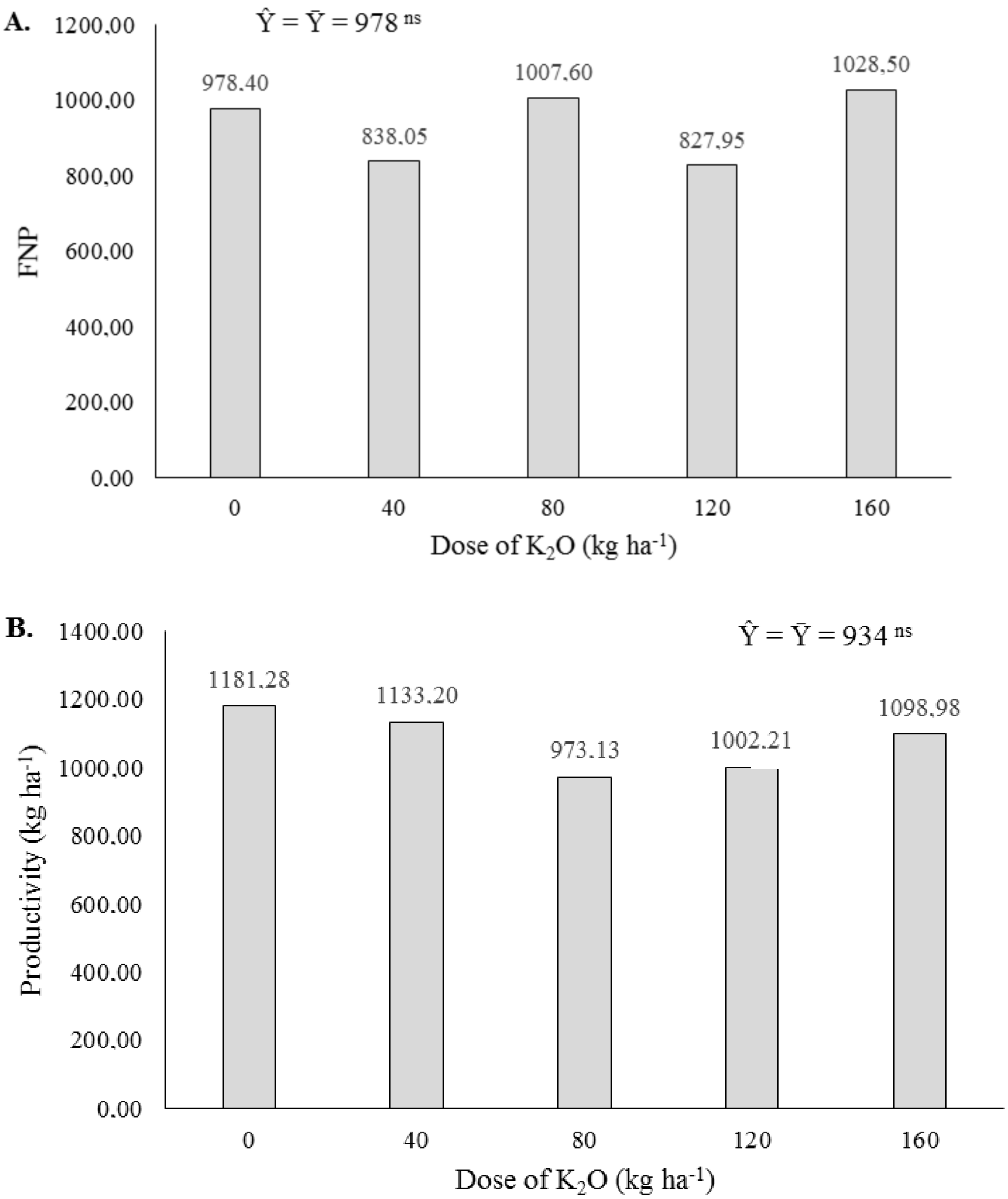

Figure 3. Average results for fruit number per plant (A) and productivity (B) depending on the K_2O doses applied in the crambe crop grown in Oxisol typical of Toledo, PR.

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REFERENCES

Alves Neto AJ, Belmonte C, Moratelli G, Gonçalves Junior AC (2016). Impactos ambientais no sistema de plantio direto não consolidado of Agronomic Sciences, Umuarama 5(especial):14-25.

Avila MR, de Lucca A, Scapim CA, Albrecht LP (2004). Adubação potássica em canola e seu efeito no rendimento e na qualidade fisiológica e sanitária das sementes. Acta Scientiarum Agronomy, Maringá 26(4):475-481.

Baez O (2007). Crambe a grande aposta das pesquisas em Mato Grosso do Sul. Jornal Pantanal news. Disponivel em: http://www.biodieselbr.com/noticias/em-foco/crambe-grande-aposta-pesquisas-mato-grosso-sul. Acessado em 10 de janeiro de 2016.

Bertozzo F, Janegitz MC, Lara AC, Silva, TMN, Silva IPF, Grassi Filho H (2011). Composto orgânico como fonte de nitrogênio no desenvolvimento de plantas de crambe. IN: II SIMPÓSIO Internacional Sobre Gerenciamento De Resíduos Agropecuários E Agroindustriais, 1, 2011, São Pedro. Anais...Sigera pp. 1-4.

Broch DL, Roscoe R (2010). Fertilidade do solo, adubação e nutrição do crambe. In: FUNDAÇÃO MATO GROSSO DO SUL. TECNOLOGIA E PRODUÇÃO CRAMBE, 1, 2010, Maracajú: Fundação Mato Grosso do Sul pp. 22-36

Carlsson AS (2009). Plant oils as feedstock alternatives to petroleum – a short survey of potential oil crop platforms. Biochimie 91:665- 670.

Cordeiro LAM, Reis MS, Alvarenga EM (1999). A cultura da canola. Viçosa: UFV, Cadernos Didáticos 60 p.

Degenhardt DF, Kondra ZP (1981). The influence of seeding date and seeding rate on seed yield and yield components of five genotypes of *Brassica napus.* Canadian J. Plant Sci. Ontário 61(2):12-15.

Epstein E, Bloom AJ (2004). Nutrição mineral de plantas: princípios e perspectivas. 2. Ed. Londrina: Planta P 403.

EMBRAPA (2006). Empresa Brasileira de Pesquisa Agropecuária. Sistema brasileiro de classificação de solos. Brasília.

Ferreira DF (2011). Sisvar: a computer statistical analysis system. Ciência e Agrotecnologia. (UFLA) 35(6):1039-1042.

Freitas MEE (2010). Comportamento agronômico da cultura do crambe (*Crambe abyssinica* Hochst) em função do manejo empregado. 2010. 42 p. Dissertação (Mestrado) Universidade Federal da Grande Dourados, Mato Gross do Sul.

Khan HZ, Malik MA, Saleem MF, Aziz I (2004). Effect of different potassium fertilization levels on growth, seed yield and oil contents of canola (*Brassica napus* L.). Rev. Int. J. Agric. Biol. Faisalabad 6(3):557-559.

Lana MC, Fey R, Fradoloso JF, Richart A, Fontaniva S (2010). Análise química de solo e tecido vegetal: práticas de laboratório. UNIOESTE, Marechal Cândido Rondon 129 p.

Machado MF, Brasil AN, Oliveira LS, Nunes DL (2007). Estudo do crambe (*Crambe abyssinica* Hochst) como fonte de óleo para produção de biodiesel. In: CONGRESSO DA REDE Brasileira De Tecnologia De Biodiesel, 2, 2007, Brasília. Anais... Itaúna: Universidade Federal de Minas Gerais.

Mai Neto C, Primieri C (2009). Avaliação da produtividade e teor de óleo de crambe através de diferentes tipos de adubações. Artigo referente ao Curso de Agronomia. Faculdade Assis Gurgarz. Cascavel.

Marschner H (1995). Mineral nutrition of higher plants. 2.ed London: Academic 889 p.

Mauad M, Garcia RA, Vitorino ACT, Silva RMMF, Garbiate MV, Coelho LCF (2013). Matéria seca e acúmulo de macronutrientes na parte aérea das plantas de Crambe. Ciênc. Rural 43(5):771-778.

Mourad AL (2006). Principais culturas para obtenção de óleos vegetais combustíveis no Brasil. In: Encontro de Energia no Meio Rural, 2006. Disponível em: http:///www.proceedings.scielo.br/scielo.php. Acessado em: 18 de jan. 2016.

Pitol C (2008). Cultura do Crambe. Tecnologia e Produção: Milho Safrinha e Culturas de Inverno. Maracaju: Fundação MS, 2008. Disponível em: <http://www.fundacaoms.org.br/request.php?51> Acesso em: 06 fev. 2014.

Pitol C, Broch DL, Roscoe R (2010). Tecnologia e produção: crambe. Fundação Mato Grosso do Sul: Maracajú.

Rossetto CAV, Nakagawa J, Rosolem CA (1998). Efeito da adubação potássica e da época de colheita na produtividade de canola. Rev. Bras. Ciênc. do Solo Viçosa 22(2):87-94.

Rudolf E, Wang Y (2012). Crambe. In: KOLE, C. (Edt.) Wild crop relatives: Genomic and Breeding Resources Oilseed. Disponível em: <http://books.google.com.br/books. Acessado em 09 jan. 2016.

Silva MI, Marchezan E, Albrecht, JC (1983). Efeito do espaçamento e da densidade de semeadura sobre o comportamento agronômico da colza (*Brassica napus L*. var. oleifera Metzg). In: Reunião Anual De Programação De Pesquisa E De Assistência Técnica Da Cultura Da Colza, Porto Alegre: Anais. Santa Maria: Universidade Federal de Santa Maria pp.14-21.