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Influence of application form of potassium chloride on golden linseed

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Abstract

In Brazil, the studies on the golden linseed planting are scarce, especially when related to the cultural treatments, possibly because this is a short duration culture and still has little interest when compared to soy or corn. Several factors can affect the linseed production potential, and with regard to fertilization, it can be done by applying part of the fertilizer at sowing furrows, by throwing sowing or in the soil coverage. The objective was to evaluate the golden linseed response (*Linum usitatissimum* L.) to application way of potassium chloride (KCl), the main mineral commercial source of potassium fertilizer. A totally randomized design was arranged by cultivation lines, consisting of a planting system with 3 forms of potassium fertilizer (K) application. The first application (T1) took place at planting time, applying potassium in the furrow, covering with a thin layer of soil, dropping the seed and then covered with earth. In the second application (T2), potassium was applied between the planting lines, also at golden linseed planting time, while the third (T3) potassium application happened just 12 days after sowing, i.e., after the germination. The T1 showed better performance, followed by T2 and T3, indicating that the best place and moment to apply KCl is in the furrow during the cultivation.

Key words: *Linum usitatissimum* L., fertilizer, farming practices.

Introduction

The golden linseed (*Linum usitatissimum*) is the flax seed, used in large quantities in cuisine and ingested with its bark. It is a nutritional source of fibre, fatty acids and other components used even for medicinal purposes, but it also has glycosides, which can be toxic and carcinogenic for humans depending on the ingested amount [2, 11, 40].

Originated from Asia, it is consumed over the world. The oldest reports of its use are dated from Mesopotamia. This culture can be utilized as food, fibre, tissue and fuel [25]. The linseed was first introduced in Brazil in Santa Catarina, in the middle of seventeenth century [21,22]. Actually its cultivation in Brazil is concentrated mainly in Rio Grande do Sul, where temperatures close to -1°C are necessary to promote the flowering [33].

The oil content in linseeds (close to 43%) can be destined to the manufacturing of paints, PVC plastics, varnishes, and in pharmaceutical and personal care products [17, 30, 33].

The cooked seeds can be used against rheumatism and mature abscesses. Mucilages, known for their emollient and anti-inflammatory properties are present in the plant seeds, which may explain the traditional uses of flaxseed [31, 32]. It is proven that the linseed soluble fibre slows the gastric emptying, promoting a glycemic control and reducing cholesterol [21, 26].

The linseed oil has isoflavones, coumestranes (conjugated isoflavone) and lignans. Lignans are alpha linolenic acids, phenolic compounds, present in flaxseed and help to prevent the bone loss and osteoporosis through blocking prostaglandin synthesis and reduction of bone resorption [4]. Lignan precursors can be found in many grains (especially linseed, fruits and vegetables). The intestinal microorganisms transform these plant lignans in enterolactone and enterodiol, considered phytoestrogens, which have estrogenic function and their presence in food can modulate endocrine actions in the body [18, 45].

The linseed cultivation tends to occur in May and June, and the harvest generally happens from October to December. The linseed's short planting cycle is most common, during about 150 days. The recommended planting density is between 90 and 120 plants per square metre, varying depending on the purpose that can be fibres or seeds [21]. The culture does not require great cultivation care, being indicated for culture rotation, and among others, aims to recover the land and avoid the soil wear and erosion[47].

According Tomassoni *et al.* [46], several factors could affect the linseed production potential. Some Paraná regions highlight themselves in the use of tillage system on straw in their cultivation areas. These soils generally present residual fertility effect, i.e., nutrient accumulation in surface layers, which promotes

successive cultures [38, 42].

In this sense, Mistios and Rowell [24] relate that the potassium release in tillage system tends to be directly proportional to the amount of their sources, the first and second minerals in the soil, and the potential for each plant in decrease of the K concentration in solution until concentrations that induce the mineral liberation, what usually happens in the rhizosphere [34]. The speed that the potassium can be liberated correlates to particle size, weathering degree, size and distribution in the soil [23, 27].

According to Barber [5], the diffusion is the main mechanism that transports soil potassium to the plant roots, representing 86% of the supply, followed by mass flow and root system interception, respectively, with 11 and 3%. Vargas [49] found that similar values, between 72 and 95% of potassium provision in corn culture come by diffusion. Rosolem *et al.* [35] and Fernandes [10] concluded that the primary mode of potassium uptake by plants is via diffusion. According to Costa *et al.* [9], the direct relation between the diffuse flow of potassium and soil humidity is not universal, like predicted by the diffusion equation. Thus, individual studies become necessary in each type of region and soil, taking into account the precipitation.

The extra potassium consumption by the plant turns out to be a waste of resources, leading to an economic waste too. The fertilization in some cultivation can be realized by applying part of the fertilizer at the furrow sowing and another part in covering. In some situations, there is still the possibility to anticipate these fertilizations, like apply by throwing, before the sowing. However, the application of high doses of potassium at the furrow sowing reflects in large salt effect, and by this reason should be avoided. Therefore, elevated doses should be reduced in the sowing, the rest being applied in the covering, in the period of elevated demand of culture [13, 14].

The objective of this study was to evaluate the response of golden linseed (*Linum usitatissimum* L.), taking as variables different application forms of potassium chloride (KCl), which is the most used potassium source, with 60% of K_2O.

Material and Methods

The experiment was developed in an experimental area in the Universidade Estadual do Oeste do Paraná (UNIOESTE), campus of Cascavel, with a geographic location 24°59'20.5" South, 53°26'58.7" West. The soil is classified as dystrofic Red Latosol, an annual precipitation is 1.640 mm and an average temperature 19°C, and climate is super humid and temperate mesothermal [12, 15]. The experimental soil characterization is presented in Table 1.

Table 1. Soil composition where the experiment was developed.

Ca	Mg	K	Al	H+Al	S. de Bases	CTC	C	Org. Matter
				Cmolc/dm³				g/dm³
5.27	1.64	0.42	0.00	3.28	8.23	11.51	20.74	37.67
Sat. Bases (%)			P	Fe	Mn	Cu	Zn	pH
					mg/dm³			$CaCl_2$
65.8			12.96	15.48	146.38	7.86	4.61	5.30

The experimental design was completely randomized, starting from cultivation lines and three potassium fertilizer (K) application ways. The first treatment (T1) took place at planting time, applying potassium in the furrow, covering with a thin layer of soil, dropping the seed and then covered with earth. In the second treatment (T2), potassium was applied between the planting lines, also at golden linseed planting time, while in the third treatment (T3) the potassium application happened 12 days after sowing, i.e., after the germination. There were six replicates of each treatment (Table 2).

Table 2. Planting systems used in the experimental area of Unioeste, Cascavel – PR.

Treatments	T1	T2	T3
Kg.ha^{-1} (k)	140	140	140
Fertilizing	Furrow	Between lines	Post germination (next to the line)

The sowing was realized 1 cm underground, and 20 days after the planting thinning was realized, defining a distance of 2 cm between plants. The planting system used was in 0.45 cm spaced rows, 3 lines for each treatment, 2.5 m long, where the treatments were separated by border strips (without treatment), totalizing 9 treatment lines and 4 border strips, matching 4.5 m^2 per treatment.

The amount of potassic fertilizer was defined using data from Rossetto *et al.* [36], that utilizing 120 kg·ha^{-1} of potassium gave greater height, and using 160 kg·ha^{-1} presented better results in all other linseed studied characteristics.

According to Soares *et al.* [44], the flaxseed culture happens in fall, from May to June, while the harvest occurs in November, December and January. The experiment began on June 6, 2013, and the harvesting 130 days after the sowing, by the morning, and among the samples, the following characteristics were evaluated: plant height (AP), number of capsules per plant (NC), fresh (MFS) and dry mass (MSS) seeds, fresh (MFP) and dry mass (MSP) of the plant, stem diameter (DC) and number of ramifications (NR) of the plant. The dry mass was determined after the samples remained in a greenhouse at 65°C, in three days, or until reached constant dry weight mass [6, 20].

To verify statistical differences between the considered groups, the Tukey's test was adopted, using 5% of significance, and using the statistical software Assistat® version 7.5 Beta [52].

Results and Discussion

The potassium is found in plants in concentrations that are close to the nitrogen ones, and for that occur an optimum plant development, the potassium contents are between 2 and 5% of dry weight, depending of each type [37].

In Table 3, all analyses had a significant F ($F < 0.01$), in the population density of planting system. The line sowing system led to results that are different among themselves through average comparison using Tukey's test, in the context of different forms of application of potassium fertilizer, irrespective of the response analysis applied at treatment T1, always differed significantly ($p < 0.05$) from treatments T2 and T3.

Sguario Jr *et al.* [41] studied two different potassium application forms at bean culture, Carioca cultivar, being the first in line and the second by throwing, had no significant differences between the application ways. However, in the current study, differences were observed in the three treatments, significant at 5% level, applying the Tukey's test to the analyses of AP, DC, NC NR and MSP.

Bernardi *et al.* [7] studied the potassium fertilization efficiency considering the doses, types (at the furrow, by throwing and split) and application times (pre-sowing, planting and coverage), in soybean, millet and cotton cultures, and, in the conditions applied

Table 3. Effect of different potassium fertilization forms in golden flaxseed.

Treat.	AP	DC	NC	NR	MFP	MSP	MFS	MSS
Unity	cm	Mm			G	G	G	g
T1	68.83a	55.50a	65.00a	3.00a	9.00a	68.83a	4.56a	3.03a
T2	57.83b	28.33b	16.50b	1.67b	2.64b	57.83b	1.66b	1.19b
T3	49.16c	18.16c	10.00c	1.00c	1.66b	49.17c	1.00b	0.87b
F	44.1**	193.1**	299.4**	70.0**	17.6**	44.0**	13.5**	24.9**
CV%	6.21	10.01	13.95	15.78	52.52	6.21	52.40	33.53
Gen. Aver.	58.61	34.00	30.50	1.89	4.43	58.61	2.41	1.70

Averages followed by the same letter in the column do not differ statistically among themselves by Tukey's test ($p < 0.05$). **Relative at 1% level's probability ($p < 0.01$). * Relative at 5% level's probability ($0.01 = < p < 0.05$). CV%: Coefficient of Variation.

for this study, no differences were between the amounts and types of potassium fertilization for soybean yield.

The production of leaves, stems, seeds, number of capsules, number of branches and diameter of the stem and even the plant height, rises with improved phosphorus absorption by the plant, or with the appropriate amount or the manner and period of application. Bevilaqua *et al.* [8] affirm that the potassium and phosphoric fertilization reflected directly in the roots and flower production elevation.

Corroborating with this study, Vieira *et al.* [50] found significant differences in the analyses of plant height, green mass, dry weight and number of capsules, when different amounts of potassium are applied in linseed cultivation. In other words, the potassium reflects directly in the growth conditions of the flaxseed culture.

Statistically, the better response of the potassium fertilization was obtained from furrow application, followed by fertilizer applied between rows, and finally the potassium fertilizer after germination, inferring that for flax, golden seed, it can be recommended the furrow fertilization, in planting. Thus, it is also possible to have economic gains with the fertilization system that can be conducted in conjunction with the planting system as it is redirected to the same groove.

The plant dry mass (MSP) showed significant differences between the three application forms of potassium, being possible to correlate this with the amount of plant fibres. In relation with the fibre quality, there is usually an improvement, or increase, with the provision of potassium. This happens because this nutrient maintains the foliage and regulates the cycle, as in cotton, causing cellulose deposition in the fibre, maximizing the fibre maturity, as reported by Bernardi *et al.* [7], Sabino *et al.* [39] and Nascimento Júnior *et al.* [28].

The potassium application in the furrow presented better response by the fact that some linseed cultivars, when treated with potassium fertilization are resistant to some diseases such as fusarium [16].

Lewis *et al.* [19] also affirm that in some potassium levels, the leaf area of many oilseed crops tends to increase concomitantly with the steam girth, number of grains per ear and oil content. In the present work, it was found that this potassium level can also expand its concept, and the amount of potassium applied to the soil for the cultivation of flax, was the same in all treatments, differing only in their moment or application form. Thus, it can be considered that this application can also affect the linseed response, maximizing the effectiveness of plant response when applied in the furrow.

It can be pre-judge a greater absorption of potassium fertilization in the furrow, when is considered the statement of Turner [48] that the potassium is an element responsible on fibre content elevation in linseed, which is a reply inculcated in the analyses realized.

Rosseto *et al.* [36] noted a significant response to potassium application when the fertilization with the referred macronutrient, of two linseed varieties (golden and brown) was analysed, and related that the golden flaxseed showed more expressive responses when compared to the brown cultivar. According to Nunes and Leal [29], it is important to consider that the linseed as well other cultures requires a soil that provides all the essential nutrients for their development, without increasing the cost of production. This way, applying the potassium fertilizer effectively, the earnings would be maximized by avoiding the wastage of fertilizer.

To complement this work would be an interesting study of response to doses of potassium chloride applied in the furrow at planting time of golden linseed fertilizer.

Conclusions

The fertilization using potassium chloride showed in all the analyses, AP, NC, MFS, MSS, MFP, MSP, DC and NR, better response in the flaxseed culture, golden cultivar, when applied in the furrow at the planting time. The fertilization with potassium chloride between lines and after germination differed by Tukey's test, in 5 of 8 analyses (AP, DC, NC, NR and MSP). It can be inferred that the fertilization with chloride potassium between rows during the planting period is more effective in fenometric response that the covering fertilization with the same fertilizer.

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