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Potassium dosis in the crambe crop

Doses de potássio na cultura do crambe

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RESUMO

O crambe (*Crambe abyssinica*), pertencente à família Brassicaceae, se destaca pelo seu potencial agrícola. Contudo, pouco se sabe sobre as exigências de potássio da cultura. Por isso, o objetivo do presente trabalho foi avaliar o efeito de doses de potássio (K_2O) sobre o desenvolvimento e produção das plantas de crambe. Para tanto, foi instalado experimento em casa de vegetação no município de Marília-SP no ano de 2023, para verificar as respostas a diferentes doses de K_2O. Empregou-se o delineamento inteiramente casualizado, com quatro tratamentos, constituídos pelas doses de K_2O (0; 50; 100 e 200 kg ha^{-1} K_2O), e cinco repetições, totalizando 20 unidades experimentais. As unidades experimentais foram constituídas por vasos de 3,5 L preenchidos com solo de barranco. Enquanto a dose de 50 kg ha^{-1} K_2O foi toda aplicada no momento da semeadura, as doses de 100 e 200 kg ha^{-1} K_2O foram divididas entre a adubação de plantio (50 Kg ha^{-1}) e o restante em cobertura (30 dias após a semeadura) para minimizar a salinização do solo. Utilizou-se como fonte de K_2O o fertilizante Aspire. Além disso, na semeadura, utilizou-se o formulado NPK 10-46-00 + 9% S, aplicando-se, respectivamente, 22, 100 e 19,8 kg ha^{-1} de N, P_2O_5 e S. Com 109 dias após a semeadura (DAS) foram avaliadas a massa verde de folhas e o teor de K nas folhas e com 122 DAS, as plantas no estádio de maturidade, foram avaliadas a massa seca das plantas e a produtividade. A utilização das diferentes doses de K_2O não causou efeito significativo nos parâmetros de crescimento das plantas de crambe. Por outro lado, os dados de produtividade apresentaram resposta linear crescente em função das doses de K_2O. Esses resultados demonstram que apesar da sua rusticidade, plantas de crambe apresentam capacidade de respostas à adubação potássica.

PALAVRAS-CHAVE: *Crambe abyssinica*; K; cultura de inverno; planta de cobertura; safrinha.

ABSTRACT

Crambe (*Crambe abyssinica*), belonging to the Brassicaceae family, stands out for its agricultural potential. However, little is known about the crop's potassium requirements. Therefore, the objective of the present work was to evaluate the effect of doses of potassium (K_2O) on the development and production of crambe plants. Thus, an experiment was installed in a greenhouse in the municipality of Marília-SP in 2023, to verify the responses to different doses of K_2O. A completely randomized design was used, with four treatments, consisting of doses of K_2O (0; 50; 100 and 200 kg ha^{-1} K_2O), and five replications, totaling 20 experimental units. The experimental units consisted of 3.5 L pots filled with ravine soil. While the dose of 50 kg ha^{-1} K_2O was all applied at the time of sowing, the doses of 100 and 200 kg ha^{-1} K_2O were divided between planting fertilization (50 kg ha^{-1}) and the remainder in coverage (30 days after sowing) to minimize soil salinization. Aspire fertilizer was used as a source of K_2O. Furthermore, when sowing, the formula NPK 10-46-00 + 9% S was used, applying, respectively, 22, 100 and 19.8 kg ha^{-1} of N, P_2O_5 and S. At 109 days after sowing (DAS), the green mass of leaves and the K content in the leaves were evaluated and at 122 DAS, plants at maturity, the weight and yield were evaluated. The use of different doses of K_2O did not cause a significant effect on the growth parameters of crambe plants. On the other hand, productivity data showed an increasing linear response in response to K_2O doses. These results demonstrate that despite their rusticity, crambe plants are capable of responding to K_2O fertilization.

KEYWORDS: *Crambe abyssinica*; K; winter culture; cover plant; second harvest.

INTRODUCTION

Crambe (*Crambe abyssinica*), an oilseed crop of the Brassicaceae family, has a dual origin and domestication history attributed to both Ethiopia and the Mediterranean region (WEISS 2000, KNIGHTS 2002).

In 2007, the first crambe cultivar was launched in Brazil. It offers the possibility of mechanized planting and can be used with the same equipment as grain crops, and is also characterized by its rusticity, precocity and high adaptation (PITOL et al. 2010). Crambe is considered a winter crop, with uniform maturation, a cycle varying between 90 and 100 days, tolerance to low temperatures, drought, oil content of 35 to 38% and resistance to pests (MACHADO et al. 2017, PITOL et al. 2010). Thus, it is characterized as an interesting crop option for the second harvest. Nevertheless, this crop remains understudied and underutilized in both academic research and agricultural production.

Used as an industrial oil, an ingredient in synthetic rubber and as an anticorrosive, among others, it contains long-chain fatty acids that are used in the manufacture of nylon, adhesive glues and plastic films and more than 50% erucic acid (SAMARAPPULI et al. 2020).

Crambe responds to soil fertility similarly to other *Brassica* species, such as rapeseed (*Brassica rapa* L.) and mustard (*Brassica juncea* L.) (KNIGHTS 2002). Plants require high potassium (K) levels in their cellular cytoplasm to ensure efficient enzymatic activity, which explains their substantial nutrient demand (MARSCHNER 1995). K is related to the synthesis of carbohydrates and proteins and its deficiency results in decreased protein synthesis and accumulation of soluble nitrogen compounds; reducing the efficiency and use of nitrogen from fertilizers (FAQUIM 1994, LOPES & GUILHERME 1992, SOUMARE et al. 2023).

According to SARDANS & PEÑUELAS (2021), potassium enhances starch and sugar storage, promotes vegetative growth, improves water use efficiency, and increases resistance to pests and diseases.

An important option for winter cropping and crop mixing systems, there is limited information regarding crambe response to potassium fertilization in southwestern São Paulo state, particularly in the Marília region, which is characterized by low winter rainfall and high frost probability. Since potassium is the most required nutrient in canola and mustard, both members of the same family, understanding crambe's potassium fertilization requirements is essential. Therefore, this study aimed to evaluate potassium uptake dynamics, growth, and yield of crambe plants in response to increasing K_2O rates.

MATERIALS AND METHODS

The experiment was conducted in a greenhouse at the Experimental Farm of the University of Marília, located at 22°14'55"S latitude and 49°58'36"W longitude, at an altitude of 634 meters, in Marília, São Paulo State, Brazil.

To evaluate crambe responses to different K_2O rates, a completely randomized design experiment was conducted with four treatments of K_2O doses (0, 50, 100, and 200 kg ha^{-1} K_2O) and five replications (Table 1), totaling 20 experimental units.

Table 1. Details of potassium application throughout the experiment. Marília, SP – 2023.
Table 1. Detail of potassium application throughout the experiment. Marília, SP – 2023.

Treatments	Sowing	Coverage (30 DAS[b])	Total
	Kg ha^{-1} K[a]		
1	0	0	0
2	50	0	50
3	50	50	100
4	50	150	200

[a]Aspire fertilizer (58% K_2O and 0.5% B) was used to supply potassium. Product Approved by MAPA. [b]DAS: days after sowing.

Each experimental unit consisted of two plants grown in 3.5-L pots filled with hillside soil collected from an Ultisol (Table 2). The K_2O rates (100 and 200 kg ha^{-1}) were split between planting and topdressing to minimize salinity stress. The dose of 50 kg ha^{-1}K_2O was all applied at the time of sowing. Furthermore, for all treatments, sowing was done with 100 kg ha^{-1}P_2O_5 and 22 kg ha^{-1} N, using the formulated NPK 10-46-00 + 9% S (Sources: N – urea; P_2O_5 – triple superphosphate; S – gypsum). Aspire fertilizer (58% K_2O and 0.5% boron) was used as the potassium source. Aspire combines potassium chloride (K_2O source) with two boron sources (sodium borate and calcium borate). Boron was balanced among treatments using boric acid (~17%

B).

Table 2. Analysis of ravine soil originating from an argisol typical of the region, currently used. Marília, SP – 2023.
Table 2. Analysis of a representative regional argisol from the ravine. Marília, SP – 2023.

Parameters	Determinations	Unit	Value
P	Phosphorus resin	mg dm^{-3}	3
M.O.	Organic matter	g dm^{-3}	2
C	Organic carbon	g dm^{-3}	1
pH $CaCl_2$	Potencial hidrogeniônico		3,8
K	Potassium	mmolc dm^{-3}	0,9
Ca	Calcium	mmolc dm^{-3}	5
Mg	Magnesium	mmolc dm^{-3}	3
H+Al	Potential acidity	mmolc dm^{-3}	33
Al	Aluminum	mmolc dm^{-3}	9
S.B.	Sum of bases	mmolc dm^{-3}	8,9
CTC pH 7	Potential cation exchange capacity	mmolc dm^{-3}	41,9
Effective CTC	Current cation exchange capacity	mmolc dm^{-3}	17,9
V	Base saturation	%	21,2
m	Aluminum saturation	%	50,3
S	sulfur	mg dm^{-3}	44

Sowing was performed on May 7, 2023, and topdressing was applied 30 days after sowing. We monitor plant growth on a weekly basis. At 109 days after sowing (DAS), one plant per pot was sampled to determine leaf fresh weight and leaf K content. For K determination, 25 g of fresh leaves were mechanically ground with 100 mL of distilled water. Afterwards, an aliquot was used for reading on a K sensor (Horiba LAQUA twin K-11), following the method suggested by EMBRAPA (OLIVEIRA JÚNIOR et al. 2019). Foliar K accumulation was calculated based on K content and total leaf mass. At 122 DAS, when plants reached maturity, seed count per plant and grain mass were determined. After analysis of variance, polynomial regression analysis was performed for quantitative factors at 5% probability using AgroEstat software.

RESULTS AND DISCUSSION

Potassium (K) is one of the most essential nutrients for plant uptake. Although potassium remains in its ionic form and is not incorporated into molecules, it plays numerous roles in plants, including enzyme activation, stomatal regulation, photosynthesis enhancement, and photoassimilate transport (WANG & WU 2017). Indeed, potassium plays a crucial role in plant growth and development.

In this experiment, leaf fresh biomass of crambe showed a positive linear response to increasing K_2O rates (Figure 1). The highest leaf biomass (8 g pot^{-1}) was achieved with the application of 200 kg ha^{-1} K_2O (Figure 1). Indeed, K plays a crucial role in photosynthesis, particularly in activating the enzyme ribulose-1,5-bisphosphate carboxylase/oxygenase (RUBISCO), which is responsible for atmospheric carbon fixation (HU et al. 2023). Thus, the correct supply of K is essential for the accumulation of plant biomass (GARCIA et al. 2022), Figure 1.

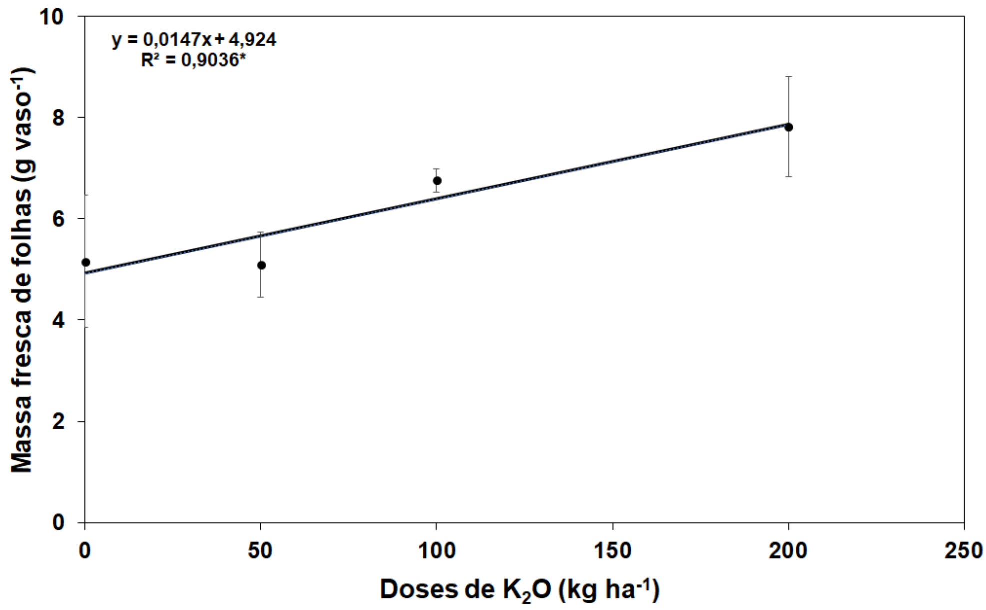

Figure 1. Fresh mass of crambe leaves (g pot^{-1}) subjected to potassium doses (kg ha^{-1} K_2O). Data presented are the mean ± standard error of the mean (n = 5).

When analyzing leaf K accumulation, an increase was observed up to 100 kg ha^{-1}, followed by stabilization and even a decrease in K accumulation in crambe leaves (Figure 2). These findings reveal limitations in K accumulation capacity in crambe leaves. Furthermore, high K_2O rates may induce soil salinization, impairing water and nutrient uptake by plants, as previously reported in potato crops by CECÍLIO FILHO et al. (2016).

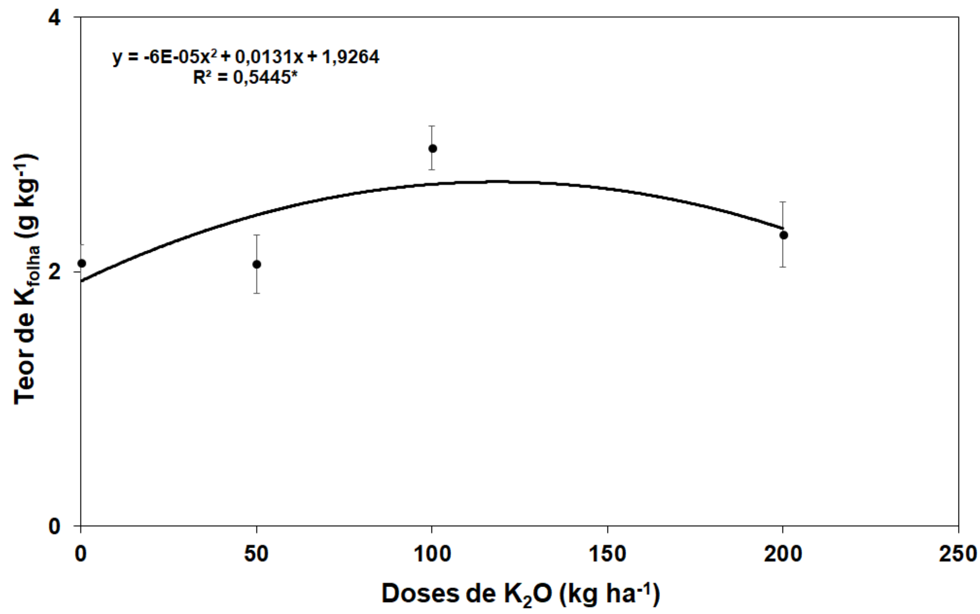

Figure 2. Leaf potassium (K) content (g kg^{-1}) in crambe plants subjected to potassium doses (kg ha^{-1} K_2O). Data presented are the mean ± standard error of the mean (n = 5).

Given the plant's potassium requirements, seed yield will serve as a key indicator for determining investment feasibility. Indeed, Figure 3 shows that a minimum fertilization threshold is required for efficient plant response, with crambe plants exhibiting increased grain production at K_2O rates above 100 kg ha^{-1} (Figure 3).

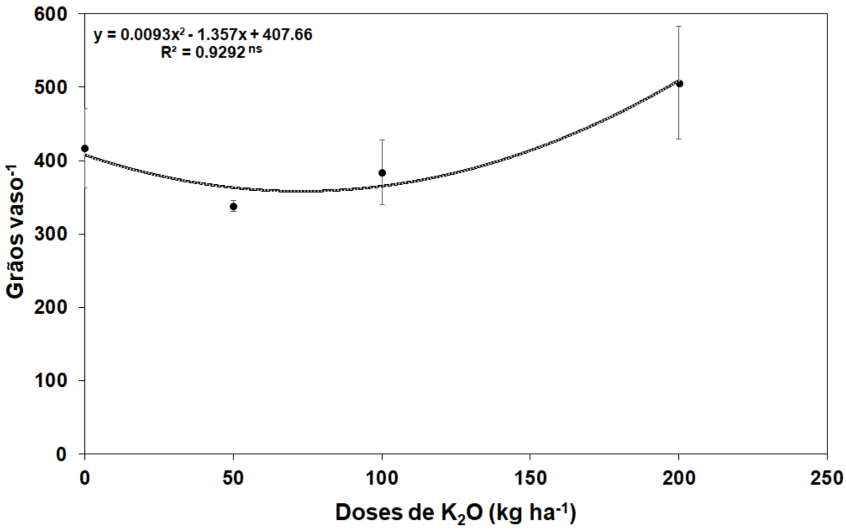

Figure 3. Number of grains in crambe plants subjected to potassium doses (kg ha^{-1} K_2O). Data presented are the mean ± standard error of the mean (n = 5).

Nutrient requirements vary according to species and genotype, with K deficiency being one of the most limiting factors for agricultural production, particularly in tropical regions (MALAVOLTA et al. 1997, PHILP et al. 2021). Indeed, Figure 4 demonstrates the potassium fertilization requirement for crambe cultivation, as evidenced by a positive linear response in grain mass to increasing K_2O rates (kg ha^{-1}). In this case, grain yield increased by more than 30% in response to increasing K_2O application rates (Figure 4). K plays a crucial role in photoassimilate translocation from source tissues (mature leaves) to sink organs (e.g., fruits) (WANG & WU 2017). Therefore, adequate potassium nutrition is crucial for achieving high yields, as crambe plants are highly responsive to potassium fertilization (Figure 4).

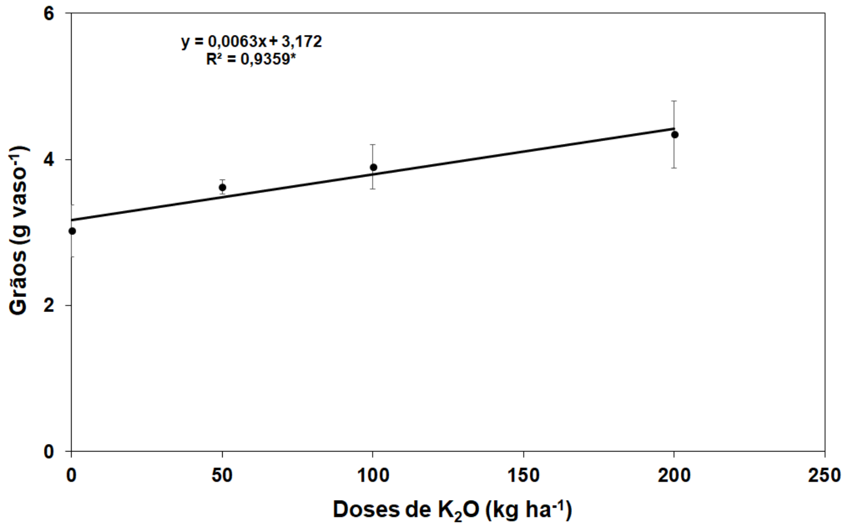

Figure 4. Grain mass (g pot^{-1}) produced by crambe plants subjected to different doses of potassium (kg ha^{-1} K_2O). Data presented are the mean ± standard error of the mean (n = 5).

The results presented are in line with information from other species belonging to the Brassicaceae family that have a high K requirement (MALHI et al. 2007). ROSOLEM & STEINER (2014) found that the highest grain yield in crambe was achieved with K_2O rates of 150 kg ha^{-1}, resulting in leaf K concentrations of 36.9 g kg^{-1}. Indeed, these findings highlight the crucial role of K in achieving high yields. Potassium plays a crucial role in plant metabolism by activating enzymes, promoting photoassimilate redistribution, and regulating stomatal movement, thereby enhancing plant stability and resistance to pests, diseases, and excessive foliar water loss (MALHI et al. 2007, TRIPATHI et al. 2022). Is the high K demand responsible for crambe's hardiness, adaptability, and drought resistance, or does K metabolism in the plant promote these traits? Currently, crambe cultivation is widely used in winter crops after soybean harvest, relying solely on residual nutrients from the previous crop, conditions that may not favor the expression of its full potential.

CONCLUSION

These findings indicate that despite their hardiness, crambe plants respond positively to potassium fertilization, showing increased leaf and grain biomass with higher K_2O soil application rates. Under the experimental conditions, grain yield peaked at 200 kg ha^{-1} of K_2O.

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