



OPTIMIZATION OF CANOLA AGRONOMIC YIELD SUBMITTED TO DIFFERENT DOSES OF POTASSIUM IN FLOWERING

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ABSTRACT

Providing nutrients in quantities and at the right time is of paramount importance to obtain high yields in canola culture. The objective of this work was to evaluate the agronomic performance of the Hyola 433 hybrid, submitted to potassium fertilization during flowering, during the 2016/2017 harvest. A randomized block design with four repetitions was used, in a 2x5 factorial scheme, with two canola phenological stages (F_1 and F_2) and five potassium doses in coverage (0, 15, 30, 60 and 120 kg ha⁻¹). The following phenometric variables were evaluated: emergence at the beginning of flowering (EIF), flowering duration (DFL), maturation duration (DFL) and cycle; as well as agronomic variables: number of silicas per plant (NSP), number of grains per silicas (NGS), plant height (ESP), mass of a thousand grains (MMG), productivity (PRO) and oil content. There was no interaction between application times and potassium doses for MMG, PRO and oil content. The dose of 60 kg ha⁻¹ increased the DFL and the cycle. The maximum number of 309 silicas per plant was obtained with the dose of 120 kg ha⁻¹ of K₂O. The increase of potassium concentrations reduced calcium concentration in plant tissue. In general, potassium fertilization during flowering increases the expression of variables related to canola phenology and agronomic performance.

Palavras-chave:

concentração de potássio
fenologia
produtividade

OTIMIZAÇÃO DO RENDIMENTO AGRONÔMICO DE CANOLA SUBMETIDA À DIFERENTES DOSES DE POTÁSSIO NO FLORESCIMENTO

RESUMO

Fornecer nutrientes em quantidades e no momento adequado é de suma importância para obtenção de altos rendimentos na cultura da canola. O objetivo em realizar este trabalho foi avaliar o desempenho agronômico do híbrido Hyola 433, submetido à adubação potássica no florescimento, durante a safra 2016/2017. Empregou-se o delineamento de blocos casualizados com quatro repetições, num esquema fatorial 2x5, sendo dois estádios fenológicos da canola (F_1 e F_2) e cinco doses de potássio em cobertura (0, 15, 30, 60 e 120 kg ha⁻¹). Foram avaliadas as variáveis fenométricas: emergência ao início do florescimento (EIF), duração do florescimento (DFL), duração da maturação (DFL) e ciclo; bem como as variáveis agronômicas: número de síliquas por planta (NSP), número de grãos por síliquas (NGS), estatura de plantas (ESP), massa de mil grãos (MMG), produtividade (PRO) e teor de óleo. Não houve interação entre épocas de aplicação e doses de potássio para MMG, PRO e teor de óleo. A dose de 60 kg ha⁻¹ aumentou a DFL e o ciclo. O número máximo de 309 síliquas por planta foi com a dose de 120 kg ha⁻¹ de K₂O. Aumentar as concentrações de potássio reduziu as de cálcio no tecido vegetal. De um modo geral, a adubação potássica no florescimento, eleva a expressão de variáveis relacionadas a fenologia e desempenho agronômico da canola.

INTRODUCTION

Canola (*Brassica napus* L. var. *Oleifera*) is an oilseed belonging to the Brassicaceae family, developed from conventional rapeseed breeding. As it is an agricultural product of great interest for the production of biodiesel, besides protein bran and edible oil of high nutritional value, its cultivation has been occurring in several regions of the world, including in the South of Brazil, as an alternative for winter culture in systems rotation with cereals and legumes (TOMM, 2014).

Canola, like other plants, needs ideal conditions to complete its subperiods and express its maximum genetic and productive potential. Climate, management and cultural treatment are fundamental components during its development (BANDEIRA *et al.*, 2013). The management of soil fertility is also a decisive factor in the agronomic performance of the crop (PULL *et al.*, 2015).

Potassium (K) in this context, is the third most important nutrient for canola, required as a cofactor in the activation of more than 40 enzymes. Furthermore, potassium acts as the main cation in the establishment of cell turgor and promotion of tissue resistance from the thickening of the cell walls. Studies have proven the importance of this macronutrient in increasing the mass of a thousand grains, in resistance to disease and lodging (SHARMA; KOLTE, 1994; CIBOTTO *et al.*, 2016).

Other studies addressing the importance of K in the physiological, chemical and biochemical activities of canola, confirm that the element contributes to the physiological and sanitary quality of seeds and resistance to water loss, since it acts in the process of opening and closing stoma and in cell osmotic regulation (RENKEMA *et al.*, 2015; SEVERTSON *et al.*, 2016).

McGregor (1981) and Pahlavani *et al.* (2007) reported that canola produces twice as many flowers as silicas and the photosynthetic capacity of the plant may not support the number of different flowers. Therefore, a good nutritional supplementation during flowering can bring benefits and help to maintain the number of flowers that will be converted into silica.

According to Courpron *et al.* (1973) and Rose *et al.* (2008) the potassium is found in increasing amounts in the plant, until the beginning of the grains maturation. On the other hand, Barraclough (1989) showed that the largest accumulation of this

macronutrient, as well as phosphorus, occurred at the end of grain filling. Rose *et al.* (2007) verified that the supplement with K at the beginning of flowering promoted a significant increase in the nutrient concentration in the roots, stems, leaves and silica. However, these authors did not find increases in grain yield and oil content.

The uniformity in the silica ripening process was observed by Rossetto *et al.* (1998) when the culture was fertilized with a dose of 40 kg ha⁻¹ of K₂O. These authors also found greater germination and vigor of seeds in response to the use of potassium in coverage compared to the control, even under conditions of six months of storage in a cold chamber.

In this context, the scarce results found in the national and international literature, with regard to potassium fertilization at the beginning of canola flowering, do not clearly address the real effects of these practices on the formation of flowers, flower buds and silica setting. Furthermore, they do not accurately delimit the possible gains in the agronomic performance of the crop. Therefore, the objective of this work was to study the agronomic response curve of the application of different doses of potassium in two phenological stages of canola flowering.

MATERIAL AND METHODS

The experiment was performed in the field and under rainfed conditions, in the Western region of Paraná in the period from 05/10 to 08/30/2016. The area's soil is classified as Eutrophic Red Latosol with a clay texture (SANTOS *et al.*, 2006). The climatic conditions allowed a good development of the culture with precipitations registered for ten years and temperatures varying between 8 and 30 °C (Figure 1).

A randomized block design was used, with four repetitions, in a 2 x 5 factorial scheme, two phenological stages of canola flowering (F1 - first open flowers and F2 - numerous open flowers and lengthening of the floral branch) and five doses of K₂O in coverage (0, 15, 30, 60 and 120 kg ha⁻¹). The plots consisted of six sowing lines 5 m long, 0.45 m spaced apart, featuring an experimental unit of 13.5 m² with a usable area of 3.6 m², consisting of two central lines of 4 m length.

The sowing fertilization was performed based on the chemical analysis of the soil (Table 1) and expected productivity of 2,000 kg ha⁻¹. Thus, 444 kg

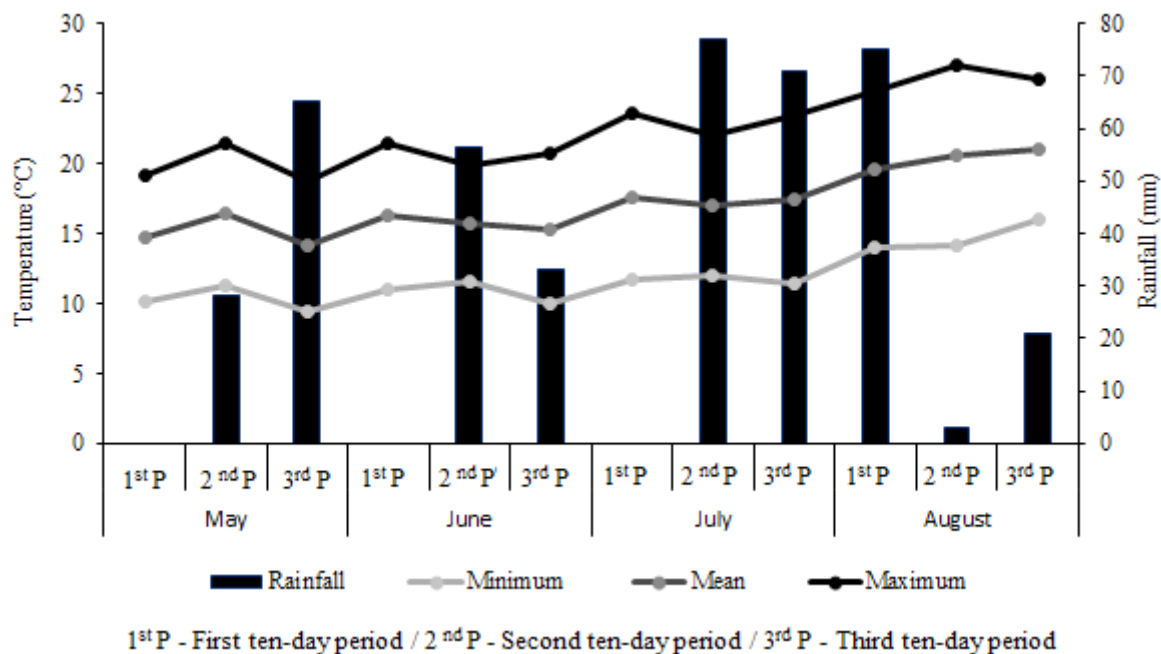


Figure 1. Temperature (°C) and separation (mm), collected by ten days, during the experiment

Table 1. Chemical characterization of the soil sample in the experimental area performed at 20 cm depth before sowing canola

Soil chemical analysis										
P	OM	pH CaCl ₂)	H+Al	Al	K	Ca	Mg	SB	T	V%
mg dm ³	g dm ³	0,01 mol L ⁻¹	-----cmol _c dm ³ -----							
4.5	20.3	5.8	4.0	0.07	0.20	6.83	3.07	10.	14.4	72

P - Phosphorus, OM - Organic matter, H - hydrogen, Al - Aluminum, Ca - Calcium, Mg - Magnesium, SB - Sum of bases, T - Cation exchange capacity, V - Base saturation.

ha⁻¹ of the formulated 06-18-08 (6% N, 18% P₂O₅ and 8% K₂O) were applied. When the crop reached the B4 phenological stage (four fully developed leaves), a dose of 380 kg ha⁻¹ of ammonium sulfate fertilizer ((NH₄)₂ SO₄) was applied (BATTISTI *et al.*, 2013).

Sowing was performed on May 10, 2016 on oat straw, using a 6-row seeder with regulation aiming at the deposition of 22 seeds per meter, at a 2.0 cm depth. The hybrid canola Hyola 433, of short cycle (120 to 150 days) with polygenic resistance to black cinnamon (*Leptosphaeria maculans*), registered in 2008 and indicated for high fertility soils was used (TOMM *et al.*, 2009).

Weed management was performed at the rosette stage by manual weeding. During the period of elongation and formation of the floral bud, the control of crucifer moths (*Plutella xylostella*) was performed by the application of Teflubenzuron,

a growth regulating insecticide and inhibitor of chitin synthesis, belonging to the chemical group of the Benzoylureas. No diseases were found.

The beginning of flowering was counted from the moment when at least 50% of the plants presented their first open flower and the end of flowering was characterized by the absence of flowers. The doses of 0, 15, 30, 60 and 120 kg ha⁻¹ of K₂O were adjusted proportionally to the plot size and the quantity distributed in each treatment was weighed on a digital scale. Potassium chloride (KCl) was used as the nutrient source.

At 21 days after fertilization in F1 and 14 days after fertilization in F2, when the culture characterized the G3 phenological stage (first silica lengths greater than 4 cm), sampling for tissue analysis was carried out by randomly collecting the aerial part of five plants in each plot. After

washing and drying in air, the plants were packed in paper packages and put to dry in an oven with forced air circulation, for a period of 72 hours, at a temperature of 65 °C.

The plant material was weighed and ground, a sample of approximately 1.0 g was digested with a mixture of 6 mL of nitric acid (HNO₃) and 1 mL of perchloric acid (HClO₄) following the methodology of Tedesco *et al.* (1995). The determination of K was performed using a flame photometer. Calcium (Ca) and magnesium (Mg) were determined using an atomic absorption spectrophotometer.

In addition to nutritional analysis, the following phenometric variables were evaluated: emergence at the beginning of flowering (EIF), flowering duration (DFL), maturation duration (DMA) and crop cycle, as well as the agronomic variables such as number of silicas per plant (NSP), number of grains per silica (NGS), plant height (ESP), mass of a thousand grains (MMG) and productivity (PRO). The oil content in the grains was estimated using the solvent extraction method, using the Soxhlet extractor (WENNERSTEN, 1992).

The data set was submitted to analysis of variance, applying the F test, at 5% probability level. The averages of the phenological stages were compared by the Tukey test, also at 5% probability level. To study K₂O doses, regression analysis was applied and the Sisvar statistical program was used in all procedures.

RESULTS AND DISCUSSION

The fertilization with potassium in two phenological stages of flowering did not influence

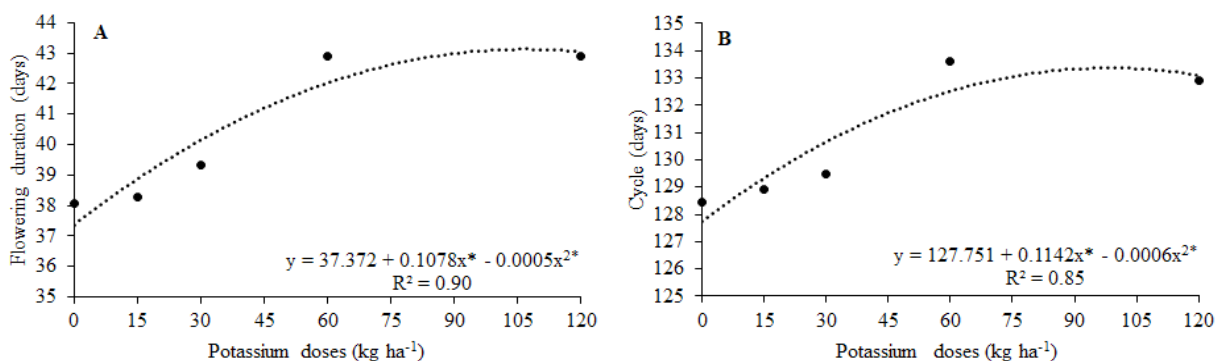


Figure 2. Flowering duration (A) and Hyola 433 hybrid cycle (B) as a function of potassium doses in coverage, regardless of the time of application. * significant at 5% probability level by the “t” test

the following variables: emergence at the beginning of flowering, duration of maturation, plant height, weight of a thousand grains, productivity and oil content in the Hyola 433 hybrid grains. However, it should be noted that the average productivity of the crop was 1,553 kg ha⁻¹, with 38% of oil in the grains and 3.3 g in the mass of a thousand grains.

Regardless of the time of application, K₂O doses changed the flowering duration (DFL) and the crop cycle. The variables, when adjusted in quadratic models, expressed maximum points in 43 and 133 days, respectively and the highest estimated efficiency dose was 107.8 and 95.2 kg ha⁻¹ respectively (Figure 2A and B). The prolongation of flowering was the main factor responsible for the extension of the crop cycle.

Ahmaed *et al.* (2015) found that K₂O doses greater than 30 kg ha⁻¹ extended the canola cycle by seven days. The authors justify that the higher concentration of the nutrient in the tissues reduced the fall of flowers and flower buds, reflecting directly on the prolongation of flowering and, consequently, the crop cycle. A study by Rose *et al.* (2008), confirmed that the greatest accumulation of K in canola occurs at the end of flowering and beginning of grain filling.

In this context, the Potassium is present in numerous biochemical and physiological activities of the plant such as the synthesis of Adenosine Triphosphate (ATP), osmotic balance and strengthening and permeability of cell membranes that culminate in the structural resistance of the plant (NOVAIS *et al.*, 2007). However, according

to Taiz and Zeiger (2016), concentrations above 50 g kg⁻¹ of K promote harmful effects on cell metabolism by rupture of membranes, protein degradation and physiological and enzymatic cell destabilization.

In the absence of K in coverage, it was observed that the average number of silicas per plant was 283, an average value found in tests with base fertilization recommended for the crop (KRÜGER *et al.*, 2011). However, the proposed polynomial model showed that compared to the control, the number of silica per plant increased to 301.8 and 309 when subjected to doses of 60 and 120 kg ha⁻¹ of K₂O, respectively (Figure 3 A).

An average increase of one grain per silica for each 60 kg ha⁻¹ of K₂O added in coverage was observed (Figure 3B). Cheema *et al.* (2012) also verified that even in soils with adequate concentrations of K, there was an increase in the number of silicas per plant and in the number of grains per silica, beyond the mass of a thousand grains and the productivity of two canola cultivars in the Northeast region of Pakistan. On the other hand, Rossetto *et al.* (1998) found no effect between doses of K with productivity and oil content; however, they confirmed greater retention of silicas with doses greater than 40 kg ha⁻¹.

According to the results obtained for the agronomic and phenometric variables evaluated, the amounts of K₂O applied based on the chemical analysis of the soil are sufficient to meet the essential demands related to the productivity and oil content of the crops. However, the supplementary

fertilization with K₂O in coverage, allows a smaller fall of flowers, which provides greater production of silicas per plant and grains per silica. Szczepaniak (2014) confirms that potassium supplementation at the beginning of flowering, resulted in a greater number of silicas, besides increasing the concentration of K in the branches and providing structural resistance to the plants.

The K concentrations in plant tissues increased linearly with increasing doses of the nutrient in coverage, reaching the level of 32.22 g kg⁻¹ when submitted to a dose of 120 kg ha⁻¹ (Figure 4). Malavolta (2006) states that concentrations between 10 and 30 g kg⁻¹ of K are considered suitable for the normal development of plants, and values below 8 and above 50 g kg⁻¹, respectively, characterize symptoms of deficiency and toxicity.

Although leaf K concentrations did not reach toxicity levels and have contributed to the development of variables analyzed in this study, the results obtained confirm the phenomenon of antagonism, where doses above 60 kg ha⁻¹ of K₂O substantially reduced absorption and consequently the concentration of calcium (Ca²⁺) in the tissues; an important constituent of the middle lamella of cell walls (HAWKESFORD *et al.*, 2015).

It should be noted that before performing potassium fertilization in coverage, it is necessary to be aware of the soil moisture conditions. Since diffusion is the main mechanism of mobility of the element, the water content in the soil becomes essential to facilitate the loading of the ion close to the root absorption zone.

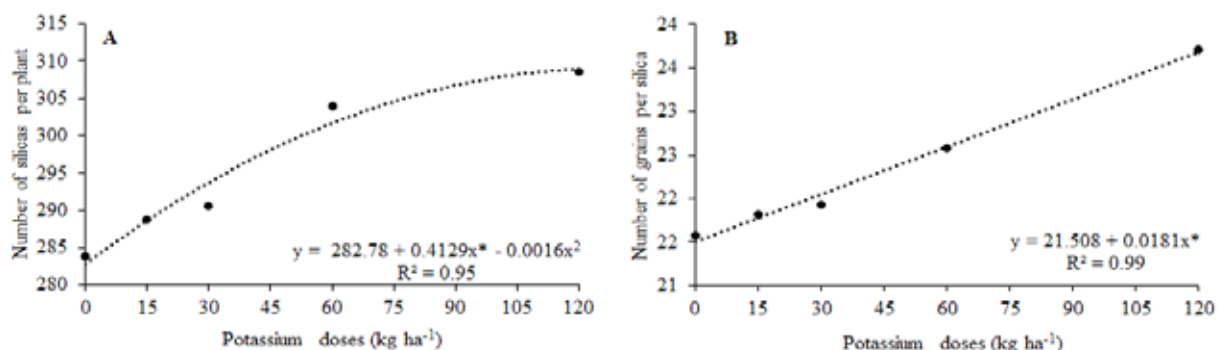


Figure 3. Number of silicas per plant (A) and number of grains per silica (B) as a function of potassium doses applied in the flowering of the canola hybrid Hyola 433. * significant at 5% probability by the “t” test

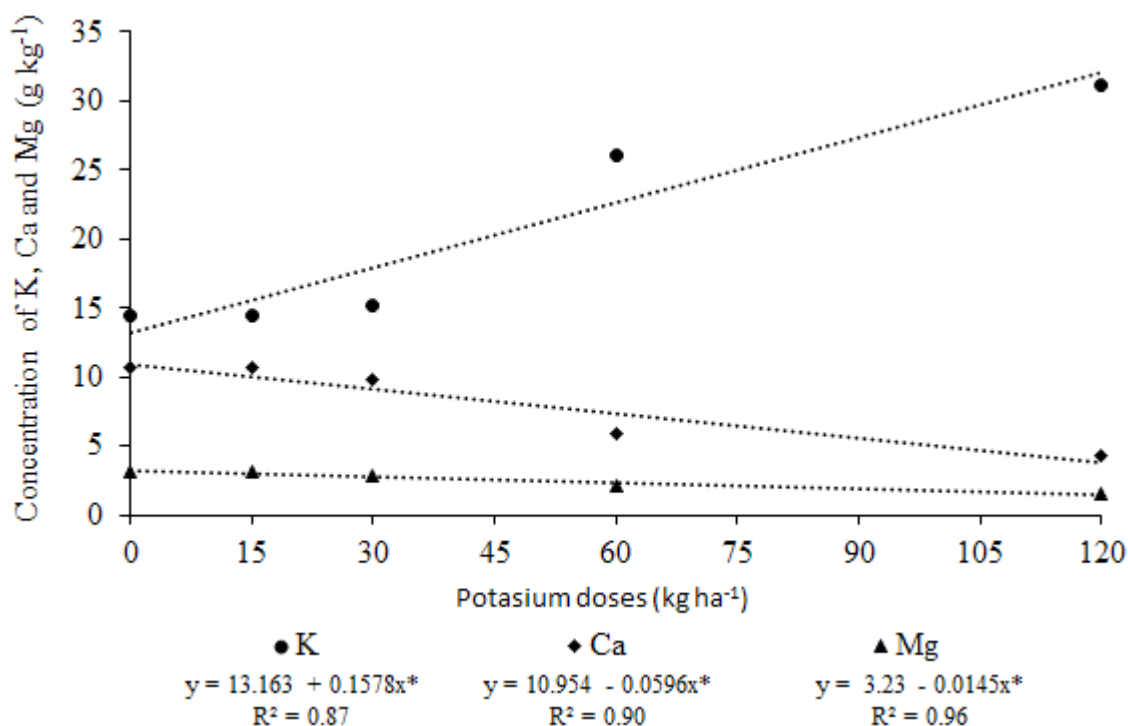


Figure 4. Concentration of K⁺, Ca²⁺ e Mg²⁺ in the aerial part as a function of fertilization with potassium in coverage in the canola hybrid Hyola 433. * Significant at 5% probability by the “t” test

CONCLUSION

- The responses of potassium fertilization in coverage occurred independently of the applied phenological stage (F1 and F2).
- In soils with average available potassium content, the Hyola 433 canola hybrid responds to potassium fertilization for the variables flowering duration, number of silicas per plant and number of grains for silicas, up to a dose of 120 kg ha⁻¹.
- The fertilization in coverage with doses greater than 60 kg ha⁻¹ of K₂O reduces the absorption and concentration of Ca in the aerial part of the plant.

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