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RESEARCH NOTE

Potassium fertilization of cauliflower and broccoli in a potassium-rich soil

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Abstract

A.L.P. Silva, A.B. Cecílio Filho, J.W. Mendoza-Cortez, and J.A. Lima Junior. 2016. Potassium fertilization of cauliflower and broccoli in a potassium-rich soil. Cien. Inv. Agr. 43(1):151-157. Cauliflower and broccoli are important vegetables but have lacking and divergent information about potassium (K) fertilization in soil with a high K content. Two experiments were carried out from 2-1-2010 to 5-20-2010 in Jaboticabal City, São Paulo, Brazil, aiming to evaluate the effect of different K doses (0, 50, 100, 150 and 200 kg ha⁻¹ K₂O, in potassium chloride) on the yield of cauliflower 'Verona' and broccoli 'BRO 68' in Rhodic Eutrudox soil with a high K content. The broccoli and cauliflower responded positively but differently to potassium fertilization. The maximum yield of broccoli (12,476 kg ha⁻¹) was obtained with 160 kg ha⁻¹ K₂O, while the yield of cauliflower increased linearly with increasing K dose, yielding 38,285 kg ha⁻¹ with 200 kg ha⁻¹ K₂O.

Key words: *Brassica oleracea* var. *botrytis*, *Brassica oleracea* var. *italica*, productivity.

Introduction

Fertilizing agricultural soils is one of the most expensive agricultural practices, although its economic return is usually high due to its effects on productivity, product uniformity and quality (Ricci *et al.*, 1995). In horticulture, because fertilization has a high economic return, farmers usually do not economize when applying fertilizers to the plants.

Cauliflower and broccoli crops are among those with the highest demand for potassium; it is the second most absorbed nutrient by plants of these species (Castoldi *et al.*, 2009; Takeishi *et al.*, 2009). According to Islam *et al.* (2010), K is the most important nutrient for broccoli productivity. Increased plant resistance to diseases and drought stress, increased vegetable quality and increased efficiency of non-K nutrient use are the most important effects of K on plants (Armstrong, 1998).

established, few studies have investigated the effects of this nutrient on the productivity of these species. Farmers frequently apply K fertilizers to horticultural plants in doses greater than those officially recommended because horticultural plants usually show positive responses to potassium fertilizers, even in potassium-rich soils. This procedure adopted by the farmers is probably based on the fertilizer dose recommendations found in tables for old cultivars that were less productive than are modern cultivars, which are highly responsive to soil fertilization.

Under soil conditions of high levels of available K, the fertilizer recommendations for broccoli and cauliflower crops are divergent. Trani *et al.* (1997) recommend the application of 120 kg ha⁻¹ at the planting time of both species, followed by a dose of 60 kg ha⁻¹ K₂O in a sidedress application. Fontes (1999a, b) recommended a dose of 20 kg ha⁻¹ at planting and 80 kg ha⁻¹ K₂O in a sidedress application. In potassium-rich soils, the Comissão de Química e Fertilidade do Solo (2004) recommended a dose of 220 kg ha⁻¹ K₂O. In addition to the discrepancies in the recommended doses, another intriguing fact is the recommendation of the same dose for two different horticultural species, given that this recommendation does not consider species differences regarding nutritional requirements, nutrient accumulation, productivity, spacing or other cultural practices.

Considering the abovementioned facts, the objective of this study was to verify the effects of different potassium fertilizer doses on the productivity of cauliflower and broccoli plants growing in a potassium-rich soil.

Materials and methods

Experimental site

Two experiments (cauliflower and broccoli) were carried out from February 01 to May 20, 2010, in the municipality of Jaboticabal, state of São

Paulo, Brazil, and at a latitude of 21°15'22" S, longitude of 48°18'58" W and a mean altitude of 575 m above sea level.

Soil type and characteristics

The soil of the experimental area was classified as Rhodic Eutrudox (Soil Survey Staff, 1999). The textural and chemical analyses of the soil conducted with samples taken at depths between 0 and 20 cm before the experiment began produced the following results: 253, 132 and 615 g kg⁻¹ sand, silt and clay, respectively; 5.4 pH (CaCl₂); 20 g kg⁻¹ organic matter; 103 mg dm⁻³ P (resin); 3.6, 25, 7, 28 and 64 mmol_c dm⁻³ K, Ca, Mg, H+Al, and cation exchange capacity, respectively; and 56% soil base saturation.

Treatments, experimental design and experimental unit

Doses of 0, 50, 100, 150, and 200 kg ha⁻¹ K₂O were evaluated; these doses were adopted considering the report of Trani *et al.* (1997), who recommended 120 kg ha⁻¹ K₂O for cauliflower and broccoli when the K content in the soil is high. In each experiment, the experimental units were distributed in the field according to a randomized complete block design with four replications. The experimental unit was composed of two six-plant rows, of which only the four central plants were used for experimental data.

Plant material, planting and harvesting

The seedlings of cauliflower 'Verona' and broccoli 'BRO 68' cultivars were grown in propylene trays with space enough for 200 seedlings in a BIOPLANT organic mineral substratum (Bioplant Agrícola Ltda, Nova Ponte city, Minas Gerais, Brazil). Transplantation to the seed bed took place on February 1, 2010, when the seedlings exhibited four leaves. Cauliflower seedlings were

placed at a distance of 0.7 m between rows and 0.50 m between plants. Broccoli seedlings were placed at a distance of 0.7 m between rows and 0.35 m between plants in the row. The distance between seed beds was 0.5 m. Cauliflower was harvested from May 14 to 20, and broccoli was harvested from April 2 to 13, 2010.

Management practices

Soil liming of the whole area was performed to increase the soil base saturation to 80% using calcined lime with a neutralization power of 124% and CaO and MgO contents of 48% and 16%, respectively. The mineral fertilization of the seed beds took place immediately before the seedling transplantation, and the amounts of fertilizers that were used were based on the recommendations of Trani *et al.* (1997). The N, P, and K sources were, respectively, urea, superphosphate, and potassium chloride. No organic fertilizer was applied. The sidedressing of fertilizers also followed the recommendations of Trani *et al.* (1997), although the doses were applied only at 15, 30, and 45 days after transplantation (DAT). Approximately 40% of the total K of each treatment was applied at planting, and the remaining portion was divided and applied at the aforementioned moments. Irrigation was provided throughout the plant life cycle using a sprinkler system.

Parameters that were evaluated

The potassium foliar content was measured in the leaf that developed immediately after the inflorescence started to grow, according to the instructions of Trani and Rajj (1997). The potassium soil content was determined after harvest, according to methodology proposed by Rajj *et al.* (2001). The mass and diameter of the inflorescence and the productivity were also determined.

Data analysis

An analysis of variance and a polynomial regression of the data were performed. The equation with a significant F and with the highest determination coefficient was chosen.

Results and discussion

Foliar K content

The potassium level in cauliflower leaves was influenced by K doses. A quadratic adjustment was found for K levels in the leaves and K doses. The K levels in the leaves increased from 29.2 g kg⁻¹ when the K₂O dose was null to 34.9 g kg⁻¹ when the K₂O dose was 200 kg ha⁻¹. In broccoli plants, however, the K foliar level was not influenced by K₂O dose - the mean value was 34.4 g kg⁻¹ (Figure 1).

The potassium foliar levels found for both cauliflower and broccoli plants were within the adequate ranges (25 to 50 g kg⁻¹) according to Trani and Rajj (1997). The difference in the response shown by cauliflower and broccoli should be due the better adaptation displayed by the cauliflower cultivar to the high temperatures that were registered during the experiment. Although both cultivars are recommended for summer cultivation, broccoli cultivars have shown poor growth and productivity

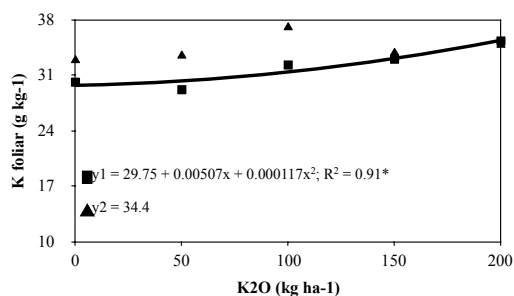


Figure 1. Potassium foliar level in cauliflower 'Verona' (y1) and broccoli 'BRO 68' (y2) as a function of the K₂O doses.

when the environmental conditions include high temperatures and pluvial precipitation, indicating that genetic improvement for more heat-tolerant broccoli cultivars is needed. This explains – at least partially – why increased doses of K_2O did not result in increased levels of potassium in broccoli leaves. Highly productive cauliflower cultivars for summer, winter, and midseason conditions are available.

Inflorescence diameter

The effects of K_2O doses on the inflorescence diameter were different for cauliflower and broccoli. In cauliflower, the response of the inflorescence diameter to K_2O doses showed a polynomial quadratic adjustment pattern starting from 50 kg ha^{-1} (the maximum diameter of 21.8 cm resulted from the K_2O dose of 200 kg ha^{-1}). In broccoli plants, the inflorescence diameter increased with K_2O doses up to 150 kg ha^{-1} , which was the dose that resulted in the highest diameter: 14.6 cm (Figure 2a).

Increments in the inflorescence diameter were less expressive in broccoli than in cauliflower. Monteiro *et al.* (2010) observed a diameter of 25.3 cm in cauliflower plants of the ‘Verona’ cultivar growing under summer conditions in Jaboticabal.

Inflorescence mass

The inflorescence mass increased with K_2O doses. The highest inflorescence masses in cauliflower (1,086.3 g) and in broccoli (362.1 g) resulted from the respective K_2O doses of 200 and 155 kg ha^{-1} (Figure 2b). The mass in this experiment was similar to that (1,120 g) reported by Monteiro *et al.* (2010) in work with the ‘Verona’ cultivar in a summer experiment for the observation of cauliflower hybrids. This value was, however, larger than that reported by Pôrto *et al.* (2012) (860 g) in an experiment in which the plants grew at the

same population density. Islam *et al.* (2010) also reported responses with quadratic adjustments of the broccoli inflorescence diameter and mass to K_2O doses – these authors used doses ranging from 0 to 360 kg ha^{-1} K_2O .

These authors also verified that the maximal inflorescence diameter and mass were gained when the K_2O dose was of 240 kg ha^{-1} and that doses larger than this started to have depressing effects on those characteristics. The productivity of both cauliflower and broccoli plants was significantly influenced by K_2O doses.

Productivity

Cauliflower productivity was observed to increase linearly with doses of K_2O - the dose of 200 kg ha^{-1} resulted in a yield of 38,285 kg ha^{-1} (Figure 3). This dose is larger than that recommended by Fontes (1999a, b) (100 kg ha^{-1}) and is close to that recommended by Trani *et al.* (1997) (180 kg ha^{-1}) for potassium-rich soils. When K fertilizer

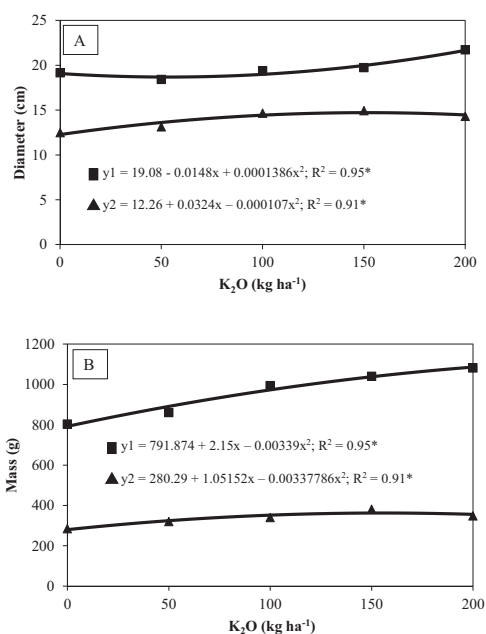


Figure 2. Diameter (A) and mass (B) of cauliflower ‘Verona’ (y1) and broccoli ‘BRO 68’ (y2) as a function of the K_2O doses.

was not applied, the inflorescence production was 30,351 kg ha⁻¹, a value representing 79% of the maximum yield (Figure 3). A high productivity without the application of K may be ascribed to high soil fertility with a high level of K - 3.6 mmol_c dm⁻³. However, when K₂O fertilizer was applied to the soil, cauliflower was responsive, and an increase of 40 kg ha⁻¹ in inflorescence was registered for each 1 kg of K₂O fertilizer that was applied.

The maximum productivity verified for cauliflower is approximately twice as much as the national average (20,000 kg ha⁻¹). In an experiment in which cauliflower genotypes were evaluated during the summer, Monteiro *et al.* (2010) found a productivity of 22,340 kg ha⁻¹ for the ‘Verona’ cultivar and a productivity between 14,560 and 23,760 kg ha⁻¹ for the other hybrids. Pôrto *et al.* (2012) reported productivities between 11,381 and 23,035 kg ha⁻¹ for the ‘Verona’ cultivar, depending on the plant population.

Broccoli productivity showed an adjustment to the quadratic equation in response to K₂O doses, with a maximum yield of 12,476 kg ha⁻¹ when the K₂O dose was 160 kg ha⁻¹ (Figure 3). This dose is slightly greater than that recommended by Fontes (1999a, b) and close to that recommended by Trani *et al.* (1997) (180 kg ha⁻¹ K₂O when the lowest side-dressed dose - 60 kg ha⁻¹ - is added to the 120 kg ha⁻¹ applied at planting). The productivity, however, is lower than that reported by Cecílio Filho *et al.* (2012), who evaluated the distance between plants and the doses of N and K and verified a ‘Mônaco’ broccoli productivity of 22,082 kg ha⁻¹ in the best treatment (315 kg ha⁻¹ N and K₂O and a spacing combination of 0.2 m between plants and 0.8 m between rows). However, this experiment used an Autumn crop, which was more favorable for productivity, and had a larger plant population because the authors did not cultivate broccoli in seed beds. Islam *et al.* (2010) verified larger yields with 240 kg ha⁻¹ K₂O when evaluating doses from 0 to 360 kg ha⁻¹ K₂O.

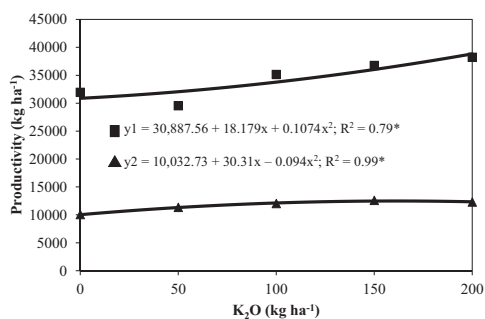


Figure 3. Cauliflower ‘Verona’ (y1) and broccoli ‘BRO 68’ (y2) productivity as a function of the K₂O doses.

Examining the productivity of both species, it was verified that broccoli was agronomically more efficient than cauliflower because up to a dose of 70 kg ha⁻¹, broccoli produced a higher inflorescence per kilogram of K₂O. Doses higher than this (100, 150, and 200 kg ha⁻¹) decreased the broccoli agronomical efficiency, with respective yields of 20.9, 16.2, and 11.5 kg of inflorescence per kilogram of K₂O. These same K₂O doses resulted in 28.9, 34.3, and 39.7 kg of cauliflower inflorescence per kilogram of K₂O. When cauliflower and broccoli were applied respective maximizing doses of 200 and 160 kg ha⁻¹ K₂O, the agronomical efficiencies were, respectively, 39.7 and 15.1 kg of inflorescence per kilogram of K₂O.

The level of potassium in the soil was significantly influenced by K₂O dose. When no K was applied, the K levels in the soil were 1.8 and 2.5 mmol_c dm⁻³ in the cauliflower and broccoli areas, respectively. With increasing K₂O doses of up to 200 kg ha⁻¹, the K level in the soil increased linearly, reaching 4.0 and 4.5 mmol_c dm⁻³ in the cauliflower and broccoli areas, respectively (Figure 4).

The level of K in the soil before the experiment began, 3.6 mmol_c dm⁻³, was maintained after the inflorescences were harvested when cauliflower and broccoli were fertilized with 165 and 110 kg ha⁻¹ K₂O, respectively (Figure 4). Doses higher than these resulted in increased levels of K in the soil with increments compared to the initial level

of 11% and 25%, with the initial level already being a high value, according to Rajj *et al.* (1997). The lower recovery of the applied nutrient shown by broccoli plants compared to that shown by cauliflower indicates differences between the two species, probably influenced by the adaptability to the cropping environment. Pôrto *et al.* (2012), when evaluating the effects of the time of 'Verona' cauliflower cultivation (Spring-Summer and Autumn-Winter), reported significant differences in the number of leaves, stem diameter, inflorescence diameter, inflorescence mass, productivity, and cycle.

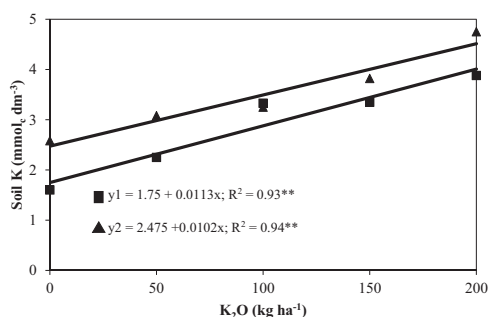


Figure 4. Potassium level in the soil as a function of the K₂O doses in areas of cauliflower 'Verona' (y1) and broccoli 'BRO 68' (y2).

When cauliflower and broccoli were cultivated with K₂O doses lower than 165 and 110 kg ha⁻¹ K₂O, respectively, the K levels in the soil decreased. These reductions increased as the K₂O doses decreased and reached 50% and 30% for cauliflower and broccoli, respectively, cultivated without potassium fertilizer. The greater reduction in K level in the soil for cauliflower plants may be attributed to the greater K demand shown by this species than by broccoli, as reported by Castoldi *et al.* (2009) and Takeishi *et al.* (2009). The results for cauliflower inflorescence diameter and mass and yield suggest that this brassica was not negatively affected by the increased K level in the soil, which reached 4.5 mmol_c dm⁻³ when the highest dose of K₂O was applied (Figure 4), different from that observed for broccoli.

Based on the observed results, broccoli and cauliflower plants growing in K-rich soils respond to K fertilization. The maximum yield of broccoli was reached when the K₂O dose was 160 kg ha⁻¹, and that of cauliflower was reached when this dose was 200 kg ha⁻¹.

Resumen

A.L.P. Silva, A.B. Cecílio Filho, J.W. Mendoza-Cortez, y J.A. Lima Junior. 2016. Fertilización potásica de coliflor y brócoli en un suelo con alta concentración de potasio. Cien. Inv. Agr. 43(1):151-157. La coliflor y el brócoli son dos hortalizas económicamente importantes, sin embargo carecen de informaciones acerca de la fertilización con potasio (K) en suelo con alta concentración de ese nutriente. En ese contexto, fueron realizados dos experimentos del 01 de febrero al 20 de mayo de 2010, en la ciudad de Jaboticabal, São Paulo, Brazil, con el objetivo de evaluar cinco dosis de K (0, 50, 100, 150 y 200 kg ha⁻¹ de K₂O), utilizando cloruro de potasio, sobre la productividad de la coliflor 'Verona' y del brócoli 'BRO68', en suelo tipo Rhodic Eutrudox con alta concentración de K. El brócoli y la coliflor respondieron positivamente a la fertilización con potasio, pero con respuestas diferenciadas. La máxima productividad del brócoli (12 476 kg ha⁻¹) se obtuvo con 160 kg ha⁻¹ de K₂O, mientras que la productividad de la coliflor aumentó linealmente con el incremento de las dosis de K, produciendo 38 285 kg ha⁻¹ con 200 kg ha⁻¹ de K₂O.

Palabras clave: *Brassica oleracea* var. *botrytis*, *Brassica oleracea* var. *italica*, productividad.

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