Influence of Potassium Doses on the Development of Chrysanthemum Plants

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ABSTRACT

The chrysanthemum is one of the main flowers cultivated in the world, comprises the main merchandise of all floriculture. The difficulty in expanding the crop is related to the lack of technical information about its cultivation, mainly on the nutritional needs. The experiment was conducted at the Federal Institute of Espírito Santo - Campus Itapina with a completely randomized design with four treatments and twenty four replications. The treatments consisted of different doses of potassium fertilization (0, 60, 120 and 240 kg.ha^{-1} of K_2O). At the end of the cycle, plant height (cm) analyzes were performed; stem diameter (mm); number of leaves; leaf area (cm²); SPAD index and fresh and dry matter (g). Doses between 150 and 240 kg.ha^{-1} of K_2O provided positive results for the development of the plant, while doses under 150 kg.ha^{-1} presented unsatisfactory results.

SAMPLE ABSTRACT:

Aims: Evaluate the influence of potassium doses on the development of cutting chrysanthemum plants.
Place and Duration of Study: Horticulture Sector of the Federal Institute of Education, Science and Technology of Espírito Santo - Campus Itapina, between May 2017 and August 2017.
Methodology: The experimental design was DIC (completely randomized design) with four treatments and twentyfour replications considered useful plants within each plot. The treatments consisted of three diferent doses of potassium fertilization and one control: 0 kg.ha^{-1} of K_2O (without any application of potassium); 60 kg.ha^{-1} of K_2O (fertilizer used by producers in the region); 120 kg.ha^{-1} of K_2O (recommended according to the amount of potassium in the soil analysis) and 240 kg.ha^{-1} of K_2O (double the dose recommended by the soil analysis), being used as source potassium chloride.
Results: The height of the plant presented an increasing linear, the results show that the dose of 240 kg.ha^{-1} of K_2O was adequate in order to supply potassium in the ideal amount for the growth of chrysanthemum plants. When the diameter of the stem was evaluated, a quadratic model was generated with a maximum of 7.05 mm diameter of the stem when applied 179 kg.ha^{-1} of K_2O. An increase in the number of leaves per plant was observed, from 27 at 0 kg.ha^{-1} dose of K_2O to 51.75 at 240 kg.ha^{-1} dose of K_2O. When estimating the ideal dose with the equation $\hat{Y} = 277.7146 + 4.1805*x - 0.0136*x^2$, the dose of 153.69 kg.ha^{-1} of K_2O provided the largest leaf area, reaching the value of 598.97 cm². The SPAD

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(Chlorophyll content) the linear model better explained the data with coefficient of determination (R^2) of 0.79. The highest volume of fresh matter found was 81.56 grams with the dose of 203.22 $kg.ha^{-1}$ of K_2O. Through the adjusted model was verified that the dose that maximized the dry matter of the plant with 16.17 grams, was the dose of 161.66 $kg.ha^{-1}$ of K_2O.

Conclusion: Doses between 150 and 240 $kg.ha^{-1}$ of K_2O provided positive results for the development of the plant, while doses under 150 $kg.ha^{-1}$ presented unsatisfactory results.

Keywords: *Dendranthema grandiflorum; mineral nutrition; flower shop; fertilizer.*

1. INTRODUCTION

The floriculture trade in Brazil has shown great growth, presenting as an agricultural investment area. The production of flowers and ornamental plants is constantly expanding in the agribusiness, due to the great diversification of the species, implantation of new technologies of production and technical qualification of the members of the productive sector of flowers. [1] pointed out that between 2008 and 2011 the supply of flowers increased by 10% in the market, and in the year of 2013 it handled a total of R$ 5.22 billion, being 8.3% higher than the year 2012.

Chrysanthemum is one of the main flowers cultivated in the world, together with roses, carnations and gerberas, it comprises the main commodity of all flower shops [2]. In Brazil it stands out as the second cut flower in production volume. This is because the flowers present several varieties of color, shape and size, characteristic of inflorescence longevity, early production and rapid return of invested capital [3].

The difficulty in the expansion of the chrysanthemum crop is related to the lack of technical information about its cultivation, mainly on the specific nutritional needs of the crop, which generates a complexity in quantifying doses of fertilizers to be applied according to the lack of the plant. In general, the producers use unbalanced doses, which interfere with the quality, productivity and longevity of the inflorescences and the plant [4]. As a result of the strong competition in the flower market, the nutritional management of this crop would provide a differential for improving the production and providing lower production costs.

According to [5] the mineral nutrients act in the metabolism of the plants, developing vital functions for the growth and development of the vegetables. It is essential to use adequate amounts of these elements, such as nitrogen, phosphorus and potassium, which are directly related to the formation of flower buds, production and quality of inflorescences.

Followed by nitrogen, potassium is the second nutrient most required by plants, exerts essential functions in cells, osmotic regulation, in the control of stomatal movements, in the water relations of the plant and its high concentrations in the cytosol and chloroplasts. Potassium is important to balance the charge of soluble and insoluble anions, resulting in the stabilization of pH between 7 and 8, contributing to the numerous enzymatic reactions [5, 6].

In the chrysanthemum culture, potassium is essential in several stages of cultivation, from the first six weeks, when the plants grow rapidly until the flowering period, when the flower buds are formed and the color formation of the inflorescences [2]. According to [7] the deficiency of this element interferes in the vegetative phase and in the flowering, causing yellowing at the edges of the leaves and malformation of the inflorescences.

Due to the importance of potassium to the physiology of plants and the lack of studies of fertilization and nutrition of cut chrysanthemum, it is necessary to develop research to obtain this information. Thus, the objective of this work was to evaluate the influence of potassium doses on the development of cutting chrysanthemum plants in the Colatina-ES region.

2. MATERIAL AND METHODS

The experiment was carried out in the field of Horticulture of the Federal Institute of Education, Science and Technology of Espírito Santo - Campus Itapina, located in the municipality of Colatina, in the northwestern region of Espírito Santo, with geographical coordinates of 19 ° 32 '22 "south latitude; 40 ° 37 '50' west longitude and altitude of 71 meters. The region is characterized by irregular rainfall and the extent of serious temperatures and the climate, it is classified as Tropical Aw, according to Koppen's climatic classification [8].

The experiment was constructed a bed of 12 m², consisting of 10 m of length and 1.20 m of width. This area was divided into four equal parcels of 3 m², with different doses of potassic fertilization, installed in each plot. For the tutoring, a nylon net, formed by 15x15 cm squares, was used to keep the flower stems upright and avoid tipping.

The planting was carried out in May 2017, with seedlings obtained from a supplier company, partner of the research with the cultivar White Reagan, planting 1 seedling per square of the net, obtaining on average 44 plants/m², thus, on average, 528 plants in every experiment. For the evaluation, 96 plants were withdrawn, 24 plants per plot, counting as a useful plot only the center of the bed, neglecting the borders. Night illumination was also used to stimulate vegetative growth, using 12 W led bulbs lit from 6:00 p.m. to 8:00 p.m., installed at 1. M of height. Irrigation was performed taking into account the water demand of the crop during its development cycle, keeping the soil close to the field capacity.

Phosphate and nitrogen fertilization was carried out according to soil analysis (Table 1) and crop recommendation [7], in all treatments, varying only the doses of potassium fertilization.

The experimental design was DIC (completely randomized design) with four treatments and twentyfour replications considered useful plants within each plot. The treatments consisted of three diferent doses of potassium fertilization and one control: 0 kg.ha^{-1} of K_2O (without any application of potassium); 60 kg.ha^{-1} of K_2O (fertilizer used by producers in the region); 120 kg.ha^{-1} of K_2O (recommended according to the amount of potassium in the soil analysis) and 240 kg.ha^{-1} of K_2O (double the dose recommended by the soil analysis), being used as source potassium chloride.

Table 1: Soil chemical characteristics

pH	P	K	P-REM	Ca	Mg	H+Al	CTC	T	SB	MO	V
	mg/dm^{-3}		mg/mL	cmol$_c$/dm^{-3}						%	
6,96	73,9	166,0	30,4	3,27	0,98	7,2	32,9	6,0	4,7	1,56	78

At 90 days after planting, when the inflorescences were open, the following analyzes were performed: height of the plant (cm) using a graduated ruler; measuring from the ground level to the top of the plant; diameter of the stem (mm) using a digital caliper, evaluating the diameter in the average height of the plant; number of sheets by counting; leaf area using Liqueur Liquor Model 3100 (cm²) leaf scanner; SPAD index through KONICA MINOLTA portable chlorophyll meter SPAD-502 Plus; fresh matter (g) measured using a digital scale and dry matter (g), placing the samples in a forced circulation oven at 70°C for 72 hours and then weighed on a digital scale.

Data were submitted to analysis of variance by the F test, at 5% probability. When significant the regression models, they were adjusted to better explain the effect of potassium doses on the characteristics analyzed. The entire statistical procedure was performed by the statistical program R [9].

3. RESULTS AND DISCUSSION

All values for the determination coefficient (R^2) were significant in this experiment, indicating that the increase in doses affected the parameters evaluated.

The height of the plant presented an increasing linear model in relation to the doses used, with a R^2 coefficient of determination of 0.77 (Figure 1). This incensement was evident when the highest doses of potassium were used. According to [10] potassium plays an important role in enzymatic activation, protein synthesis, ion absorption and transport, photosynthesis and cellular respiration. The lack of this nutrient causes less translocation of photoassimilates to vegetal components of the plant, leading to losses. Thus, the results show that the dose of 240 kg.ha^{-1} of K_2O was adequate in order to supply potassium in the ideal amount for the growth of chrysanthemum plants.

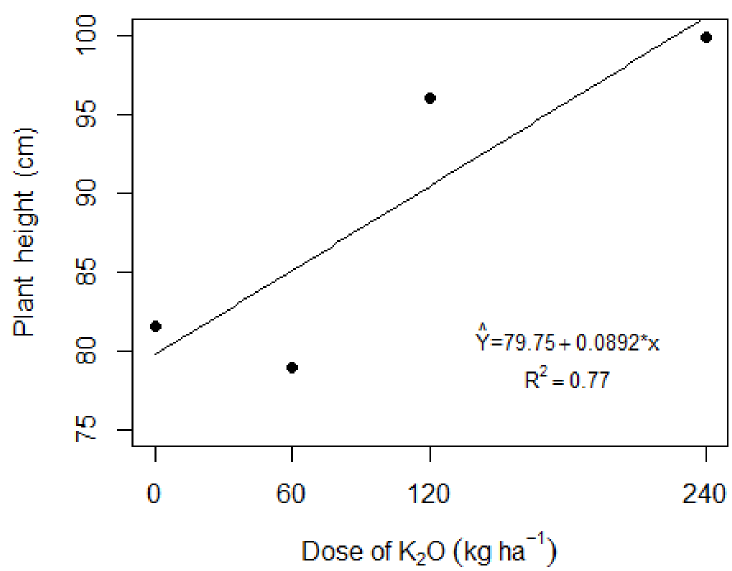

Figure 1: Regression analysis for the height characteristic of the chrysanthemum plant as a function of different doses of potassium.

When the diameter of the stem was evaluated, a quadratic model was generated with a maximum of 7.05 mm diameter of the stem when applied 179 kg.ha^{-1} of K_2O (Figure 2). The value of stem diameter found is within the recommendation, according to [11] a stem diameter greater than 6 mm is ideal for the cultivation of cut chrysanthemums. In relation to the dose that provided the largest diameter of the stem, it does not correspond to the highest dose used in this experiment, but it is above that recommended by the soil analysis, this situation corresponds to several situations that potassium is often in the soil, but is not in the form to be absorbed by the plants. According to [12] only about 10% of the potassium in the solution of the soil is readily available in ionic form, which is absorbed by the roots of the plants and the remain is in fixed form, not available to the plants.

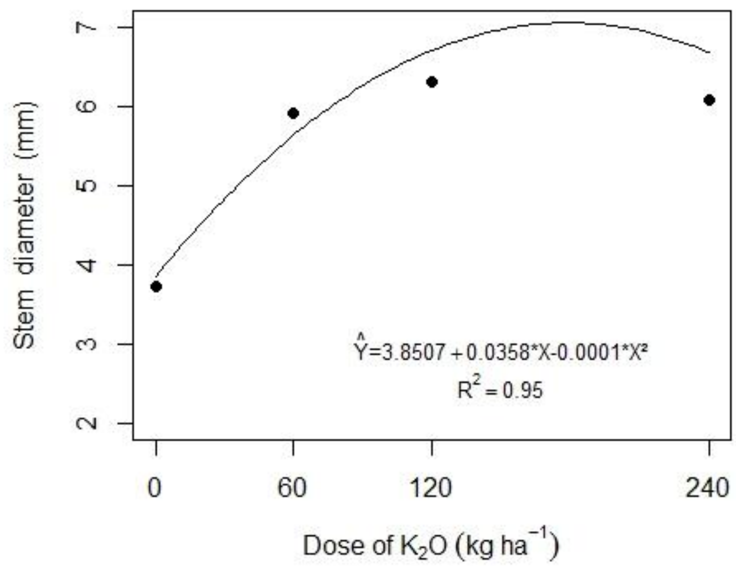

Figure 2: Regression analysis for chrysanthemum stem diameter as a function of different doses of potassium.

Based on the regression analysis presented (Figure 3), it was observed that for the number of leaves, there was an adjustment of 0.96 for the determination coefficient, indicating that the regression equation and the increasing linear regression model were representative. An increase in the number of leaves per plant was observed, from 27 at 0 kg.ha^{-1} dose of K_2O to 51.75 at 240 kg.ha^{-1} dose of K_2O. These results corroborate with that found by [13], studying potassium levels in fertigation in chrysanthemum culture, highlighted that the maximum dose used (400 mg.L of K) provided better development and quality of the chrysanthemum, including a larger number of leaves, as seen in this research.

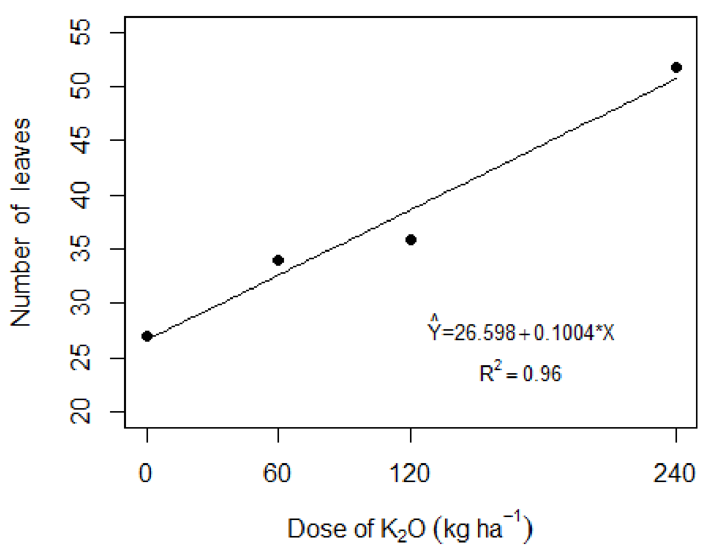

Figure 3: Regression analysis for the number of leaves of chrysanthemum plants as a function of different doses of potassium.

The leaf area of the chrysanthemum plants as a function of the potassium doses, can be visualized in Figure 4, and the quadratic regression better described the data with R^2 of 0.99. When estimating the ideal dose with the equation $\hat{Y} = 277.7146 + 4.1805 * x - 0.0136 * x^2$, the dose of 153.69 $kg.ha^{-1}$ of K_2O provided the largest leaf area, reaching the value of 598.97 cm^2. The study of the application of potassium chloride and potassium silicate in geranium cultivated in pot, also provided the highest value of leaf area (833.1 cm^2) with the highest doses of potassium (150 and 200 mg L^{-1}) provided in silicate.

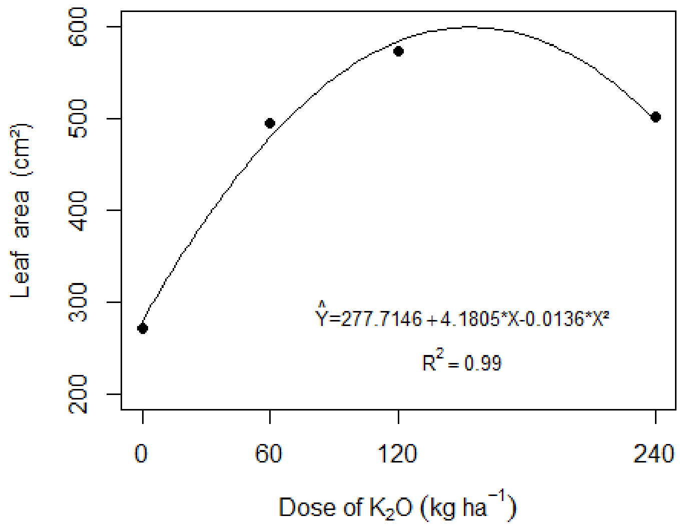

Figure 4: Regression analysis for leaf area of chrysanthemum plants as a function of different doses of potassium.

The different potassium doses significantly affected the SPAD (Chlorophyll content) index as presented in Figure 5, the linear model better explained the data with coefficient of determination (R^2) of 0.79. A linear increase in chlorophyll content was observed increasing the dose of K_2O, highlighting the role of potassium and nitrogen in the formation of chlorophyll in plant tissue, which can be attributed to the better nutrition of plants.

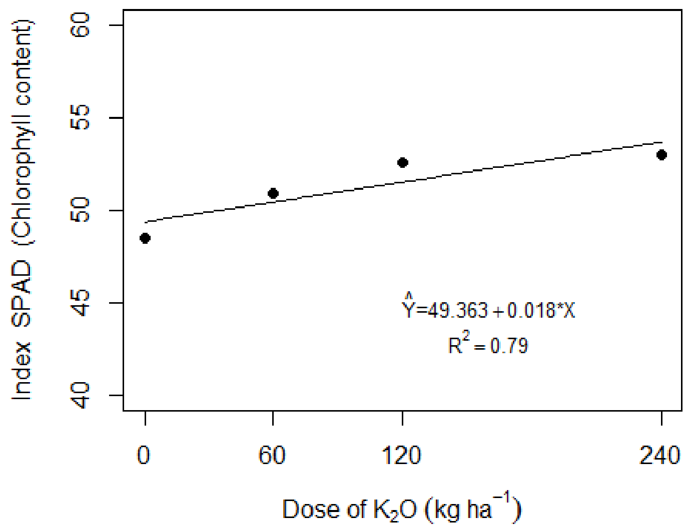

Figure 5: Regression analysis for SPAD index of chrysanthemum plants as a function of different doses of potassium.

Analyzing Figures 6 and 7, it was possible to observe that the fresh and dry matter was influenced by K_2O doses, both with R^2 of 0.98, presenting a quadratic positive response with increasing potassium doses.

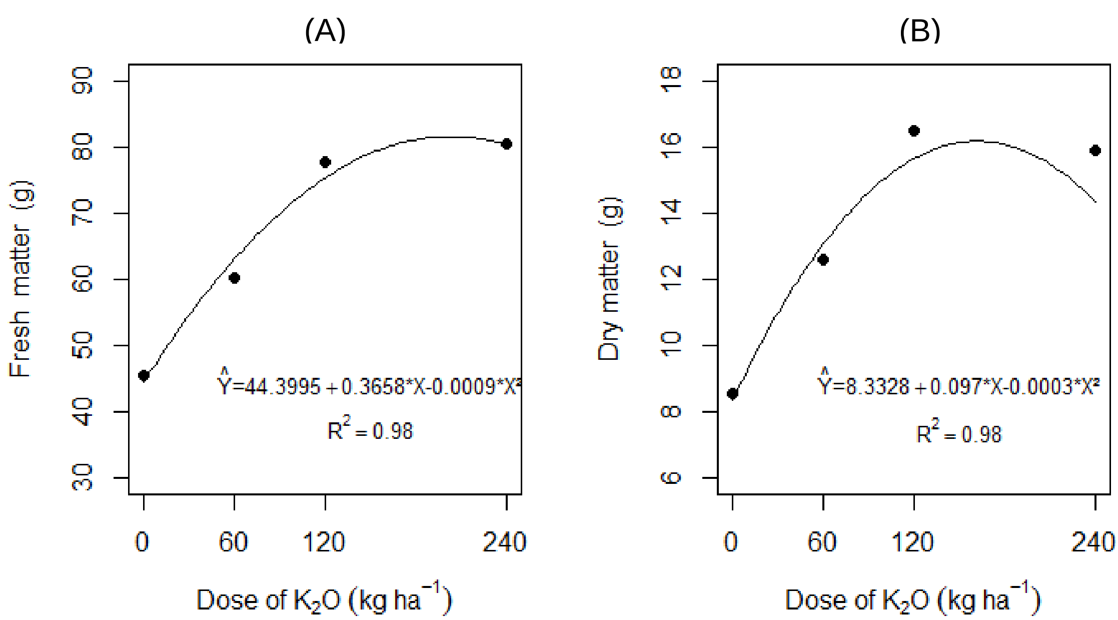

Figure 6 and 7: Regression analysis for fresh matter (A) and dry (B) of chrysanthemum plants as a function of different doses of potassium.

The highest volume of fresh matter found was 81.56 grams through the equation $\hat{Y} = 44.3995 + 0.3665 * x - 0.0009 * x^2$ with the dose of 203.22 $kg.ha^{-1}$ of K_2O, this result can be explained by the fact that the increase of the potassium concentration in the cytoplasm of the cells increases the osmotic potential of the vacuole, and with this, there is a greater absorption of water by the cell, resulting in a greater fresh mass of the tissue [10].

Through the adjusted model was verified that the dose that maximized the dry matter of the plant with 16.17 grams, was the dose of 161.66 $kg.ha^{-1}$ of K_2O. [14] studying heliconia flower stems under macronutrient deficiency, observed that potassium deficiency resulted in lower values of dry matter of the flower stem, lower post-harvest durability and accumulation of carbohydrates in the leaves. For flowers such as chrysanthemum and heliconia, it is desirable high values of dry matter, which can represent strong and consistent plants, providing a longer post-harvest life [15].

According to [16] potassium is the nutrient most absorbed by chrysanthemum plants, which usually occurs with all plants of the Asteraceae family, due to their high requirement in this element. The deficiency of this element results in lower growth, production and quality of chrysanthemum flowers.

4. CONCLUSION

This study revealed that there was a significant response of all variables to the application of potassium doses in chrysanthemum plants. Doses between 150 and 240 $kg.ha^{-1}$ of K_2O provided positive results for plant growth and development, while lower doses presented unsatisfactory results.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration with all authors. The authors RFA and EVC designed the study and followed the conduction of the experiment in the field with author JCS. The first draft of the manuscript was made by the author LGFS. The authors JCS and LGFS performed the statistical analysis and the authors RFA and EVC contributed with the corrections of the manuscript. The final translation and correction of the manuscript were performed by the author RFA. All authors read and approved the final manuscript.

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