# Potassium fertilization in radish plants: Production and quality of tuberous roots

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## ABSTRACT

The application of mineral fertilizers provides advantages, especially in short-cycle crops such as radish. This is because it contains high concentrations of nutrients that make plants available faster, in addition to being easy to handle compared to organic fertilizers applied to the soil. The objective of this study was to evaluate the agronomic performance of radish under the effect of the application of different doses of potassium fertilizer in the region of Bom Jesus-PI. The experiment was conducted in the field in an experimental area of the Federal University of Piauí, at the Campus Professora Cinobelina Elvas, located in the municipality of Bom Jesus-PI. The treatments consisted of six doses of K using potassium chloride as a source of the nutrient. The experimental design was randomized blocks consisting of six treatments (K doses) with four replications. The results obtained with the application of potassium fertilizer suggest that the radish crop responds positively and differently to increasing doses of potassium. The different rates of topdressing potassium fertilization influence the productive attributes of radish plants and the P, K and M.O. contents of the soil. The increase in K doses applied in topdressing promotes higher plant yields when compared to the non-application of this nutrient. Under the conditions in which the experiment was carried out, it is recommended to provide 400 kg $ha^{-1}$ of K2O for radish cultivation.

**Keywords:** *Raphanus sativus* L., Brassicaceae, Mineral fertilization.

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## INTRODUCTION

Originally from the Mediterranean regions, radish (*Raphanus sativus* L.) is a crop that has globular roots with a reddish color on the outside and white pulp, with a spicy flavor and small size, being used by consumers in the form of salads and preserves and among other cold dishes (CASTRO et al., 2016). This vegetable was highly appreciated in the cuisine of the Egyptian, Roman, and Greek civilizations, as it has low calories, in addition to diuretic and stimulant properties (LIMA et al., 2019).

Radish cultivation has been gaining prominence among Olericulturists, due to attractive characteristics, such as short cycle, rusticity and quick financial return (MATOS et al., 2015). In addition to being a food consumed mainly *in natura*, it is rich in mineral salts, vitamins and nutraceutical compounds related to immunodefense (BANIHANI, 2017).

Compared to other crops, radish has several specificities during its cycle, including intolerance to transplanting practice, and it is recommended to sow directly in its definitive location (LACERDA et al., 2017). In planted areas and economically, it is not as expressive as other vegetables that have a greater commercial importance, such as onions, for example.

Some studies carried out with applications of different doses of mineral fertilizers have found that the agronomic performance of radish responds positively and differently according to the increasing doses of potassium and nitrogen fertilization (JILANI et al., 2010).

Potassium fertilization, regardless of nitrogen application, has positive effects on radish crop yield according to the increasing doses applied. Even with certain amounts of potassium available in the soil, potassium fertilization is recommended to obtain greater productivity in the radish crop, because during its cycle it forms large amounts of mass in the storage organ making the plant need a high amount of nutrients, where potassium stands out. This is because the plant demands a greater amount of potassium in relation to the other essential nutrients for root formation (CASTRO et al, 2016).

Compared to other vegetables, radish does not have such a high demand for nutrients, but some authors point out that in the field, as well as other vegetables, positive responses are observed when fertilizers are applied, as soil fertility directly affects root size (REIS et al., 2012).

Among the most widely used technologies in Brazilian agriculture, mineral fertilizers stand out. The main advantage provided by these fertilizers is the increase in productivity, even in the face of the limitation of the arable area (OGINO et al., 2021). In addition, mineral fertilizers offer faster nutrient availability to plants, which is particularly critical for short-cycle crops such as radish. Castro et al. (2016) report that the promising results of radish productivity with potassium fertilization may be related to the increase of available potassium in the soil, and with the function it plays in the plant, being important in the translocation of carbohydrates, thus improving the efficiency of water use.

In this context, the objective of this study was to evaluate the agronomic performance of radish under the effect of the application of different doses of potassium fertilizer in the region of Bom Jesus-PI.

## MATERIAL AND METHODS

### CHARACTERIZATION OF THE EXPERIMENTAL AREA

The experiment was conducted in the field in an experimental area of the Federal University of Piauí, at the Campus Professora Cinobelina Elvas, located in the municipality of Bom Jesus-PI (09º 04' 28" S, 44º 21' 31"W and average altitude of 277 m) from July to August 2019. The climate of the region is hot and humid, classified by Köppen as Awa (Tropical rainy with a dry season in winter and an average temperature of the hottest month greater than 22 °C), with an average temperature of 26.2 °C and average rainfall between 900 and 1200 mm $^{year-1}$ (INMET, 2024). The soil of the experimental area was classified as Oxisol (EMBRAPA, 2013).

Before the installation of the experiment, soil samples were collected from the 0-20 cm layer in the experimental area and determined the chemical and physical characteristics of the soil. The soil was prepared by plowing and harrowing and, as a result of the soil analysis, liming and fertilization were carried out to meet the nutritional requirements of the radish, as well as the application of K doses of the pre-established treatments. The flowerbeds were made in a mechanized way with the enchanter.

### TREATMENTS AND EXPERIMENTAL DELICTION

The treatments consisted of six K doses (0, 80, 160, 240, 320 and 400 kg $^{ha-1}$ of K2O) using potassium chloride as a source of the nutrient. The experimental design was randomized blocks consisting of six treatments (K doses) with four replications. The area of each plot was composed of four rows spaced 0.25 m apart and 2.5 m long, corresponding to 2.125 m2. The useful area of the plot was 0.5 m2 in two central lines (80 plants), neglecting 0.25 m at the beginning and end of the lines. The total area of the experiment was 105 m2 (6 m wide x 17.5 m long).

### CULTIVATING AND CULTURAL TREATMENTS

Given the varieties available on the market, the choice of the radish cultivar Apolo da Isla, was due to its characteristics of adaptability to the climate of the region, which is characterized by Köppen, as hot and humid, in addition to having tolerance to cracking and isoporization, has a pleasant flavor and has already been used in practical classes and presented good adaptation and precocity to the climate of the region.

Radish sowing was performed in beds with 0.25 m spacing between rows. At seven days after sowing (DAS), thinning was performed by removing excess plants and adjusting the spacing to 0.05 m between plants. Irrigation was carried out by micro-sprinkler with perforated strips, with daily irrigation shift divided into two applications (morning and afternoon). Weed control was done manually and periodically in the beds and streets, keeping them always clean during the course of the experiment, providing favorable conditions for crop development. Pest and disease control were not carried out, as there were no incidences of the same in the area during the experiment.

## VARIABLES STUDIED AND STATISTICAL ANALYSES

Harvesting was carried out 30 days after emergence, when the tuberous roots reached the commercial diameter. At the end of the experiment, the following analyses were performed to obtain the agronomic performance of the radish crop:

- **Commercial yield (CP):** roots with more than 2 cm in diameter and without cracks and rots were considered commercial, being weighed on a digital scale with a capacity of 5 kg, and yield was estimated in t/ha;
- **Total yield (PT):** all plant roots harvested in the useful area were weighed on a digital scale with a capacity of 5 kg, and where yield was estimated in t/ha;
- **Shoot dry mass (MSPA) and tuberous root dry mass (MSR):** after harvesting the plants, the tuberous leaves and roots were washed with drinking water (running water) and distilled water and packed in a brown kraft paper bag, identified with a label and taken to a forced air circulation oven at a controlled temperature of 65ºC until it reached a constant mass. After this period, the dry mass of the aerial part and the dry mass of the tuberous root were obtained by weighing in an analytical balance with an accuracy of 0.001g;
- **P, K and M.O. contents in the soil:** after harvesting the plants, soil samples (0-20 cm) were collected in each experimental plot, where the samples were analyzed using the methodology used by the Soil Chemistry and Fertility Laboratory of the Federal University of Piauí, Professor Cinobelina Elvas Campus.

The data of the analyzed variables were submitted to analysis of variance using the F test ($\alpha \leq 5\%$). For K doses, polynomial regression studies were conducted by choosing the significant equation with the highest coefficient of determination.

## RESULTS AND DISCUSSION

Based on the results obtained, there was a significant effect of the different doses of potassium applied on the following attributes: commercial yield, total yield ($p < 0.05$), root dry mass, shoot dry mass ($p < 0.01$) (Table 1). Also for phosphorus, potassium and soil organic matter contents ($p < 0.01$) (Table 2).

Table 1: Summary of the analysis of variance regarding plant height (PA); number of leaves (NF); commercial productivity (CP); non-commercial productivity (PNC); total productivity (PT); root dry mass (MSR); shoot dry mass (MSPA); cracked radishes (RR) and classification ≤ 45 mm (CLA) in radish plants as a function of potassium dose application.

| FV | PC | EN | MSR | MSPA |
|---|---|---|---|---|
| | -------------t $^{ha-1}$------------ | | ------g planta$^{-1}$------ | |
| **K Doses (F)** | 3.33* | 3.58* | 13.21** | 24.52** |
| **DMS** | 10.60 | 11.55 | 0.20 | 0.10 |
| **CV (%)** | 16.63 | 18.83 | 10.05 | 8.55 |

C.V. = coefficient of variation, DMS = minimum significant difference; $^{ns}$ = not significant; ** = significant at the level of 1% probability *(P<0.01); * = significant at the level of 5% probability (P<0.05).*

Table 2: Summary of the analysis of variance regarding the contents of phosphorus (P), potassium (K) and organic matter (M.O.) in the soil under radish cultivation as a function of potassium dose application. Bom Jesus, PI.

| FV | P | Towards | M.O. |
|---|---|---|---|
| | -----------------mg dm$^{-3}$------------------ | | g $^{kg-1}$ |
| **K Doses (F)** | 12.55** | 132.00** | 9.85** |
| **DMS** | 2.49 | 92.52 | 1.35 |
| **CV (%)** | 17.87 | 11.55 | 4.21 |

C.V. = coefficient of variation, DMS = minimum significant difference; $^{ns}$ = not significant; ** = significant at the level of 1% probability *(P<0.01); * = significant at the level of 5% probability (P<0.05).*

It was observed that both for the variable commercial productivity (Figure 1A) as well as for total productivity (Figure 1B) of radish, there was a linear increase in the values with an increase in the doses of K fed to the plants, with maximum CP and PT estimated at 33.84 t $^{ha-1}$ and 33.93 t $^{ha-1,}$ respectively, at the dose of 400 kg ha-1 of K2O (Figure 1B). recording that between the lowest and highest doses of K2O, there was an increase of approximately 31.38% in CP and 37.99% in TST. A study carried out by Castro et al., (2016) also observed positive results of potassium fertilization in increasing radish productivity. The response of radish yield to the increase in the supply of potassium fertilization may be related to the increase in its availability in the soil, a fact observed in the present study (Figure 2B).

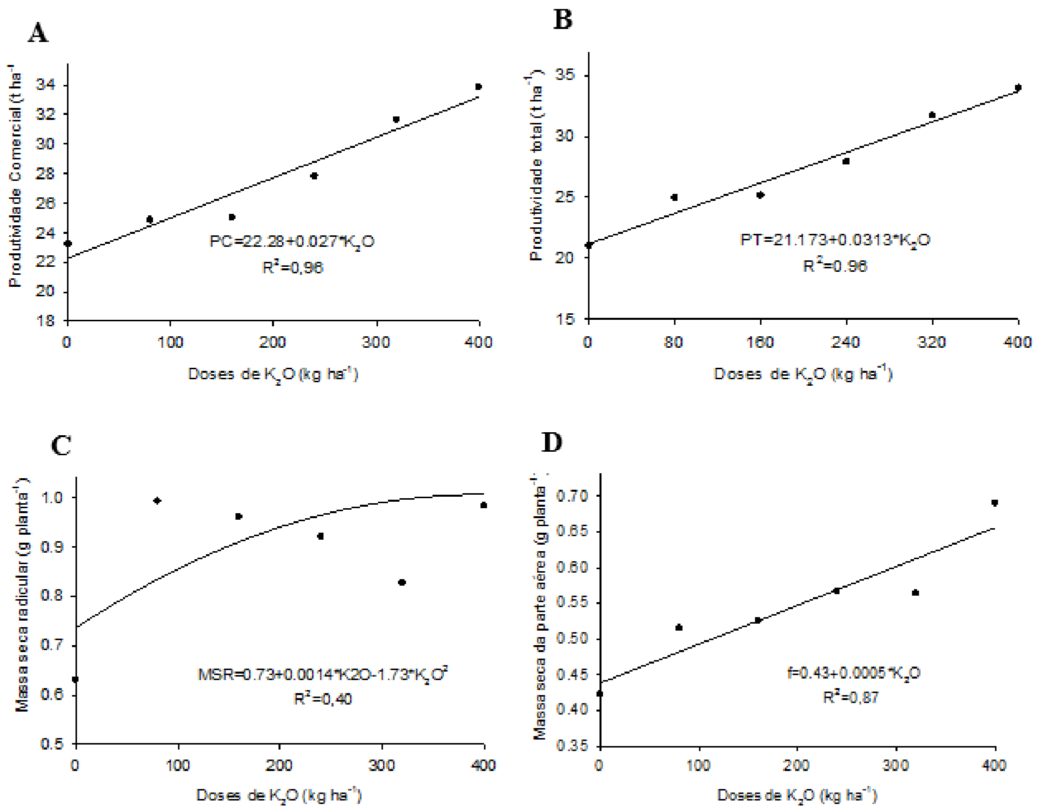
The literature presents substantial evidence on the importance of potassium (K) in radish culture. Souza et al. (2015) state that potassium is the nutrient most required by this crop, indicating the critical need for proper management of this element to optimize growth and productivity. Cecílio Filho et al. (1998) add that K application has a more pronounced impact on radish root production compared to shoot dry matter production. This finding suggests a greater allocation of resources for root development, which is critical for a crop where root production has commercial value.

Krauss (2005) reinforces this perspective by pointing out that this behavior is common in plants that store reserves in underground organs, as in the case of radish, which presents a significant increase in root productivity with the application of potassium.

These studies converge to an understanding that the management of potassium fertilization has a direct positive impact on radish yield, since the analysis of our data reveals a linear increase in the values of commercial productivity and total productivity with the increase of K doses applied. Therefore, the optimization of potassium doses is a fundamental agronomic strategy to maximize the productive efficiency of radish, directly reflecting on the economic gains and sustainability of the crop.

In addition, for Cecílio Filho et al. (1998), the application of K influences more on the production of radish roots than with fertilization with N, this may be related to the function that this nutrient plays in the plant, since K plays an important role in energy storage, in better efficiency of water use,  due to the control of opening and closing of the stomata and greater translocation of carbohydrates produced in the leaves to the rest of the plant (TAIZ & ZEIGER, 2013).

Figure 1. Commercial yield (A), total yield (B), root dry mass (C) and shoot dry mass (D) of radish as a function of potassium doses.




In general, the results observed in the study concern the importance of fertilization with this macronutrient to increase the productivity of radish crops. According to Raij (1990), K is presented as a quality nutrient of agricultural products, which collaborates with beneficial effects on the color, size, acidity, resistance, nutritive value and industrial quality of the crop. Demonstrating the importance of a balanced and balanced fertilization with K for the maximum productive potential of the radish crop. According to Rosolem (2005), when potassium fertilization is neglected, in general, crops respond with much smaller increases in productivity.

The root dry mass (MSR) results indicate that the accumulation of MSR in radish depends on the management of potassium fertilization (Figure 1C), it is observed that the worst results for this variable (0.630 g $^{plant-1}$) were found when there was no supply of K to the plants (control), a value that is 36.5% lower than the best value (0.993 g $^{plant-1}$) recorded at the dose of 400 kg $^{ha-1}$ of K2O.

Similar results were observed by Maia et al. (2011), who identified a significant impact of potassium nutrition on root dry matter (MSR) values. The study demonstrated a 100% increase in MSR values in plants fertilized with potassium, compared to plants in the control group. This result underlines the efficacy of potassium in promoting root development, which is essential for the agronomic performance of radish.

This positive response to the gain of MSR exemplifies the importance of adequate nutrition with this nutrient for the production of plants that store reserves in subterranean organs, largely due to the fact that K is a nutrient that participates in the activation of several enzymes during the biosynthesis of photoassimilates, transport of carbohydrates from the source (leaf) to the reservoirs or drains (roots) and enzymatic activator of starch synthesis (TAIZ & ZEIGER, 2013).

However, the results found in the present study differ from those reported by Souza et al. (2015), who studied the effects of the time of application and doses of potassium fertilizers for radish crops and did not observe positive effects of this nutrient on MSR at any time of application.

The literature on potassium nutrition in radish is still scarce, revealing a significant gap in this field of study and highlighting the need for further research (SOUZA et al., 2015). This scarcity of studies conducted so far highlights the importance of deepening knowledge about the role of potash in the development of this crop.

The disparity in the results found in this study in comparison with the existing literature on the influence of potassium fertilization on root dry matter and other parameters indicates the complexity of the topic and the variability of plant responses to nutritional management. While some studies, such as those by Cecílio Filho et al. (1998) and Maia et al. (2011), show a significant positive impact of potassium fertilization, other studies present less conclusive results.

This variability points to the need for further scientific investigations that can provide more consistent and robust results. It is imperative that further studies be carried out in order to better understand the specific conditions that affect the efficiency of potassium fertilization, such as time and form of application, influence of soil type and sources of potassium fertilizer, in order to develop more accurate management recommendations for radish crops.

The accumulation of shoot dry matter (MSPA) was significantly affected by the increase in potassium doses applied to the soil (Figure 1D), with a linear response of the data. At the maximum dose of 400 kg $^{\text{ha-1}}$ of K2O, a maximum accumulation of 0.690 g $^{\text{plant-1}}$ of MSPA was observed, representing an increase of 38.69% to the 0.423 g $^{\text{plant-1}}$ reported at the dose 0 kg $^{\text{ha-1}}$ of K2O. Coutinho Neto et al. (2010) reported that potassium fertilization significantly increased the dry matter production of radish shoots.

Souza et al. (2015) and Soares et al. (2020), on the other hand, reported that the dry mass of the aerial part of radish plants was not affected by the application of K. According to Filgueira (2008), topdressing potassium has shown few satisfactory results in some vegetable crops. However, this fact, according to Coutinho Neto et al. (2010), is dependent on the initial levels of K in the soil and the amount of K supplied, a fact observed in this study, since it was found that the increase in K doses promoted significant increases in the dry matter of the shoots of radish plants.

It is important to highlight that, in the aforementioned studies by Souza et al. (2015) and Soares et al. (2020), potassium fertilization used restricted doses up to the maximum concentration of 120 and 210 kg ha-1, respectively. In our study, we investigated the influence of potassium (K) fertilization up to a maximum dose of 400 kg ha-1. This increase in the range of doses applied may be a significant factor in the observed response of radish plants to potassium fertilization.

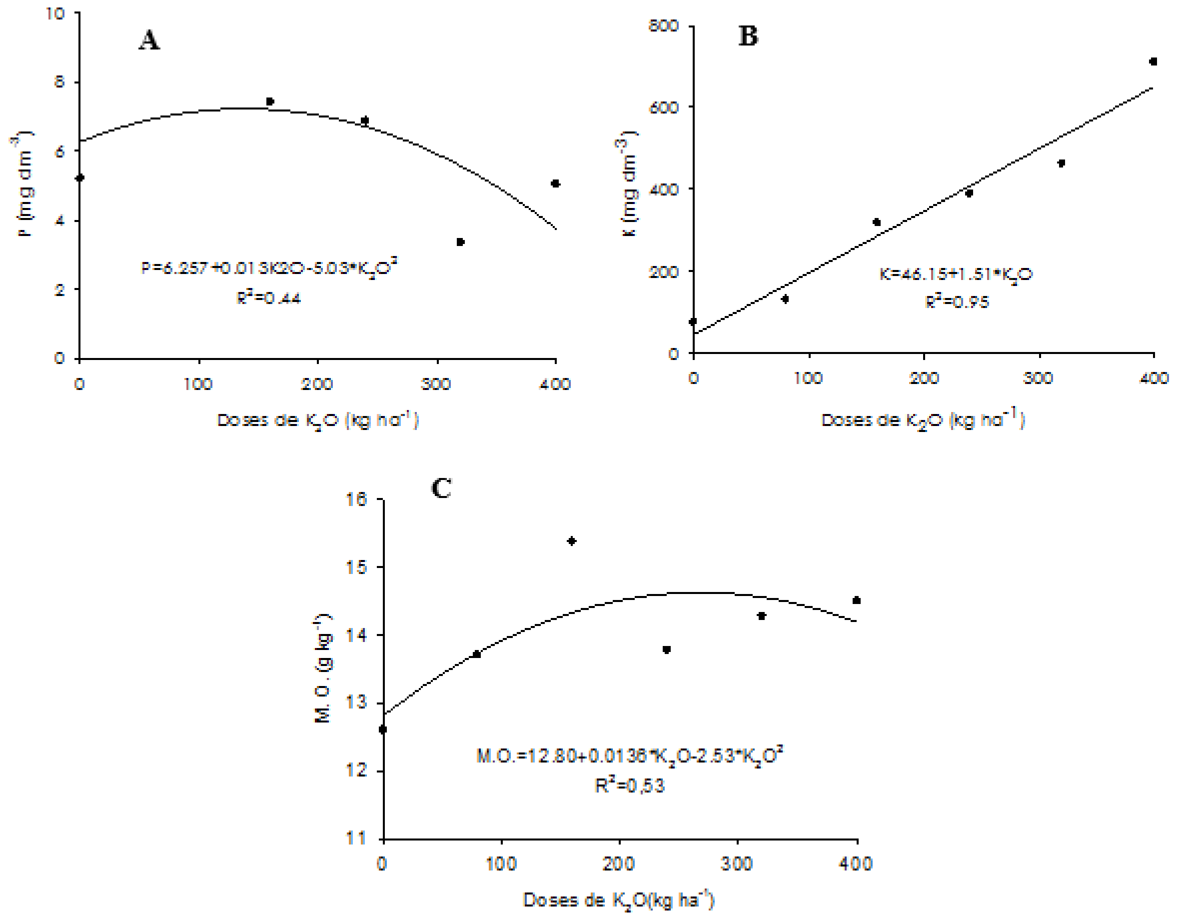
The variation in K doses used in the different studies highlights the need to adopt experimental regimens with a wide range of doses. This will allow a more detailed and accurate assessment of the dependence of potassium dose and its impact on dry matter production, both of the roots and of the aerial part of the plants. The inclusion of a variety of doses in future trials may elucidate the dose-response relationship in a more cohesive manner, allowing a better understanding of the optimal management of potassium fertilization for radish crops.

Our study suggests that higher doses than those traditionally investigated may offer greater gains in MSPA, prompting a perception different from that found in some studies in the literature to date. Therefore, further investigation is important to optimize the use of potassium.

Regarding the phosphorus content in the soil, it was observed that in the highest doses of potassium applied, there was a decline in the amount of this element in the soil (Figure 2A). Demonstrating that the fertilization of the radish crop, with the highest doses of K2O supplied to the plants under the conditions of the present work, may be the one that allows a more balanced absorption of nutrients by the radish plants, an event evidenced by the higher productivity of the crop at these doses (Figures 2A and 2B). According to Coutinho Neto et al. (2010), due to its rapid growth and short cycle, radish cultivation requires high levels of soil fertility, demanding large amounts of nutrients in a short period of time.

The amount of phosphorus absorbed by radish plants is one of the most influential in crop productivity, as this is recognized as one of the most important elements for plant metabolism, as it plays an essential role in the establishment and development of plants, providing beneficial effects both in the root system and in the aerial part (PRATES et al., 2012).

Figure 2. Phosphorus (A), potassium (B) and organic matter (C) in radish cultivation as a function of potassium doses.




For the K contents in the soil, a linear increase is observed with the increase of the doses of potassium fertilizer added to the soil (Figure 2B). Important results for the productivity of radish plants, according to Oliveira et al. (2014), even though they have a short growth cycle, they form a large amount of mass in the storage organ, requiring large amounts of potassium and nitrogen, and these two nutrients are needed in greater quantities for root formation (ISLAM et al., 2011).

On the other hand, the organic matter (M.O.) content in the soil was affected by the K rates applied. Lower values for OM were found in areas where potassium fertilization did not occur (Figure 2C). An increase of 13.75% of M.O. was obtained in the areas with the maximum estimated dose of 247 kg $^{ha-1}$ of K2O, reaching a value of 14.61 g $^{kg-1}$ in relation to the areas without K.O. application 2010).

The results obtained with potassium fertilizer application suggest that radish cultivation responds positively and differently to increasing doses of potassium. It is known that in radish cultivation, as in many others, there is the problem of providing a correct amount of fertilizers that can lead the plant to maximum production. According to Marschner (2005) and Malavolta (2006), for a correct recommendation of fertilizers, it is essential to know the nutritional dynamics of the plant, which is a function of the speed of plant growth and cultural ecophysiology, therefore, it is not recommended to extrapolate results obtained in other ecological systems.

## CONCLUSION

The different rates of topdressing potassium fertilization influence the productive attributes of radish plants and the levels of K, P and M.O of the soil;

The increase in K doses applied as topdressing promotes higher plant productivity when compared to the non-application of this nutrient;

Under the conditions in which the experiment was carried out, it is recommended to provide 400 kg $^{ha-1}$ of K2O for radish cultivation.

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