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Do organic fertilization and *azospirillum brasilense* influence radish cultivation?

A adubação orgânica e o azospirillum brasilense influenciam o cultivo do rabanete?

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ABSTRACT

The association of conventional fertilizers with fertilizers of organic origin is a well-known practice in agriculture for achieving high productivity and also with the adoption of inoculants, composed of bacteria for promoting better plant development of crops. Thus, the objective of the work was to investigate the growth and productivity of radish with organic fertilization and the influence of the use of nitrogen fixing bacteria of the genus *Azospirillum spp.* radish (*Raphanus sativus L*.) Hybrid Margaret Queen. The treatments were the use of different doses of organic fertilizer and the application of *Azospirillum brasilense*, besides the control. At the end of the cycle, plant height, tuber diameter, tuber fresh mass, tuber dry mass, and total tuber fresh mass were evaluated. With and without application of A. *brasilense,* increases of 16.5% and 6.40% in tuber diameter were obtained, respectively. Without application of A. *brasilense*, there was an increase of 0.37% in leaf dry mass when the maximum concentration of 8 kg m² of organic fertilizer was used. For root fresh mass and root dry mass, with foliar application of A. *brasilense*, there was an increase of 9.57% and 0.67%, while without *A. brasilense* there was an increase of 2.43% and 0.22%. There were increases of 12.83% for total fresh mass with the management of A. *brasilense* and 3.4% without *A. brasilense*, using the maximum concentration of 8 kg m² of organic fertilizer. For height, there was an increase of 5.12% without *A. brasilense.* It was concluded that organic fertilization alone or combined with *A. brasilense* is an alternative in radish production.

KEYWORDS: *Raphanus sativus L;* nutrition; productivity; vegetables.

RESUMO

A associação de fertilizantes convencionais com fertilizantes de origem orgânica é uma prática bastante conhecida na agricultura por alcançar alta produtividade e também com a adoção de inoculantes, compostos por bactérias por promoverem melhor desenvolvimento vegetal das lavouras. Assim, o objetivo do trabalho foi investigar o crescimento e a produtividade do rabanete com adubação orgânica e a influência do uso de bactérias fixadoras de nitrogênio do gênero Azospirillum spp. rabanete (Raphanus sativus L.) Híbrido Margaret Queen. Os tratamentos foram o uso de diferentes doses de adubo orgânico e a aplicação de Azospirillum brasilense, além da testemunha. Ao final do ciclo, foram avaliados altura da planta, diâmetro do tubérculo, massa fresca do tubérculo, massa seca do tubérculo e massa fresca total do tubérculo. Com e sem aplicação de A. brasilense, foram obtidos aumentos de 16,5% e 6,40% no diâmetro do tubérculo, respectivamente. Sem aplicação de A. brasilense, houve aumento de 0,37% na massa seca foliar quando utilizada a concentração máxima de 8 kg m² de adubo orgânico. Para massa fresca de raiz e massa seca de raiz, com aplicação foliar de A. brasilense, houve aumento de 9,57% e 0,67%, enquanto sem A. brasilense houve aumento de 2,43% e 0,22%. Houve incrementos de 12,83% para massa fresca total com manejo de A. brasilense e de 3,4% sem A. brasilense, com a utilização da concentração máxima de 8 kg m² de adubo orgânico. Para altura, houve aumento de 5,12% sem A. brasilense. Concluiu-se que a adubação orgânica isolada ou combinada com A. brasilense é uma alternativa na produção de rabanete.

PALAVRAS-CHAVE: *Raphanus sativus L*; nutrição; produtividade; vegetais.

INTRODUCTION

Radish (*Raphanus sativus* L.) is an herbaceous plant originating in the Mediterranean, belonging to the Brassicaceae family, and has a small size and globular roots with, reddish color (POHLMANN et al. 2019). It has a high nutritional value such as iron, phosphorus, calcium, vitamins B1, B2, C and nicotinic acid (FERNANDES 2018).

Radish production is highly relevant to the vegetable sector because of its short cycle, where it is separated by vegetative and productive phases. In addition, its production cycle is around 20 to 40 days after sowing, so the nutrients in a short period are essential for the best development of the crop, besides suffering from the influence of the environment (DA SILVA BERILLI et al*.* 2020). The radish does not tolerate transplanting, so it must perform the no-till system, with organic fertilization improving the structure and contributing to the increase of organic matter content in the soil, increasing the cation exchange capacity, regulating soil temperature and stimulating microbial activity, among other benefits (TRANI et al. 2013).

Besides organic fertilization other sources such as the *Azospirillum brasilense* bacterium a source of nitrogen, being the nitrogen component of amino acids, proteins, pigments such as chlorophyll, enzymes, coenzymes, RNA, DNA and vitamins (TEJO & SANTOS 2021). Nitrogen is essential for plants, being enzyme activators, participating in the processes of ion absorption, photosynthesis, respiration, biochemical syntheses and vegetative growth (TRANI et al*.* 2014).

However, excess N or the supply at the inadequate time concerning the requirements of plants affects the health, quality and quantity of tubers at harvest and post-harvest (HIGASHIKAWA & MENEZES JÚNIOR 2017). Studies evidenced the role of plant growth-promoting bacteria such as *A. brasilense*, *Herbaspirillum seropedicea* and *Burkholderia phytofirmans* applied to tomato, lettuce and cucumber seedlings, promoted improved plant growth and development (MANGMANG et al*.* 2014, MANGMANG et al*.* 2015, MANGMANG et al*.* 2016).

According to BONFIM-SILVA et al. (2021), research has been developed for the cultivation of radish using organic fertilizers to provide sustainable methods, that is, to reduce damage to the environment and the use of mineral fertilizer. In the same way that organic material in the soil improves the chemical and physical characteristics, because it provides nutrients and helps in the development of the roots, aeration and water retention, in the soil structure and decreases the plasticity and cohesion, its use increases the quality of the soil, as more fertile and productive (BONFIM-SILVA et al. 2021).

According to the study of PEREIRA et al*.* (2013), about the use of organic fertilizers in the culture of radish and other species, it was verified that it had a positive effect on the physical, chemical and biological properties of the soil, besides not harming the environment, showing that its use has advantages such as the preservation of nature and low production cost. Mineral fertilization offers benefits such as high concentrations of nutrients and fast availability for crops. However, the excessive and constant use of mineral fertilizers can cause changes in the physical, chemical, and biological properties of the soil, leading to its degradation (FERNANDES 2018).

However, there is a lack of studies in Brazil on the appropriate management of organic fertilization in the crop, aiming to achieve high yields, with minimal environmental impacts and without reducing the nutritional value (DANTAS et al. 2014, VENDRUSCOLO & LIMA 2021). In this context, the objective of the study was to investigate the growth and productivity of radish with organic fertilization and the influence of the use of nitrogen-fixing bacteria of the genus *Azospirillum*.

MATERIAL AND METHODS

The experiment was conducted in a protected environment, with the pots placed on a metal bench, 1.2 m high. The soil used in the experiment was collected from the experimental area of the State University of Mato Grosso do Sul (UEMS), University Unit of Cassilândia-MS. The site has a latitude of -19.1225º (19º07'21 ''S), longitude of -51.7208º (51º43'15'' W) and altitude of 516 m. The climatic data inside the greenhouse were obtained with an automatic station (Irriplus, model E 4000) and the average temperature and relative humidity were 26°C and 46%, respectively.

Quartzenic Neosol (125 g kg^{-1} clay, 75 g kg^{-1} silt and 800 g kg^{-1} sand) with the following chemical characteristics were used: pH ($CaCl_2$) 4.4; 15 g dm^3 of OM; 3.0 mg dm^{-3} of P_{resin}; 31.0 mmol$_c$ dm^{-3} of H+Al; 2.9 mmol$_c$ dm^{-3} of K; 11.0 mmol$_c$ dm^{-3} of Ca; 11.0 mmol$_c$ dm^{-3} of Mg; base sum of 25.0 mmol$_c$ dm^{-3}; cation exchange capacity of 56 mmol$_c$ dm^{-3}; base saturation of 45%. Third days before sowing, agricultural lime was added to the soil to obtain a base saturation of 80%.

The design was in randomized blocks, in a 2 x 4 factorial scheme, with four repetitions. The treatments consisted of a combination of two treatments: fertilizer in concentrations (0, 2, 4, 6 and 8 kg m^{-2}) and the fertilizer composition is shown in (Table 1), with and without foliar application of *Azospirillum brasilense* at a dose of 4 mL L^{-1}, with four repetitions.

The design was in randomized blocks, in a 2x4 factorial scheme, with four repetitions. The treatments consisted of a combination of two treatments: fertilizer at concentrations (2, 4, 6 and 8 kg m-²) and the control treatment, being fertilizer application and the fertilizer composition is presented in (Table 1), with foliar application of Azospirillum brasilense at a dose of 4 mL L-1 and the control treatment, with foliar water application, with four repetitions each treatment.

Table 1. Laboratory analysis of the composition of the elements present in the organic fertilizer.

Element	Result	Unit
Nitrogen (N)	1,13	%
Phosphorus P_2O_5 (P. total)	0,45	%
Potassium (K_2O)	0,09	%
Calcium (Ca)	0,90	%
Magnesium (Mg)	0,12	%
Sulfur (S)	0,079	%
Iron (Fe)	2,88	%
Manganese (Mn)	0,027	%
Copper (Cu)	0,0071	%
Zinc (Zn)	0,0093	%
Boron (B)	0,0029	%
Sodium (Na)	0,03	%
Cobalt (Co)	0,0007	%
Molybdenum (Mo)	<0,0001	%
Aluminum (Al)	2,18	%
Humidity 65 (U 65)	28,92	
Humidity 110 (U 110)	29,27	
Organic Matter (OM)	20,66	%
Ash (Cin.)	79,34	%
Organic Carbon (TOC)	9,7	%
C/N ratio	8,58	
Density (Dens.)	0,782	g mL^{-1}
Electrical Cond.	45,5	micros cm^{-1}
Cap. Ret. Water Retention Capacity (CRA)	91	%
Tr. Cap. Cations (CTC)	43	mmolc Kg^{-1}
Pot. Hydrogen (pH)	6,81	

Each experimental unit consisted of a pot with a capacity of three liters of soil for Margaret queen radish hybrid. After liming, the soil was turned over with doses of organic fertilizer and the pots were filled. To accelerate the liming process and soil fertilization, daily irrigations were performed, as necessary to accelerate the process of dissolving the compounds. After 10 days of liming, the plant was sown in pots, with 10 seeds at a depth of 3 cm per pot, followed by daily irrigation. 10 days after sowing, the seedlings were thinned, leaving only four seedlings per pot. When the plants emitted the first pair of true leaves, the *A. brasilense* bacterium was sprayed at a foliar dose of 4 ml/l in the treatments (with N fertilization).

Weed control was carried out manually and no source of top dressing was used other than *A. brasilense*. The harvest was performed 40 days after sowing, collecting three plants, within each per treatment.

The variables evaluated were plant height (cm) (PH), tuber diameter (cm) (RD), tuber fresh mass (RFM), tuber dry mass (RDM), total fresh mass (TFM). The height was measured with a graduated ruler, while the diameter was measured with a digital pachymeter. To obtain the dry matter mass, the leaves and tubers were weighed on a precision scale to two decimal places and placed in bags and then placed in an air oven at 65 °C until constant mass was obtained (72 hours).

The results were submitted to the analysis of variance by F test ($p<0.05$) and regression test.

RESULTS

There were effects by the F test ($p<0.05$) for the characteristics root diameter (RD), leaf dry mass (DM), root fresh mass (RFM), root dry mass (MSR), total fresh mass (TFM) and plant height (PH) of radish fertilized with different doses of organic fertilizer and, with and without Azospirillum. brasilense application (Figure 1A, B, C, D, E and F).

With and without the application of *A. brasilense*, there were increases of 16.5% and 6.40% in RD, respectively (Figure 1A). For LDM without *A. brasilense* application, there was an increase of 0.37% when the maximum concentration of 8 kg m² of organic fertilizer was used (Figure 1B). For RFM and RDM, with foliar application of *A. brasilense*, there were increases of 9.57% and 0.67%, while without *A. brasilense*, there were increases of 2.43% and 0.22% (Figure 1C and D).

There were increases of 12.83% for TFM with *A. brasilense* management and 3.4% without *A. brasilense*, when the maximum concentration of 8 kg m² of organic fertilizer was used. For PH, there was an increase of 5.12% without *A. brasilense* (Figure E and F).

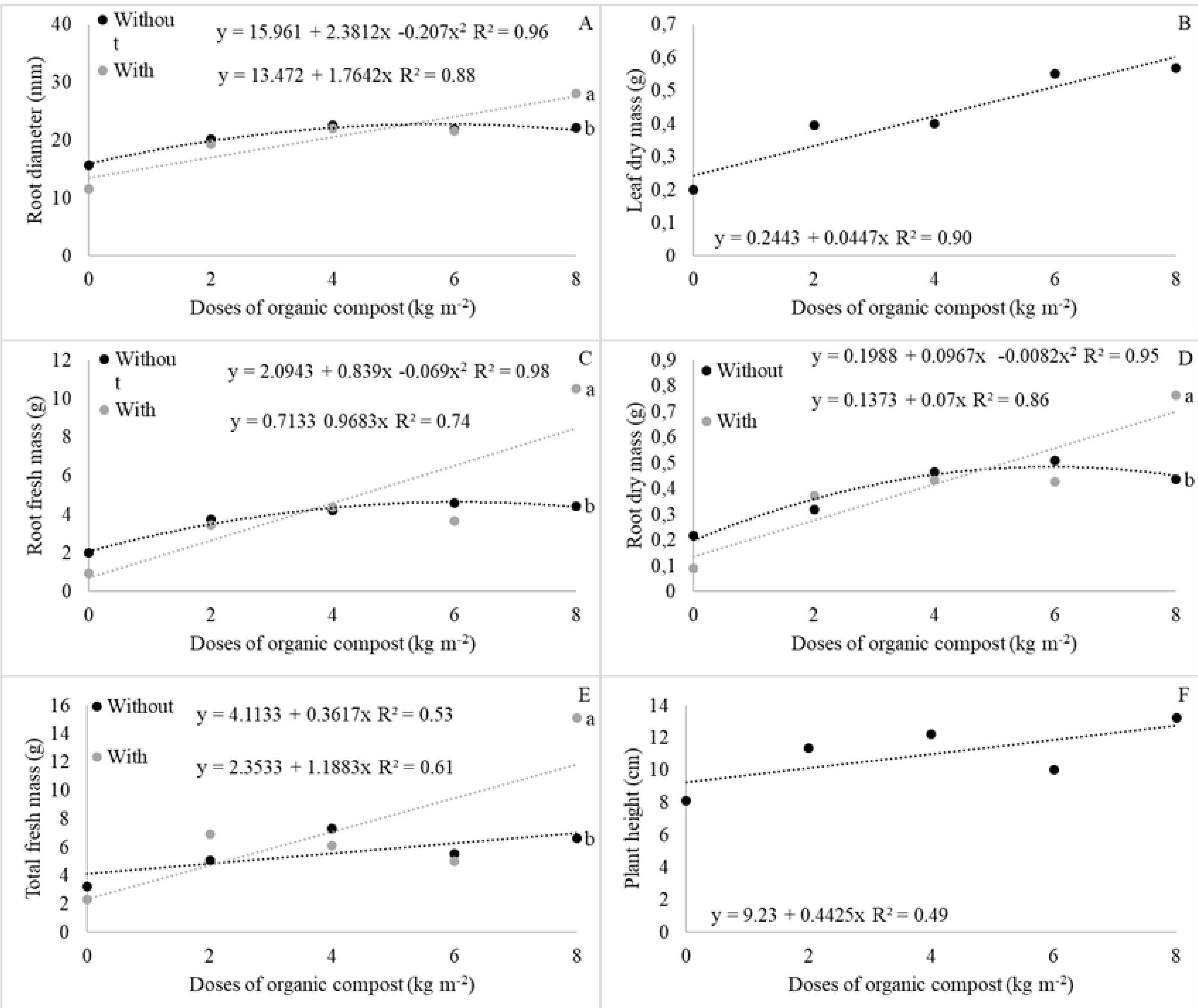

Figure 1. Root diameter (A), leaf dry mass (B), root fresh mass (C), root dry mass (D), total fresh mass (E) and plant height (F) in radish plants fertilized at different fertilizer doses. Cassilândia-MS, UEMS.

DISCUSSION

Adequate fertilization is crucial to maximizing productivity and quality in radish culture (SILVA et al*.* 2020). Studies show that the increase of organic matter in the soil positively influences the vegetative growth of several crops. Mainly in the slow release of nitrogen, because it increases the efficiency of absorption of the element by plants (GUIMARÃES et al*.* 2017). Nitrogen is considered the second main element for the radish culture, adding to the development and yield of the species (OLIVEIRA et al*.* 2006).

It was verified for PH the increase of 5.12% without the use of *A. brasilense*, only with organic fertilization (Figure 1 F). Following LOPES et al. (2019), who evaluated the growth of radish as a function of levels and sources of organic fertilizers, obtaining plant height of up to 11.36 cm. These authors state that the greater availability of nutrients in organic composts, such as cattle and sheep manure, is responsible for greater crop growth because these materials are usually sources of nitrogen and potassium. In complement, SUBEDI al. (2018) evaluated the management of organic and inorganic fertilization in radish varieties, finding a maximum height of 15.94 cm using manure-based fertilizer.

It is observed that with and without the application of *A. brasilense* there were increments of 16.5% and 6.40% in RD, respectively (Figure 1A). In agreement with MAIA et al*.* (2018) investigated the productivity of radish fertilized with different doses of bovine manure and obtained a tuber diameter of 3.06 cm. Similar results were observed by RODRIGUES et al*.* (2013), using organic inputs to replace mineral fertilization in radish culture, they verified a 5% increment in root diameter. SILVA et al. (2017) evaluated radish productivity as a function of different amounts of biomass incorporated into the soil, resulting in tubers with 5.69 cm in diameter and dry mass of tuberous roots of 1.74 g per plant. After this study, they verified an increase of 0.22% in RMS with organic fertilization (Figure 1D).

For MFR and MSR, with foliar application of *A. brasilenses* there were increases of 9.57% and 0.67% and without *A. brasilense* there were 2.43% and 0.22%, respectively (Figure 1 C and D). In a study conducted by SOUSA (2017), he verified an increase in dry matter production in response to the application of nitrogen to the radish crop. Accordingly, other studies point out the success obtained with the use of *Azospirillum brasilense* in grasses allowed the expansion of the planted area, such as soybean (SILVA et al*.* 2019), bean (FILIPINI et al*.* 2021), sunflower (EL_KOMY et al*.* 2020).

The SM without application of *A. brasilense* showed an increase of 0.37% when the maximum concentration of 8 kg m² of organic fertilizer was used (Figure 1B). FERNANDES (2018) concluded that radish when fertilized with organomineral fertilizer shows better growth performance. According to RIBEIRO et al. (2020), the use of increasing doses, up to 20 Mg ha^{-1}, of cattle manure positively affects the development and productivity of chili pepper plants. Positive results were also found by PEREIRA et al. (2021), showed a beneficial interaction between the bacteria (A. brasilense) and the corn plant, with an increase in the root system and chlorophyll content, in relation to the control treatment, without application.

Spraying A. brasilense increased the TMF by 12.83% and 3.4% without A. brasilense, when the maximum concentration of 8 kg m² of organic fertilizer was used. The study evidences the role of plant growth-promoting bacteria such as *A. brasilense*, *Herbaspirillum seropedicea* and *Burkholderia phytofirmans* applied to tomato, lettuce and cucumber seedlings, promoted improved plant growth and development (MANGMANG et al*.* 2016).

CONCLUSION

The use of increasing doses of organic fertilizer benefits radish development up to a dose of 8 kg m^2, when applied alone. However, the addition of *Azospirillum. brasilense* stimulates the development of the plants up to the highest dose studied, 8 kg m^2.

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