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Influence of calcium silicate in the culture of black beans

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Abstract: Beans are grown in different regions of the country, with an estimated average national production of 1.3 million tons in 2018. Their production is affected by nutrient deficiency, disease and / or soil acidity. One way to improve the use of agricultural inputs is to use silicates that are sources of silicon. Observing the importance of calcium silicate in crops of economic interest, the objective was to evaluate different doses of calcium silicate in the development of black beans. The experiment was carried out in pots with a capacity of 2,5 L filled with a typical dystrophic Red Latosol, with acidic pH around 3.88 $cmol_c$ / dm^3 according to chemical analysis, where 0, 50, 60, 70, 80 and 90% calcium silicate under greenhouse conditions. The bean was harvested after 45 days, where it was verified the fresh mass of the shoot, fresh root mass, root length, plant height, aerial dry mass. The data were submitted to the Tukey test at 5% significance level. From the parameters evaluated fresh shoot mass, fresh root mass, shoot dry mass and plant height showed significant results the application of calcium silicate from the 60% dose, thus demonstrating its importance for the vegetative development of the bean crop.
Keywords: *Phaseolus vulgaris* L. silicon. soil acidity

Introduction

Bean is a low-cost food that is easily accessible to the population and is inserted in Brazilian food culture (Ferreira et al., 2011), considered a culture of great socioeconomic importance for Brazil (Barili et al., 2015). According to the ninth CONAB (2018) survey, production for the 2017/2018 harvest is estimated at 1.3 million tons. If confirmed, there will be 538.5 thousand tons of common bean, 177.2 thousand tons of common black bean and 616.6 thousand tons of cowpea in an area of 1.5 million hectares (increase of 121 , 3 thousand hectares), especially cowpea, which should have 173.8 thousand more hectares in the current harvest, reaching 1,035.7 thousand hectares.

The genus *Phaseolus* belongs to the family of the most consumed legumes in Brazil, originating in Latin America, grown in tropical and subtropical regions. This culture has a short cycle, great nutritional requirement and straw of easy decomposition (Maeda et al., 2008). However, for the crop to obtain high productivity there is need of cultivation in fertile soils and with good physical conditions. Therefore, the correction of acidity and soil fertility (Laviola; Dias, 2008).

In most soils of Brazil, the nutrient reserve is not sufficient to supply the quantity required by the crop and the pH being in some acid regions. Fertilization is an indispensable practice for the maintenance of bean productivity over the years (CTSBF, 2012). One way to improve the use of agricultural inputs is to use silicates that are sources of silicon (Si).

In addition, the silicon is absorbed by the plant and is deposited on the walls of the epidermis cells, strengthening the structure (Dalastra et al., 2011) and protecting against pest and disease attack (Rodrigues et al., 2011). According to Crusciol et al. (2013) the physical and biochemical effects that the silicon causes in the plants a certain resistance, in addition to the formation of physical barriers and defense substances. The use of calcium and magnesium silicate becomes even more interesting because of the soil acidity, due to the formation of hydroxyls that neutralize H + ions present in the soil solution (Lima Filho, 2011), besides being a source of calcium and magnesium.

Calcium silicate is used as a source of silicon fertilization that may favor regulation of soil pH. This product is absorbed by the roots in the form of monosilicic acid - Si (OH) 4 - being almost all transported to the leaves (Barbosa Filho, 2002).

Calcium silicate is a residue that requires adequate final disposal, with similar composition and action similar to calcareous ones, being able to replace them with efficiency in increasing the pH of the soil and as a source of nutrients and, also, to influence the availability of nitrogen not alone (Claussen, Lens, 1995, Korndörfer et al., 2002).

Bean cultivation requires well-structured soil and equilibrium fertilization, according to Wolkweiss and Raij (1976), with the foliar application of silicon in the bean, it is observed the increase of the concentration in the leaf, provided a greater number of pods per plant and consequently higher productivity (Crusciol et al., 2013).

Thus, the present work aims to evaluate the influence of different dosages of calcium silicate on the development of black bean culture.

Material and methods

The experiment was conducted at the State University of Maringá CAU / UEM in Umuarama-PR, located at latitude 23° 78'91.17 "South, longitude 53 ° 25'85.12" West. For the experiment, 2.5 L pots filled with typical dystrophic Red Latosol (EMBRAPA, 2013) were used, whose chemical and physical characterization is presented in Table 1.

Table 1. Chemical characterization and clay content (0-30 cm) of a typical dystrophic Red Latosol (LVd), used as an experimental basis

pH	Al^{3+}	Ca^{2+}	Mg^{2+}	K^{+}	P	V	MO	SB	CTC	Argila
$CaCl^{2+}$	.........$cmol_c/dm^3$............			...mg/dm^3....		%	g/dm^3	....$cmol_c/dm^3$....		%
3.88	0.75	1.25	0.25	0.03	1.4	24.87	6.72	0.93	6.14	13.95

Al^{+3}, Ca^{+2} e Mg^{+2}– extractor KCl^{1} mol L^{-1}; K e P – $Mehlich^{-1}$; V – Saturação or bases; MO – Organic matter; SB – Base sum; CTC – Cation Exchange capacity.

The soil used was obtained in the vicinity of the Campus, and chemical analysis of the same was made to gauge the pH, with the objective of obtaining an acid soil. According to soil chemical analysis, it was found to have a pH of 3.88 cmolc / dm^3. Calcium silicate doses of 0, 50, 60, 70, 80 and 90%, transformed from 0; 0.7; 1.4; 2.8; 5.6 and 11.2 t ha^{-1} respectively, turning them into grams. In this way, the experiment was conducted in a completely randomized design with five treatments composed of six replicates. Each replicate was formed by three seedlings, using only one per pot.

Was applied; 0.12; 0.25; 0.51; 1.02 and 2.05 g respectively of calcium silicate (CaSiO 3%), was stirred in the soil and waited seven days for it to react. Then, a hole was drilled in each pot and 4 black bean seeds of the IPR Uirapuru variety were sown on may 2018 and fertilization was performed according to the Manual of Fertilization and Calagem of the State of Paraná (2017), for the bean crop. After 45 days in a greenhouse, the plants were collected, separating the aerial part and the root, the roots were washed in running water and directed to the Phytopathology laboratory of the State University of Maringá, Campus Umuarama, PR. The analyzed variables were fresh shoot pasta (MFPA), fresh root pasta (MFRAIZ), shoot dry mass (MSPA), and a tape measure was used to measure plant height (ALP) and root length (CRAIZ).

The data were submitted to analysis of variance at 5% of probability and, when significant, the means were submitted to the regression analysis, adjusting to the quadratic model, using the statistical program Sisvar (Ferreira, 2011).

Results and discussion

The fresh mass of aerial part showed a significant difference, it presented a positive increase in the concentration of Si (Figure 1A), that is, the more the calcium silicate dose was increased, the quantity of MFPA also increased until the dose of 50%, from this dose a gradual fall of this variable is observed.

According to Oliveira (2009), when evaluating silicon in accumulating plants such as rice and wheat and non-accumulating plants such as beans and soybeans, it was observed that both beans and soybeans showed silicon accumulation in roots of 12 to 8% and in part 88% to 92%. The authors report that these results fall within the group of silicon-excluder species by self-accumulation of silicon in the roots, as described by Heine et al. (2005).

In this context, when using calcium silicate, for the vegetative parameter of Figure 1B, which was evaluated the MFRAIZ of the bean, the results were also significant, being observed that at the dose of 70% of calcium silicate in the root system presented greater mass when compared to the other dosages applied.

Galletti et al. (2015) when studying the use of limestone and calcium silicate for the soil acidity in the bean crop, it was observed that there was an increase and accumulation of dry matter and root length, corroborating with the data of Figure 1C that presented significant results, and this variable showed the influence of the different dosages of calcium silicate, with emphasis on the dosage of 60% that presented a greater amount in grams of MSPA.

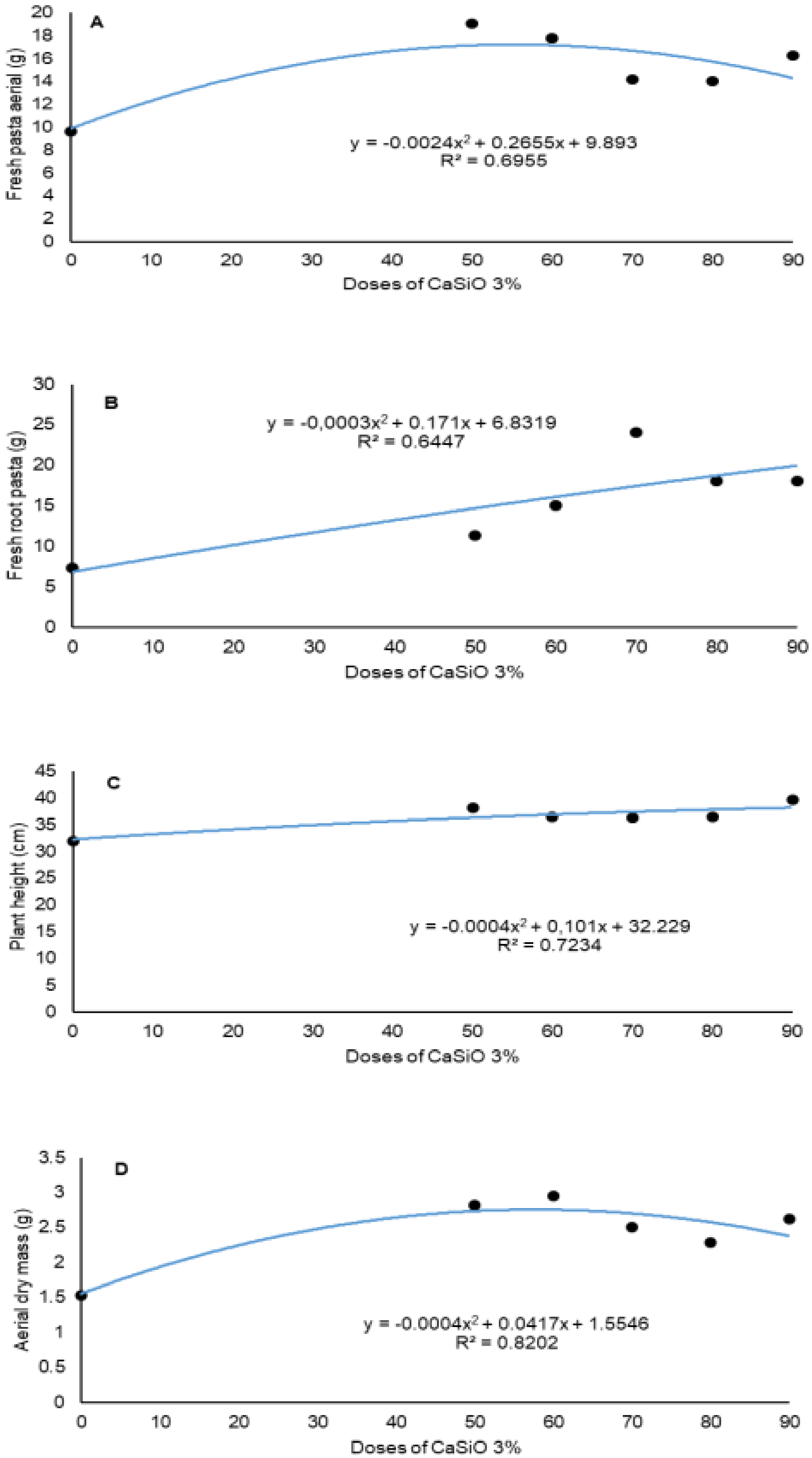

Figure 1. Evaluation of the fresh mass of the aerial part (A) and root (B), plant height (C) and dry mass of the aerial part (D) of the bean submitted to different doses of calcium silicate.

In relation to the agronomic characteristics of the BRS Ametista bean cultivar, belonging to the Carioca group, on different doses of biostimulants associated with agrosilicon (powder) as a source of calcium silicate. However, Alcantara (2015) obtained different results, being significant for MSPA with the use of biostimulants, but for the silicate source, no significance was observed differing from Figure 1C. For Fernandes et al. (2009), when studying the influence of silicate in the bean, observed that the MSPA of the plants was favored by the application of calcium silicate, with the doses of 2.31 and 6.95 being the ones with the highest efficiency.

No significant differences were found for the CRAIZ variable as a function of the doses of calcium silicate. However, when observed the variable plant height (Figure 1D), the results were significant, and the beans responded better to the different doses, expressed through shoot growth. The highest growth rate was observed at concentrations of 50% and 90% of calcium silicate.

Corroborating with these results Paiva et al. (2000), when evaluating the effect of doses of 0, 42, 84, 126, 168 and 201 mg dm^{-3} of calcium silicate and magnesium in development parameters, such as plant height, for common bean cultivars BRS Pontal and BRS Pérola, observed that the cultivar BRS Pontal, contrary to BRS Pérola, showed a better response to silicate fertilization, since it presented a significant difference. It was observed that the highest plant height occurred at 84 mg dm^{-3}, being higher 41.16% in relation to the 0 mg dm^{-3} concentration that obtained the lowest plant height.

There are few reports on the use of calcium silicate or even fertilization with other sources of silicon for bean, because this is a non-accumulating species, such as soy, this means that the silicon is absorbed and accumulated in the aerial part and roots in smaller amounts, when compared to accumulating species (Oliveira, 2009). The accumulation of silicon gives higher plant resistance to diseases and pests (Moraes et al., 2006) and the condition of salinity and drought deposited in the cuticle of the plants, conferring resistance (Zuccarini, 2008). Crusciol et al. (2013) observed an increase in the number of pods and production of bean grains and associated capacity of silicon in increasing the resistance of the crops to the attack of phytopathogens and diseases (Teixeira et al., 2008).

Conclusion

The use of calcium silicate promoted higher increments of fresh shoot mass, fresh root mass, shoot dry mass and plant height. There was no significant difference in the root length parameter.

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