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POTASSIUM FERTILIZATION MANAGEMENT IN COMMON BEAN PROTECTION AGAINST *COLLETOTRICHUM LINDEMUTHIANUM*

MANEJO DA ADUBAÇÃO POTÁSSICA NA PROTEÇÃO DO FEIJOEIRO CONTRA *COLLETOTRICHUM LINDEMUTHIANUM*

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ABSTRACT
Anthracnose of common bean caused by the fungus *Colletotrichum lindemuthianum* is considered one of the most important fungal diseases that attacks the aerial part of the common bean for causing significant losses in final productivity. Potassium is one of the elements that is involved in the defense of the plant. Thus, the objective was to evaluate the effect of potassium doses in the control of anthracnose in three common bean cultivars. The design used was completely randomized with five treatments in three repetitions. The severity of the disease was obtained at 15 days after inoculation using a diagrammatic scale of notes and by counting the number of lesions in the central and lateral leaflets and the length of the lesions in the midrib of the central leaflet. Potassium fertilization was efficient in controlling anthracnose in the pearl cultivar, reducing the severity of the disease at a dose of 180 kg ha-1 of potassium in the form of potassium chloride.
KEYWORDS: Anthracnose; *Phaseolus vulgaris*; Plant nutrition; Severity.

RESUMO
A antracnose do feijoeiro causada pelo o fungo *Colletotrichum lindemuthianum* é considerada uma das doenças fúngicas mais importantes que atacam a parte aérea do feijoeiro por ocasionar perdas significativas de produtividade final. O potássio é um dos elementos que está envolvido na defesa da planta. Assim, objetivou-se avaliar o efeito de doses de potássio no controle da antracnose em três cultivares de feijão-comum. O delineamento utilizado foi o inteiramente casualizado com cinco tratamentos em três repetições. A severidade da doença foi obtida aos 15 dias após a inoculação utilizando uma escala diagramática de notas e por meio da contagem do número de lesões no folíolo central e laterais e o comprimento das lesões na nervura central do folíolo central. A adubação potássica foi eficiente no controle da antracnose na cultivar pérola, reduzindo a severidade da doença na dose de 180 kg ha-1 de potássio em forma de cloreto de potássio.
PALAVRAS-CHAVE: Antracnose; *Phaseolus vulgaris*; Nutrição mineral; Severidade.

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INTRODUÇÃO

Anthracnose caused by the fungus *Colletotrichum lindemuthianum* is one of the most important fungal diseases that attack the aerial part of the common bean plant (*Phaseolus vulgaris*). The disease occurs in all plant growth stages, causing lesions on leaves, stems, branches, pods and seeds, which can cause losses of up to 100% in production when conditions are favorable to the pathogen and when susceptible varieties are used (SANTINI et al., 2005). Its control is difficult because the pathogen is easily spread through the seed and the existence of several breeds of the fungus capable of breaking the plants resistance (GADAGA et al., 2017).

Chemical control and the use of resistant cultivars are the controlling anthracnose main methods in common bean. However, the use of more efficient and safe control strategies has gained prominence in integrated disease management, since the use of fungicides in chemical control can cause contamination in soil and humans. In addition, the resistance of fungi to fungicides has required research on alternative methods to integrated management (NOZAKI; KLIEMANN, 2016).

One of the alternatives for the control of diseases caused by fungi is the management of mineral nutrition, since a well-nourished plant is more resistant to attack by pathogens. The mineral elements are involved in all the defense mechanisms of the plant and can influence the degree of resistance of the plant by modifying the morphology or histology, or even changing the chemical composition of tissues in response to infection by pathogens (MARSCHNER, 1995).

Some studies show that the management of chemical fertilization has reduced the incidence and severity of diseases. In grapevine, the decrease in powdery mildew severity was related to the increase in P, N and K levels (REUVENI et al., 1993). The decrease in onion mildew was related to potassium fertilization (DEVELASH; SUGHA, 1997). In coffee culture, the incidence of cercosporiosis decreased with the increase in fertilization with Ca and K (GARCIA JÚNIOR et al., 2003). Balardim et al. (2006) observed that the severity of Asian soybean rust reduced with fertilization with K and P. Kettlewell et. al (1990) working with wheat verified that foliar application of potassium chloride was related to the decrease in leaf spots; e Cook et al. (1993) observed this same relationship in powdery mildew.

The high susceptibility of potassium-deficient plants to certain diseases is related to metabolic functions, since potassium-deficient plants are more susceptible to diseases (ZAMBOLIM; VENTURA, 1992). Therefore, the present study aimed to evaluate the effect of different doses of potassium chloride on the resistance of common bean plants against artificial inoculation of *C. lindemuthianum*.

MATERIAL AND METHODS

The experiment was carried out in a greenhouse at the experimental station of the Technological Development Center (Centro de Desenvolvimento Tecnológico – CDT), on the premises of the Brazilian Airport Infrastructure Company (Empresa Brasileira de Infraestrutura Aeroportuária – INFRAERO), in the city of Imperatriz, in the state of Maranhão (South Latitude 5°31’32” and West Longitude 47°26’35” with an average altitude of 92 m). The climatic classification according to Köppen (1948) characterizes the region as a B1wA’a’ type, tropical savanna climate or tropical wet and dry climate.

Three common bean cultivars were used, the cultivar Pérola (susceptible to anthracnose), BRS Estilo (moderately resistant to anthracnose) and BRS Madrepérola (resistant to anthracnose), in a completely randomized design with five treatments (0, 80, 120, 140 and 180 kg ha-1 of K in the potassium chloride form) and three replications. The seeds came from the common bean breeding program of Universidade Federal de Viçosa – UFV, Viçosa - MG.

Plastic pots were used for planting, with dimensions of 23x23x18 cm and capacity for 5 kg of soil, in which they were weighed and filled with soil, in which it was submitted to analysis to check the amount of potassium and the other nutrients that constituted it.(Table 1). The potassium doses were mixed with the soil and three seeds were sown in the pot, followed by irrigation. Fertilizations were carried out according to the result of the soil analysis. Fertilization of 30 kg ha-1 of nitrogen in the form of urea was performed 20 days after seedling emergence, when thinning was carried out, leaving only one plant in each pot. Each pot containing a plant constituted an experimental unit. Throughout the experiment the soil moisture was maintained close to the field capacity, with irrigation in two shifts.

Table 1: Chemical analysis Result of the soil used to perform the experiment in a greenhouse.

Ph	O.M.	P	K	Ca	Mg	Al	H + Al	SB	CEC
$CaCl_2$	g kg^{-1}	mg dm^{-3}				Cmol dm^{-3}			
5.1	17.7	95.7	0.18	3.61	0.51	0.00	1.00	4.30	5.3

pH: potential of hydrogen; O.M.: organic matter; P: phosphorus; K: potassium; Ca: calcium; Mg: magnesium; Al: Aluminium; H+Al= potential acidity; SB: sum of bases; CEC= Cation exchange capacity.

The isolate of the fungus *C. lindemuthianum* ace 65 was obtained from the collection of the Plant Protection laboratory of the Department of Phytopathology of the Universidade Federal de Viçosa, and was grown in culture medium and cultivated at 20 ºC in the Microbiology laboratory of the Universidade Estadual da Região Tocantina do Maranhão.

Artificial inoculation was performed with a hand spray at the end of stage V4 at 35 DAE (days after emergence), with an inoculum suspension at a concentration of 1,2 x10^6 conidia/ml to obtain the suspension of conidia, the methodology proposed by the International Center for Tropical Agriculture - CIAT (2015) was followed, in which healthy 30-day-old bean leaves were collected and placed in petri dishes containing potato dextrose agar culture medium - PDA. Distilled and sterile water was added to a plate containing the fungus and the surface was scraped with a spatula in order to achieve a suspension. Distilled and sterile water was added to a plate containing the fungus and the surface was scraped with a spatula in order to achieve a suspension. With a pipette, a few drops of the suspension were deposited on the leaves already containing the culture medium. Subsequently, the plates were incubated in the BOD at 20 ºC for 12 days. After this period, distilled and sterile water was added to the petri dishes containing the grown fungus and with a sterile spatula the surface of the dish was scraped in order to separate and suspend the conidia in the water. The conidial suspension was filtered with sterile gauze to separate particles such as agar and mycelium residues. Right after the conidia concentration, it was quantified with the aid of the Neubauer chamber, according to the methodology described by CIAT (2015), and adjusted with distilled water until the concentration of 1,2 x 10^6 conidia/ml.

The severity of anthracnose was assessed when the plants were in the phenological stage R5, by counting the number and measuring the length of necrotic lesions on the rib at 15 dae. The percentage of injured area was assessed at 15 dai by the descriptive scale of Tamayo (1995), where: 1- No visible symptoms of the disease; 3- Presence of few small size lesions covering approximately 1% of the leaf area; 5- Presence of several small lesions on the petiole and primay and secondary ribs under the leaves; 7- Presence of numerous large lesions under the leaves or ribs and petioles; 9- Necroses evident in 25% or more of the plant tissue as a result of lesions on leaves, petioles, stems, branches and even at the point of growth; these necroses often cause the death of much of the plant's tissues.

The number of lesions, length of lesions and percentage of injured area were assessed in the lateral leaflets (local effect) and in the central leaflets (systemic effect). In counting the number of lesions, each necrosis in the rib tissue, which was elongated and dark brown in color, was considered symptoms of anthracnose, delimited by living tissue. The length of the lesions was measured with the aid of a millimeter ruler, considering the distance between the longitudinal ends of each lesion.

The severity data were subjected to analysis of variance at 5% probability of error using the ASSISTAT statistical program. To understand the relationship between the doses of potassium chloride and the characteristics evaluated regarding resistance to anthracnose, regression analysis was performed using ASSISTAT software. The choice of the regression equation was made through a better adjustment based on the coefficient of determination (R^2) and taking into account a probable biological biological explanation.

RESULTS

It appears that there was a significant difference for the variables of the number of lesions in the central leaflet (NLCL), lesion length in the main rib of the central leaflet (LLCL) and for severity at 15 days after inoculation (S15DAI) in the cultivar "Pérola". For variable number of lesions in the lateral leaflets (NLL), there was no significant difference between cultivars. The cultivars BRS Estilo and Madrepérola did not differentiate between themselves, but the lowest averages for all variables evaluated are observed in the cultivar Madrepérola. For severity at 15 days after inoculation, there was a significant differenc ($p > 0,05$) between treatments applied to cultivar Pérola and there was no significant difference ($p \leq 0,05$) between treatments applied to cultivars BRS Estilo and Madrepérola (Table 2).

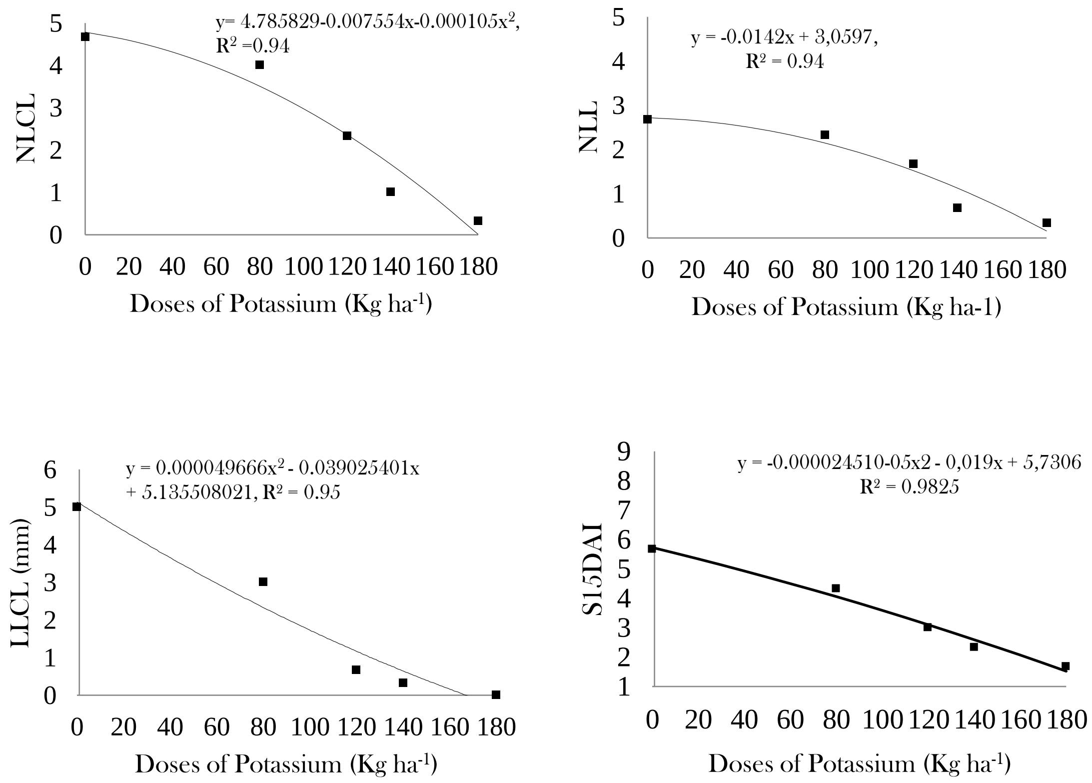
Table 2: Average data for number of lesions in the central leaflet (NLCL), number of lesions in the lateral leaflets (NLL), lesion length in the main rib of the central leaflet (LLCL) and severity at 15 days after inoculation (S15DAI).

Cultivar	NLCL	NLL	LLCL (mm)	S15DAI
Pérola	2.47 ± 0.54* a	1.53 ± 0.41 a	1.80 ± 0.87 a	3.40 ± 0.52 a
BRS Estilo	2.03 ± 0.42 a	1.73 ± 0.38 a	3.67 ± 2.56 ab	2.47 ± 0.24 ab
Madrepérola	0.27 ± 0.15 b	0.47 ± 0.29 a	1.27 ± 1.19 b	1.40 ± 0.21 b
Average	1.56	1.44	5.80	2.46

* Average ± Standard Error. Transformed data $\sqrt{X}$. The averages followed by the same letter do not differ statistically from each other according to the Tukey test at the level of 5% probability.

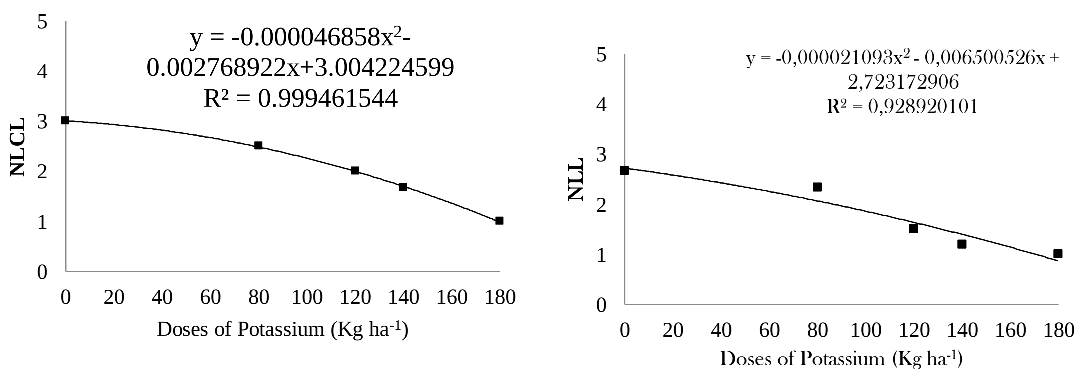
For the cultivar Pérola (susceptible), it was observed that there was a reduction in anthracnose in all characteristics, as the doses of potassium chloride increased (Figure 1). The dose of 180 kg ha^{-1} provided greater resistance in inoculated plants as it reduced the severity of the disease, thus influencing the systemic and local effect of anthracnose on the leaflets.

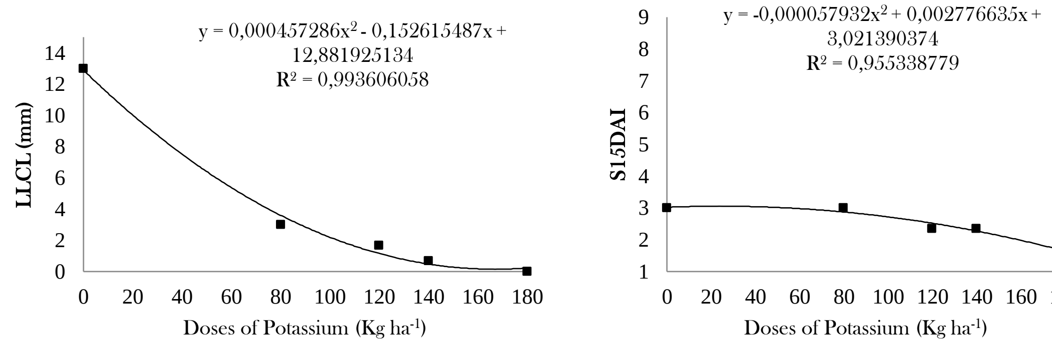
Figure 1. Effect of potassium fertilization on number of lesions in the central leaflet (NLCL), number of lesions in the lateral leaflets (NLL), lesion length in the main rib of the central leaflet (LLCL) and severity at 15 days after inoculation (S15DAI) in the cultivar Pérola.



In the cultivar BRS Estilo there was also a reduction in anthracnose in all characteristics, as the doses of potassium chloride increased (Figure 2). The dose of 180 kg ha^{-1} also provided greater resistance in inoculated plants for reducing the severity of the disease in this cultivar.

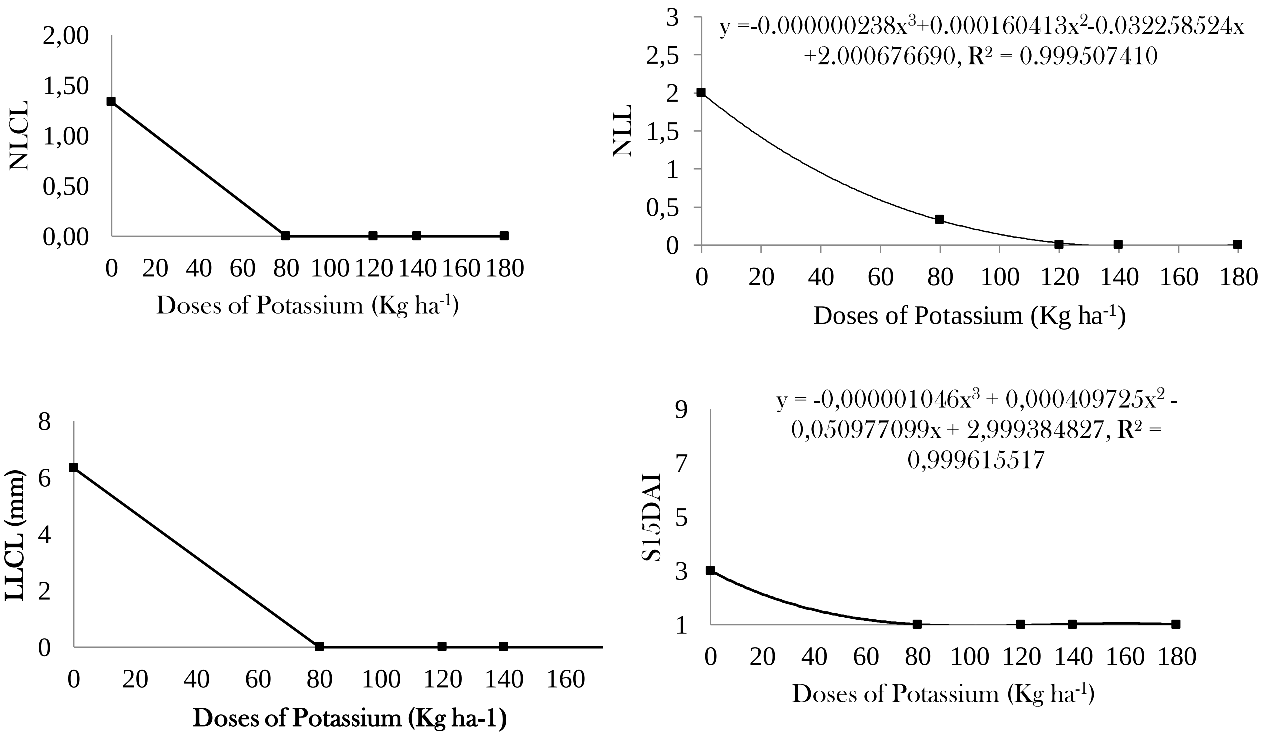
Figure 2. Effect of potassium fertilization on number of lesions in the central leaflet (NLCL), number of lesions in the lateral leaflets (NLL), lesion length in the main rib of the central leaflet (LLCL) and severity at 15 days after inoculation (S15DAI) in the cultivar BRS estilo.





The cultivar Madrepérola (resistant to anthracnose) showed few symptoms of anthracnose, results that were already expected because it is a resistant cultivar. It is observed that the potassium chloride doses did not influence the variables observed according to the increase in potassium chloride doses (Figure 3). The systemic and local effects of anthracnose were low due to the genetic resistance of the plant. The highest grade of disease severity was three, which shows the use of resistant cultivars as the most recommended method for disease control.

Figure 3. Effect of potassium fertilization on number of lesions in the central leaflet (NLCL), number of lesions in the lateral leaflets (NLL), lesion length in the main rib of the central leaflet (LLCL) and severity at 15 days after inoculation (S15DAI) in the cultivar Madrepérola.



DISCUSSION

The reduction in the incidence and severity of plant diseases is associated with potassium, but it cannot be generalized, being related to its availability in the soil and interaction with other nutrients, with edaphoclimatic conditions and plant susceptibility (HUBER; ARNY, 1985).

For the cultivar Pérola (susceptible) and BRS Estilo was observed that the potassium fertilization influence was greater in relation to the other cultivars (Figures 1 and 2). Gadaga (2009), evaluating the effect of potassium phosphite in the control of common bean anthracnose in greenhouse also observed that there was efficiency in the severity of the disease and concluded that the effect of phosphite in the control of common bean anthracnose, probably, was must directly due to the toxic effect on the pathogen and indirectly by inducing resistance.

Carvalho *et al.*, (2013) evaluated the effect of potassium and nitrogen fertilization on anthracnose in corn cultivars and observed that the largest injured leaf area occurred in the treatment with lower doses of N and K and the smaller injured leaf area in the treatment. with doses of N, associated with doses of K. Although in this study only the effect of potassium was evaluated in isolation, it is possible that interactions with other nutrients already present in the soil may have occurred, but it was still possible to observe an effect of potassium in the resistance of cultivar pearl against anthracnose because the plants were grown in relatively poor soil.

For the cultivar Madrepérola (resistant) it was observed that there was no influence of potassium fertilization on anthracnose (Figure 3). Carvalho *et al.* (2013), reported that the response to nutritional interaction is more common in moderately resistant cultivars, however the results in the present study show us a significant effect of potassium doses on the cultivar Pérola (susceptible). It can also be affirmed that this effect must be related to the activation of enzymes present in photosynthesis and respiration, since these processes provide carbon chains that provide stoma defense and regulation that influences the transport of solutes by mass flow, causing the increased availability of K facilitates absorption by roots (BLOOM, 2004).

Balardim, *et al.,* (2006) working with soybean, found that the fertilization of P and K produces excellent results when they verified the influence of nitrogen and potassium fertilization on the Asian soybean rust severity. By reducing potassium and phosphorus in fertilization, an increase in the severity of the disease was observed. While when increasing the volume of nutrients in the plant, there were excellent results. These results corroborate with the results obtained in the present study, because in the cultivar pearl the increase in the amount of potassium significantly reduced the severity of anthracnose.

CONCLUSIONS

Potassium fertilization reduces the severity of anthracnose in the cultivar pérola by inducing the resistance of plants to attack by *C. lindemuthianum.* It is possible that the interaction of K occurred with the N and P present in the soil, anyway even in isolation the effect of K was significant. The management of mineral nutrition is an alternative in the integrated management of diseases, which can be used when there are no resistant cultivars, and balanced fertilization guarantees greater success in the control of these diseases.

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