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3-2017

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Morais, E. G.; Lima, F. R. D.; Vaz, G. H. B.; Vilela, E. F.; Ferraz, R. M.; Silva, M. L. S.; and Faquin, V., "IMPACT OF INTERACTION P AND Zn ON BIOFORTIFICATION OF BEAN" (2017). *Publications from USDA-ARS / UNL Faculty*. 1713.

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IMPACT OF INTERACTION P AND Zn ON BIOFORTIFICATION OF BEAN

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INTRODUCTION: A large part of the world population has low levels of micronutrients, especially pregnant women and children in developing countries. Zinc (Zn) is a micronutrient, performing many functions in the organism. Biofortification aims to increase the concentration of certain mineral in parts consumed of the cultivated plants. The crops of most interest are those that constitute the basic diet for the majority of the population, including beans.

Two main strategies are used in biofortification, selection of cultivars more favorable to biofortification and increase the micronutrient dose. Biofortification of bean with Zn is difficult due to interaction with phosphorus (P). The decrease in zinc absorption caused by phosphorus depends on soil attributes such as pH, cation exchange capacity and direct reaction with Zn and subsequent precipitation. The increase of the dose of Zn can reduce the absorption of iron by plants by competitive inhibition.

This study aimed to evaluate the interaction between P and Zn about biofortification in two bean cultivars, evaluating the concentration of Zn and iron in the grain and production.

MATERIALS AND METHODS: The experiment was carried out in a greenhouse of the Department of Soil Science at the Federal University of Lavras, Lavras, Minas Gerais, Brazil. Treatments were arranged in a completely randomized design with two replicates and a factorial scheme 2x2x4 involving two bean cultivars (Alvorada and Estilo), two doses of P (200 and 400 mg kg⁻¹) and four dose of Zn 4 (0, 25, 50 and 100 mg kg⁻¹).

Pots were filled with 3 Kg of soil, the soil used were classified as dystroferric Red Latosol (LVdf), with a clay texture that contained the following chemical attributes: pH in water = 5; P = 1,13 mg dm⁻³; K = 54,0 mg dm⁻³; Ca = 1,5 cmol_c dm⁻³; Mg = 0,2 cmol_c dm⁻³; Al = 0,4 cmol_c dm⁻³; H+Al = 6,3 cmol_c dm⁻³; SB = 1,84 cmol_c dm⁻³; t = 2,24 cmol_c dm⁻³; T = 8,14 cmol_c dm⁻³; m = 18%; cation exchange capacity at pH 7 = 23%; organic matter = 2,87 dag kg⁻¹; P-rem = 12,93 mg L⁻¹. Was previously performed liming on the soil, increasing the saturation by base to 70 %, the levels of Ca²⁺ and Mg²⁺. The experiment was conducted with two plants per pot until the formation of the grains. At the end of the experiment was determined dry gain mass (MSG) per pot and the levels of Zn and Fe in grains.

For the application of the respective treatments it was used NH₄H₂PO₄ p.a. as source of phosphorus and for Zn, was used ZnSO₄.7 H₂O p.a. The other nutrients were applied in the following amounts, three N applications were performed during the cultivation, totaling 300 mg N kg⁻¹, K= 150 mg kg⁻¹, S= 40 mg kg⁻¹, B=0,81 mg kg⁻¹; Cu= 1,33 mg kg⁻¹; Fe= 1,55 mg kg⁻¹; Mn= 3,66 mg kg⁻¹; Mo= 0,15 mg kg⁻¹. Data were submitted to an analysis of variance (p <0.05) and regression models that fit the data.

RESULTS AND DISCUSSION: Triple interaction was observed for the effect on MSG and Zn content, for the Fe content, only interaction between P and Zn dose and between P and Cultivar dose were noticed, comparing the arrangements with each variable analyzed. For the Zn doses, regression models were tested, and the second and first degree models adjusted the data.

The greatest responses in grain production (Fig. 1) was observed in cultivar Estilo at the lowest dose of P, being increased the MSG according to the increase of the dose of Zn applied. At the highest P dose, the cultivar Estilo showed a decrease in MSG, showing a possible toxicity due to higher doses of Zn (50 and 100 mg kg⁻¹), compromising the production. The cultivar Alvorada was more tolerant to this Zn toxicity. In the lowest dose of P, did not respond to the application of Zn, was only observed at the highest dose where there were the MSG decrease linearly with the increase of the Zn dose. This result showed the antagonism between P and Zn, that the increase of available Zn limits the adsorption of P, with consequent loss in productivity. Higher levels of Zn increased the Zn content in the grain (Fig. 1), being favorable to the biofortification process, this increase was not verified for the cultivar Estilo in the dose of

400 mg P kg⁻¹, because in higher doses of Zn (50 e 100 mg kg⁻¹), the plants could not reach the reproductive stage.

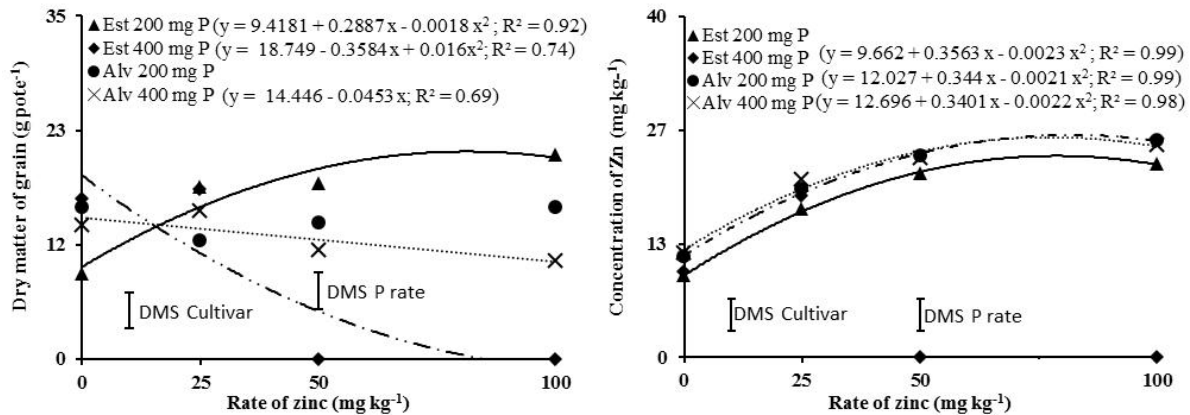


Figure 1: Effect of the interaction Cultivar x Phosphorus x Zinc on grain production and concentration of Zn, Est - Cultivate Style, Alv - Cultivate Dawn, 200 mg P - dose of 200 mg kg⁻¹ of P, 400 mg P - dose of 400 mg Kg⁻¹ of P, DMS Cultivar - minimum significant difference between cultivars, DMS P rate, minimum significant difference between doses of P. Coefficient of variation: 13.95% and 17.35% respectively for grain harvest and Zn concentration.

The Fe content in the bean grains decreased with the increase of the Zn dose, being this reduction was more expressive when it was used as higher doses of P (Fig. 2). This shows that there is an inhibition of Fe absorption due to the increase in the amount of Zn in the soil derived from the application of a larger dose, suggesting possible competition between both. A lower dose of P had higher Fe content in the grain, with increases of 160 % and 112 % respectively. P to doses of 50 and 100 mg kg⁻¹ of Zn was not observed for other doses.

Zn together with P may decrease the uptake of Fe by plants. It is observed in figure 1 that with the increase of the dose of P, the cultivar Estilo showed a decrease in the Fe content in the grains, fact not observed for the cultivar Alvorada. Among the tested cultivars Alvorada showed higher Fe content for both doses of P.

The interaction P and Zn directly influences the biofortification with Zn in the beans, and adjusting fertilizations with P does not compromise biofortification. It is also worth mentioning that the beans serve as a source of Fe for the population, and this interaction can depreciate the Fe content in the grains, thus compromising their nutritional potential.

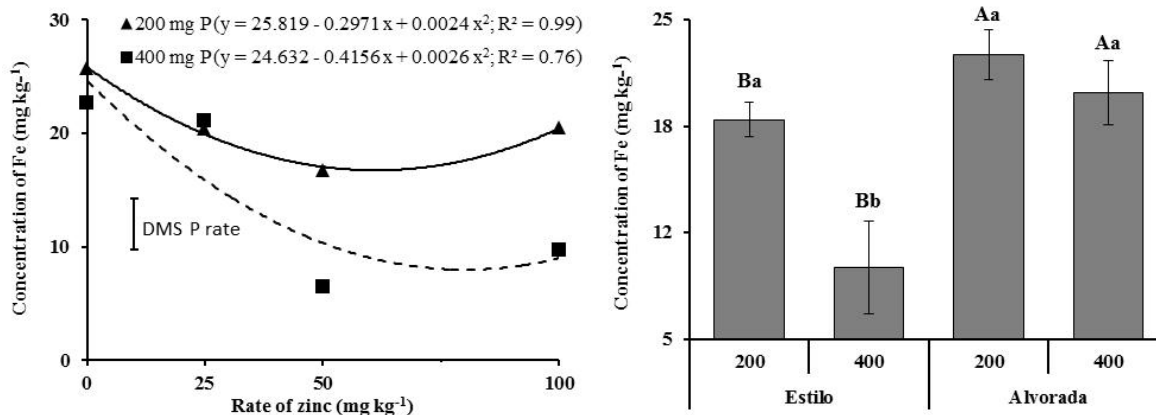


Figure 2: Concentration of Fe in the grains as a function of the interaction P and Zn, and P and Cultivar, DMS - Minimum significant difference between doses of P, upper case letters compare the cultivars within the same dose of P, lower case letters compare the doses of P within the same Cultivar, upper and lower case letters are not differentiated by the F test ($p < 0.05$), coefficient of variation: 21.66%.

CONCLUSIONS: The increase in the application rates of Zn increases concentration of Zn in grain bean. The concentration of Fe in grain of bean reduce with increases application rates of Zn in bigger magnitude to rate of P of 400 mg kg⁻¹.

The cultivar Alvorada is more tolerant to fertilization with Zn.