EFEITO DO BORO, COBRE E ZINCO EM ATRIBUTOS DE QUALIDADE DA BEBIDA DO CAFÉ[1]

Junia Maria Clemente[2], John L. Jifon[3], Yonara Poltronieri[4], Herminia Emilia Prieto Martinez[5]

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[2]PhD Student, Federal University of Viçosa, Viçosa-MG, junia.clemente@gmail.com
[3]Associate Professor, Texas A&M AgriLife Research Center, Weslaco - TX, jljifon@ag.tamu.edu
[4]Researcher, EPAMIG; , Viçosa-MG, yonarapoltronieri@hotmail.com
[5]Doctor of Science, Federal University of Viçosa, Viçosa-MG, herminia@ufv.br

RESUMO: Os micronutrientes desempenham funções específicas e essenciais no metabolismo das plantas, sendo que a falta pode ocasionar perdas no crescimento, produção e qualidade do cafeeiro. O objetivo do presente trabalho foi verificar o efeito do B, Cu e Zn supridos através de pulverizações foliares e inserção de comprimidos no tronco dos ramos ortotrópicos de cafeeiros. Os tratamentos estudados foram: controle, sem fornecimento de B, Cu ou Zn; pulverização foliar com ácido bórico, oxicloreto de Cu e sulfato de Zn aplicados nas concentrações de 0,4%; inserção de comprimido no tronco contendo sais de B, Cu, Zn, B e Cu, B e Zn, Cu e Zn and B, Cu e Zn. Avaliaram-se a condutividade elétrica, potássio lixiviado, atividade da polifenoloxidase (PPO) e teor de compostos fenólicos totais. A condutividade elétrica, potássio lixiviado e compostos fenólicos totais não foram afetados pela fertlização contendo B, Cu e Zn. A atividade da PPO foi maior nas plantas adequadamente nutridas com Cu. A atividade da PPO apresentou boa correlação com o teor de fenóis totais.

PALAVRAS-CHAVE: café, micronutrientes, qualidade

EFFECTS OF BORON, ZINC AND COPPER NUTRITION ON QUALITY ATTRIBUTES OF COFFEE

ABSTRACT: Micronutrients play specific and essential functions on plant metabolism, and the fault can cause losses on growth, production and coffee quality. The objective of this study was to verify the effect of B, Cu and Zn supplied by foliar spray and trunk injections in orthotropic branches of coffee plants. The treatments studied were: control, without B, Cu and Zn supply; foliar spray with boric acid, zinc sulphate and copper oxichloride applied in a concentration of 0.4% each; trunk injection of micronutrient tablet containing B, Zn, Cu; B and Cu; B and Zn; Cu and Zn; or B, Cu and Zn salts. Electrical conductivity, leached potassium, polyphenol oxidase activity (PPO) and the content of total phenols of coffee beans were evaluated. Electrical conductivity, potassium leaching values, and total phenols were not affected by fertilization with B, Cu or Zn. On the other hand, PPO activity was greater in coffee grains harvested from plants treated with Cu, and had a strong correlation with total phenolics content.

KEY-WORDS: coffee, micronutrients, quality

INTRODUCTION

Brazil is the world leader in coffee production. In order to meet production goals and quality standards, the coffee industry has invested heavily in key research and emerging production technologies. In addition to genetics and environmental factors, improved agronomic systems, especially balanced nutrition, is vital not only for productivity, but also for cup quality and consumer satisfaction. Numerous nutritional studies have documented the role of key essential nutrients on coffee production. While it is generally acknowledged that micronutrients can have a profound impact on coffee quality, few studies have attempted to characterize these effects.

Special coffees are those with an optimum balance among the compounds responsible for the desirables flavor and aroma, specially caffeine, trigoneline, acids, sugars and phenolic compounds. They are directly responsible for the body, acidity

and suavity of the beverage. The main way to analyze the cup quality is by the cup test, although, it is frequently criticized because of its subjectivity (Carvalho et *al*., 1994). Thus, more precise methods that correlate well with cup quality traits and precursors such as PPO activity, potassium leached, electrical conductivity, total tritable acidity, and pH of coffee beans have been developed.

Several studies have described the effect of different sources and application rates of boron (B), zinc (Zn), and copper (Cu) on coffee production, however, few studies describe these effects on the cup quality, as well as on other organoleptic traits. Deficiencies of B and Zn are common in the most of the Brazilian soils (Malavolta, 1986). In coffee plantations these deficiencies have been attributed to the exhaustion of the natural soil fertility, as well as, the use of varieties with high mineral nutrient requirements. On the other hand, in soils rich in organic matter most of the Cu can be adsorbed in carboxilic and phenolic complexes of organic soil components such as peat (Matos et *al*., 1996). Therefore, soil fertilization with such micronutrients may be ineffective and perhaps lead to toxicity problems. Alternative micronutrient fertilization methods such foliar sprays are now widely used in coffee production, however, the uptake efficiency of foliar micronutrient application depends on many factors, including weather conditions, leaf properties, and nutrient properties such as molecule size and mobility through leaf barriers. If uptake efficiency is low, then multiple application may be needed, but this can also increase production costs and result in phytotoxicity problems.

The objective of this study was, therefore, to evaluate the effect of micronutrient (B, Zn and/or Cu) application method (foliar sprays or trunk injections with tablets containing micronutrients salts) on quality attributes of coffee beans.

MATERIALS AND METHODS

The experiment was conducted in a *Coffea arabica* plantation, in an experimental farm of Federal University of Viçosa. The experiment was designed as randomized block with five treatments (control, without B, Zn and Cu supply; foliar spray with boric acid, zinc sulphate and copper oxichloride applied in a concentration of 0.4% each; trunk injection of tablet containing B salts; trunk injection of tablet containing Zn salts; trunk injection of tablet containing Cu salts; trunk injection of tablet containing B and Cu salts; trunk injection of tablet containing B and Zn salts; trunk injection of tablet containing Cu and Zn salts; trunk injection of tablet containing B, Cu and Zn salts) and 5 replications. Each plot comprised of 18 plants, at a spacing of 3 X 1 meter disposed in 3 rows, with measurements taken only from the central rows. The tablets were injected in the orthotropic branch of coffee at 10 cm above the soil surface.

PPO extraction from coffee beans was conducted according to the method described by Concellón et *al*., (2004) using DOPA (L-3,4 dihidroxifenil-alanine) as substrate. Bean total phenols were extracted by the Lane-Enyon method (AOAC, 1990) and determined by the Folin Denis method. Bean color index was determined by the method previously described by Singleton (1966) and adapted for coffee. Coffee bean electrical conductivity and potassium leached were determined according to method previously describe by Prete (1995).

Data were subjected to an analysis of variance (ANOVA) and where necessary, treatments means were compared by the Duncan test at 5% probability level.

RESULTS AND DISCUSSION

The PPO activity of the treatments containing Cu, B+Cu and Cu+Zn were significantly higher than that of controls, but were similar to the sprayed, demonstrating the Cu effect on the activity of this enzyme. The B and Zn injected in the trunk did not have any significant effect on PPO activity (Table 1). It is well documented that Cu is a structural component of PPO (Malavolta, 1980; Robinson e Eskin, 1991), and its activity is highly associated with high quality coffee beans (Amorim e Silva, 1968).

Treatments containing only B and Cu salts administered through trunk injections also differed significantly from control, however, those containing Zn, B+Cu, B+Zn and B+Cu+Zn did not differ significantly from controls and the sprayed treatments (Table 1).

Strong relations between PPO activity and phenolic content whereby, beans with low concentrations of phenolic compounds also had low PPO activities especially with the trunk injection of B and Cu. According to Camacho-Cristobal et *al*., (2002) conditions that increase the phenolic compounds also cause an increase in PPO activity, perhaps because phenolic compounds are direct substrates of this enzyme.

High concentrations of phenolic compounds are indicative of oxidative stress which results in production of reactive oxygen species that, not only attack the membranes but also affect the cup quality (Cakmak e Römheld, 1997).

Coloration index values of sprayed treatments were significantly greater than those of the other treatments, however, they were not significantly different from those of treatments with trunk injections of B, B+Zn, Zn, Cu+Zn, Cu, and controls. Only the injection treatment containing B+Cu was statistically different from sprayed treatments, but similar to the controls. It is therefore uncertain if the nature of the effect of B, Cu or Zn nutrition on coloration index (Table 1). According to

Amorim (1978) the darkening process of the coffee beans is related to PPO activity on phenolic compounds and it is also related to loss of coffee quality.
Treatments had no significant effects on potassium leached with the exception of injection treatments of B+Zn and Zn alone which had some of the highest leaching values (2.36 g kg^{-1}), suggesting a positive interaction of both nutrients on the cell membrane integrity (Table 1). The average electrical conductivity was 57.94 µS cm^{-1} g^{-1} but this parameter did not differ significantly among treatments. Previous studies have reported high positive associations between Zn nutrition and potassium leaching, and this is thought to be associated with the role of Zn nutrition on membrane integrity (Neves at *al*., 2011).

CONCLUSIONS

The effects of B, Cu or Zn nutrition on electrical conductivity, potassium leached, phenolic compounds content and coloration index were not consistent, however, there was a slight a slight positive interaction effect between B and Zn on electrical conductivity. Micronutrients supplied by trunk injections and foliar spray produced similar results for all variables. Copper nutrition had the strongest effect on PPO activity.

Table 1 - Coloration index (CI - D.O. 425 nm), polyphenoloxidase activity (PPO - U/min/gram of sample), total phenols (% - equivalent to gallic acid/g of coffee), electrical conductivity (EC - µS cm^{-1} g^{-1}) and potassium leached (Lix K – g kg^{-1}) of coffee grains submitted to foliar spray and trunk injections with tablets containing B, Cu and Zn salts

Treatments	**Crop year 2011/2012**				
	CI	**PPO**	**TP**	**EC**	**KL**
T0	0.513 a b c	74.528 b	6.379 a	57.52 a	2.15 a b
T1	0.759 a	85.930 a	5.09 ab	50.18 a	2.01 a b
B	0.744 a b	82.072 ab	4.211 b	56.77 a	2.27 a b
Zn	0.525 a b c	79.082 ab	5.701 ab	58.29 a	2.36 a
Cu	0.497 a b c	85.152 a	4.063 b	56.92 a	1.93 a b
B+Cu	0.368 c	85.508 a	4.613 ab	60.98 a	2.05 a b
B+Zn	0.661 a b c	78.382 ab	5.509 ab	58.83 a	1.86 b
Cu+Zn	0.499 a b c	85.196 a	4.870 ab	62.73 a	2.12 a b
B+Cu+Zn	0.411 b c	74.688 b	6.138 a	59.27 a	2.02 a b
CV (%)	29.94	7.59	24.63	16.33	15.99

Means followed by the same letter in the column are not significantly different by Duncan test at 5%.

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