The Effect of Several Minerals Element on Polyphenol Content and Lignocellulosic Materials in Seedling of Arabica Coffee Leaves

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ABSTRACT

Arabica coffee plants cultivated under 1000 meters above sea level become more susceptible to biotic and abiotic disturbances. In general, plants have a natural resistance to enhance disease. This natural resistance will be exposed while the plant is healthy and has sufficient nutrients. Various mineral nutrients can potentially increase plants' natural resistance, but it is not yet known which elements play a more dominant effect. This research aimed to find out which minerals are most effective in increasing the natural resistance of plants. This research was conducted using Randomized Complete Block Design with 3 times replications. There were 7 treatments in this experiment, namely control (without additional mineral element), Silica 150 mg.L^{-1}, boron 300 mg.L^{-1}, iodine 300 mg.L^{-1}, calcium 3000 mg.L^{-1}, potassium mg.L^{-1}, and mix of them. The variables observation was focused on the production of polyphenol and lignocellulosic materials as a natural defense. The statistical addition of mineral elements was very significant to polyphenol content. Mineral calcium, iodine, and potassium potential give natural resistance to plants. It is shown with polyphenols production, which higher than other minerals. The production of polyphenols also supported forming of lignocellulosic material according to the character of each mineral element.

Keywords: *Arabica coffee, lignocellulosic material, mineral element, polyphenol.*

INTRODUCTION

Arabica coffee is one of the plantation crops which is generally cultivated at an altitude of more than 1000 meters above sea level. Some farmers in Jember regency try to grow arabica coffee at an altitude of lower than 1000 meters above sea level so that the potential of leaves rust attack (1). In general, the plant has a natural resistance to disease. Plant health is key in increasing natural resistance through forming or compound production like polyphenols, lignin, cellulose, and other compounds.

Each mineral element has the specific potential to increase a plant's natural resistance. The nature of resistance provided by these nutrients is induction (resistance that occurs due to adding a nutrient). The previous research described that the mineral elements of iodine, calcium, and potassium could reduce the incidence of leaf rust disease in arabica coffee grown at an altitude of 460 meters above sea level (lowland) (2). The result of research stated that the application of silica has a positive effect on reducing cocoa pod borer attacks (3). Boron's role in increasing cacao seedlings' natural resistance to vascular streak dieback attacks (4). These studies indicate that several mineral elements can potentially increase plants' natural resistance, but it has yet to be known which minerals play a more dominant role.

Seedling phase is the right phase to seek preventive treatment, so plants are not susceptible to disease. In this phase, arabica coffee seedlings can be manipulated so the plants can become stronger and not easily infected with diseases. Healthy seedlings are one of the determining factors for the production of the coffee plant. Some potential minerals, like silica, boron, calcium, potassium, and iodine, have increased the plant's natural resistance. Each mineral element can increase the natural resistance of plants through a different mechanism. The mechanisms shown by these elements, such as strengthening the cell wall by forming a new layer, thickening of the cell wall due to the integration of calcium with pectin in the middle lamella of the cell, the phytotoxic effect caused by iodine to inhibit the pest attack, production of polyphenols and various other mechanisms. These potential minerals need to be tested as precursors to induce natural resistance in arabica coffee seedlings.

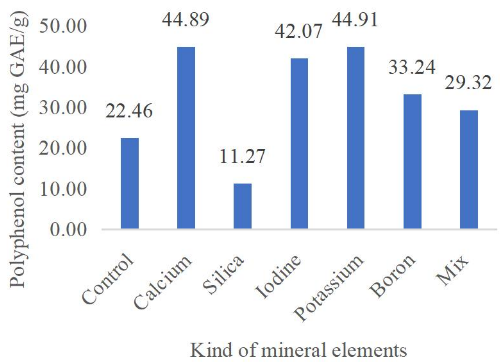
MATERIAL AND METHODS

The experiment was conducted at the greenhouse Faculty of Agriculture Jember University (an altitude of 83 meters above sea level/lowland) from May until December 2018. The experiment was designed using Randomized Complete Block Design (RCBD) with 4 replications. The experimental unit that was used was 5th month old Komasti arabica seedlings. Coffee seedlings were treated with various mineral elements, namely control (without the addition of mineral element), silica 150 $mg.L^{-1}$, boron 300 $mg.L^{-1}$, iodine 300 mg $mg.L^{-1}$, calcium 3.000 $mg.L^{-1}$, potassium 20.000 $mg.L^{-1}$, and mix/combination of the fifth minerals. Each concentration used is the optimal concentration based on literature studies that have been carried out. The applications were carried out by foliar feeding technique 5 times with an interval of every 7 days. Plants were then incubated for about 30 days for metabolic adjustment. The observation of potential plant resistance focused on secondary metabolites like polyphenols (using a standard of gallic acid) and forming of lignocellulosic materials (using Chesson methods.

The sample used is the youngest expanded leaves of coffee seedlings. The data analysis was carried out with the analysis of variance (ANOVA) to determine the effect of the treatment. The analysis then continued using Duncan's Multiple Range Test (DMRT) at 95% significance level to describe which treatment is more affected by observed variables.

RESULT

The data generated from this experiment show that the induction using various minerals elements is significantly different from the polyphenol content. The highest polyphenol production was stimulated by potassium reaching 44.91 $mg.g^{-1}$, but it was not different when compared with the induction caused addition of calcium and iodine minerals (Figure 1).



Note: All means which are followed by the same letter are not significantly different based on DMRT at 95% significant level.

Figure 1. Polyphenol content of arabica coffee leaves after treatment

The highest cellulose content in plants induced by silica reached 29.91% per gram dry weight of arabica coffee leaves, but not significantly different from the effect of iodine which also reached 29.21% of cellulose (figure 2).

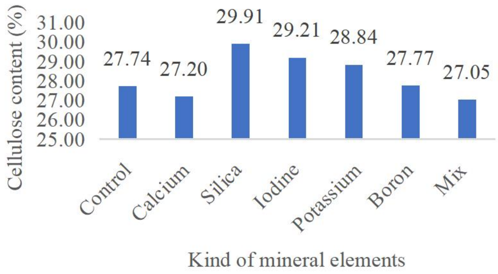


Figure 2. Cellulose content of arabica coffee leaves after treatment

The calcium and potassium induce the highest hemicellulose content. It reached 13.30% and 13.12% per gram dry weight of arabica coffee leaves, respectively (figure 3). The highest lignin content was produced due to the induced effect of potassium reaching 23.09% (figure 4). it was 1.55% higher than lignin produced by the control treatment.

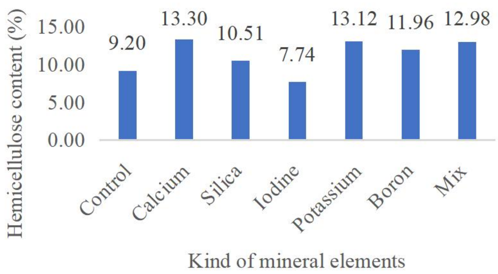


Figure 3. Hemicellulose content of arabica coffee leaves after treatment

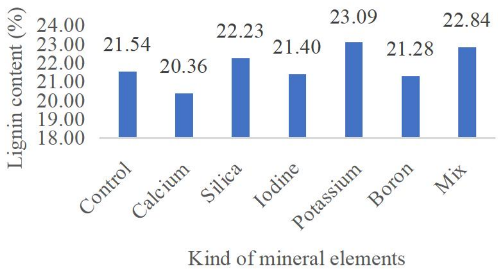


Figure 4. Lignin content of arabica coffee leaves after treatment

DISCUSSION

Leaves are the most important organ of plants. The role of leaves as photosynthetic organs greatly determines plant growth and productivity. Leaves in arabica coffee plants also determine the plant's productivity, so the leaf damage caused by pests or others needs to be controlled. Sufficient minerals can help plants recover when damage occurs (both caused by biotic and abiotic factors) because it forms a natural resistance system, or the plant immunity can go well. The forming of secondary metabolites such as polyphenols also has been reported to increase the natural resistance of plants (2,3,4). The experimental result shows that adding minerals element has a significant effect on the production of polyphenols in arabica coffee leaves (figure 1). The polyphenols content induced by calcium, iodine, and potassium minerals was higher than the induction of other elements. They were not significantly different based on DMRT (α 5%) reaching the range of 42.07 mg.g-1 up to 44.91 mg.g-1.

The three minerals have different mechanisms for producing polyphenols in the plant. Calcium in the plant is important in maintaining cell membrane stability. Calcium is associated with pectin to form calcium pectate (Ca-pectate) in the middle lamella, which makes the cell wall stronger. This calcium pectate could also function as a sensor when the plants are disturbed (by abiotic or biotic factors) (5). The availability of calcium in the plant can stimulate the synthesis of polyphenols as a signal response that can be expressed simultaneously so that the plants form defense proteins (6). The highest hemicellulose production also supports it reached 13.30% compared to other minerals elements (figure 2). The hemicellulose content in leaves can strengthen plant cell walls (6), thereby increasing the plant's natural resistance.

Iodine is a nutrient that plants need in small amounts. Therefore it is classified as a microelement. Iodine accumulation in the plant can be detrimental when it is found in excess amounts. Iodine in plants can be phytotoxic, which causes little stress. The stress can be caused the production of polyphenols in plants to be higher (7). It reached 19.61 mg.g-1 than the control (figure 1). The increase in the production of polyphenols can potentially increase natural plant resistance.

Potassium in a plant is required in large amounts. Potassium availability can affect various metabolic processes, such as the opening and closing of stomata, acting as an enzyme activator, water distribution, accumulation, and translocation of photosynthate. Potassium also plays a role in increasing plant resistance to disturbance (8). Potassium could synthesize compounds with low and high molecular weights. Polyphenols are low molecular weight compounds. The polyphenols produced due to the addition of potassium reached 22.91 mg.g-1, almost twice from control. The availability of potassium in sufficient quantities can be a precursor for forming compounds with high molecular weight (9). It means the low molecular weight compounds (such as polyphenols) will be converted into carbohydrates, proteins, and lignocellulosic materials (such as lignin). The result showed that the lignin content stimulated by potassium reached 23.09% per gram dry weight of arabica coffee leaves, 1.55% higher than the control (figure 4). The plant's accumulation of polyphenol compounds would form a phenol polymer called lignin (10). It is also reflected in the lignin content induced by potassium which reaches 23,08%. Potassium also plays a role in tissue lignification activity, especially in sclerenchyma (11).

Figure 2 shows that the highest cellulose produced by silica reached 29.91%. Silica is a beneficial element that plays a role in the natural resistance of plants. The addition of silica in plants can stimulate an increase in the association of silica with cellulose to form the silica-cellulose bonds in plant cell walls. Silica enters through the leaf stomata and is then transported by vascular vessels (xylem) to the cortical cells. The accumulation of silica in the cortical cells causes a higher concentration of silica in the cortical cells, so that silica polymerization occurs and becomes silica gel form and $SiO2$, which has an irregular shape (amorph). Silica gel formed is hydrolysis to facilitate the transport of the xylem to leaf epidermal cells, which are carried by simplast through transpiration flow. The silica polymer is deposited on the leaf's epidermal cell, which also contains a cellulose layer for resistance. This integration of silica and cellulose in the epidermal tissue gives two layers of resistance that can increase the plant's natural resistance (12,13). The cellulose content in plants which reached 29.21%, was also affected by the addition of iodine (figure 2). It means that adding iodine can produce high polyphenols and cellulose (figure 1).

Boron plays a role in facilitating the polymerization of glucose to become cellulose to thicken the cell wall so that the plants become more resistant (14). Boron acts as a constituent of the plant's cell wall so that plants become stronger (4). The addition of boron in this experiment resulted in lower polyphenol, hemicellulose, and lignin content compared to the addition of other elements, but it is still higher than the control. It means boron also has the potential as an inducer element of plant's natural resistance but compared to other tried elements, it produces a lower response.

Adding a mixed solution of various elements also increased the polyphenols content, hemicellulose, and lignin compared with the control, but the response became lower when compared to a single mineral element. It is presumed to be a reaction between the elements shortly after mixing.

CONCLUSION

Adding single mineral elements in the form of calcium, iodine, and potassium can potentially increase plants' natural resistance through the production of polyphenols compounds, lignin, cellulose, and hemicellulose in plants.

ACKNOWLEDGEMENT

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