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Effectiveness of Humic Acid Application on Growth of Coffee Seedings

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Abstract

Soil fertility is an important aspect to consider in a plantation because it can affect plantation productivity. Furthermore, degradation of soil fertility issue is increasing therefore it needs innovation to improve soil fertility. Humic acid is an alternative material which can be used for improving soil fertility and supporting plantation production. This research objective was to investigate the effectivenes of humic acid for growth of coffee seedlings. This research was done in Indonesian Coffee and Cocoa Research Institute green house. Experiment used completely randomized design trial with two factors. First factor was the materials used humic acid, coffee pulp compost, and manure. Second factor was doses of materials: 0 g, 10 g, and 30 g per 2 kg dry soil. Research parameters used plant height, number of leaves, stem diameter, wet weight, soil carbon, N, P available, K available, and pH analysis. The results showed that humic acid 30 g significant increasing plant height and K available. Furthermore, humic acid dose 10 g and 30 g resulted root, stem diameter, and leaves weight were better than compost from coffee pulp and manure. Soil carbon was increase after humic acid, compost from coffee pulp, and manure application. Humic acid, compost from coffee pulp, and manure made soil pH were stabile.

Keywords: Humic acid, soil, fertility, coffee, coffee pulp, compost, manure

INTRODUCTION

Soil fertility is a very important aspect in plantation farms. Low capacity of soil fertility can affect plantation production. Coffee is one of the plantation commodities in Indonesia, and as a perennial crop spread evenly in Indonesia. Development of coffee in Indonesia requires more attention on soil fertility because not all regions have good soil fertility for coffee growth. Sustainable coffee is needed to minimize environmental damage and to improve land quality. Pujiyanto (2016) reported that the total damage area of coffee plantation tended to increase every year. This is suspected due to the low improvement of land quality. A land can be improved by using eco-friendly materials to replace inorganic fertilizers. Thus, good improvement of land quality can be achieved.

Humic acid is one of the environmentally friendly soil stabilizers and can be used for the improvement of land quality. Humic compounds are dispersed colloidal which have amorphous, in brownish or blackish yellow, and have high molecular weight (Tan, 1993) and are resistant to microbial degradation (Stevenson, 1982). The content of humic acid is composed of the elements of carbon by 40-60%, oxygen by 30-50%, nitrogen by 1-4%, sulfur by 1-2%, and phosphor by 0.3% (Mohadi *et al.*, 2008). The use of humic acid by 15 L/ha can boost

cassava growth and production significantly (Baskoro, 2010). In addition, humic acid by 15 L/ha could increase rice production (Ihdaryanti, 2011). A research focusing on humic acid that is derived from *Thitonia* and *Gliricidia* can reduce the concentration of Al significantly, however, it is reported that *Thitionia* material could lower the concentration of Al on Ultisol more quickly compared with humic acid that is derived from *Gliricidia* (Wahyudi *et al* ., 2010).

Humic acid that is combined with urea and applied to rice plants is reported to significantly improve the N $NH4^+$ on the 28 days after planting (DAP) and the $NO3^-$ on the 42 DAP, this has improved the rice growth than pure urea treatment (Suntari *et al.*, 2015). Fauziah (2009) showed that the use of humic acid and active compost is able to improve the chemical properties of tailing and increase the availability of nutrients for *Enterolobium cyclocarpum* and *Altingia excelsa*. The results of the above studies prove that humic acid has many benefits and even Zimmer (2011) stated that one of the benefits of humic acid is the capability to increase the resilience of crops from diseases. There are many researches focusing on humic acid but there still no research that takes coffee plantations into account so that the benefits derived specifically for coffee have not been known. Based on the background, this research is important to determine the effect of humic acid effectiveness on the growth of the coffee.

MATERIALS AND METHODS

The study was conducted in a greenhouse of Indonesian Coffee and Cocoa Research Institute in August 2016 to January 2017. This study was performed by using a completely randomize design. The first factor used was the dose of 0 g; 10 g ; 10 g; and 30 g/2 kg of soil. The second factor was type of organic material such as humic acid, coffee pulp compost, and cow manure. Each treatment combination was repeated three times, and each consisted of three seedlings of coffee.

Humic acid is obtained from coffee pulp compost by using the following procedures (Leenheer & Rostad, 2004): clean samples of coffee pulp compost as much as 1 kg which has been dried and sieved to 2 mm were prepared in advance. Thereafter, 5 L NaOH 0,1 N is mixed into the coffee pulp compost. Until it became homogenous approximately for 30 minutes. Furthermore, the compost is allowed to stand for 24 hours at room temperature to separate the humin, humic, and fulvic. The next stage is to separate the humic and fulvic solution by using a solution of one L H_2SO_4 5N. The humic and fulvic are homogenized with one L H_2SO_4 5N and mixed evenly and then allowed to stand for 24 hours. The humic is obtained from the extracts of filtered material by using Whatman filter paper. The residue filtered in Whatman paper is then taken and dried.

As for the comparative materials, coffee pulp compost and cow manure were obtained from the composting process in Kaliwining Experimental Station, Indonesian Coffee and Cocoa Research Institute. The soil media used was glei humic soil while the coffee seedlings used were the Arabica coffee of Andungsari 1 clone.

Table 1. Analysis of humic acid, coffee pulp compost, and cow manure

Materials	C (%)	C/N	Reference
Humic acid	34.5	28.7	Lab test
Coffee pulp compost	29.7	16.5	Lab test
Cow manure	39.3	22.0	Lab test

Humic acid, coffee pulp compost, and cow manure were sieved to remove impurities and to homogenize the size. Then, the polybags were filled with dry soil that passed the 2 mm sieve. Soil and organic materials

were mixed according to a combination of the prescribed treatments. The seedlings of Arabica coffee of Andungsari 1 had previously been planted in the seedling nursery and after 2 months, the coffee seedlings were selected based on the growth to be moved to polybags according to each treatment. The watering was done twice in a week and the moisture level was kept until it was ready to the condition of field capacity. The treatment and fertilization were done according to the coffee seedling standard. At the end of the experiment, coffee seedlings were measured in diameter, height, and number of leaves. The final data were analyzed statistically by using Duncan Multiple Range Test in order to analyze the significant difference between treatments.

RESULTS AND DISCUSSION

The effectiveness of the humic acid addition on the growth of coffee seeds is very different because of its dosage or other materials.

The growth of coffee seedling applied with humic acid, coffee pulp compost, and cow manure showed that the height of the plant significantly inccreased in the addition of 30 g of humic acid. Application of humic acid by 30 g increased root growth more than the root weight, it was applied with coffee pulp compost and cow manure (Figure 2a). Humic acid can increase plant height because it works directly to plant metabolism by bringing humic acid to plant tissues (Vaughan & Malcom, 1985). Humic acid has positive effect on plants because it can improve the ability to retrieve and exchange the nutrients and water to support the enzymatic metabolic processes as well as the formation of plant tissues (Hermanto *et al*., 2013).

Figure 2a shows that the giving of humic acid and manure at a dose of 0.10 g and 30 g had a different effect on the fresh weight of plant roots. In this study, lower wet weight was obtained with a dose of compost by 30 g than the dose of 10 g. However, it was still higher than control. Higher dose of humic acid and manure (30 g), higher fresh weight of roots. However, from Figure 2a, it is shown that the application of humic acid by 30 g has the highest weight of roots compared to the manure with the same dose. Figure 2a shows that the addition of humic acid doses will improve the wet weight of the roots. Chen & Aviad (1990) stated that the addition of humic acid could increase the growth of roots than the shoot. These experiments, then, demonstrate that a dose of 30 g of humic acid can stimulate the higher growth of the roots than 10 g of humic acid or coffee husk compost and cow manure. With a high wet weight of roots, this also explains the number of roots after the addition of humic acid. Roots are one of the cores in the plant because it is able to absorb more optimal nutrients. Humic acid has a direct role in the growth of the plant, one of which is to stimulate

Table 2. The growth of coffee seedling after 5 months humic acid application

Treatment	Plant height, cm	Leaf number	Stem diameter, mm
Humic acid 0 g	21.6 a	19 a	5.69 a
Humic acid 10 g	25.6 abcd	26 ab	6.32 a
Humic acid 30 g	28.6 cd	27 ab	6.14 a
Coffee pulp compost 0 g	29.8 d	31 b	6.10 a
Coffee pulp compost 10 g	25.9 abcd	33 b	6.36 a
Coffee pulp compost 30 g	27.5 bcd	35 b	6.19 a
Cow manure 0 g	23.7 ab	30 b	5.90 a
Cow manure10 g	23.7 ab	31 b	5.84 a
Cow manure 30 g	24.7 abc	29 ab	5.91 a

Note: Figures in the same colum followed by the same letter(s) are not significantly different accurding to Duncan test at 5%.

the development of roots. The improvement of wet weight of roots can occur because humic acid also contains auxin hormones that are able to stimulate root growth (Suwardi & Wijaya, 2013). Research conducted by Sinuraya (2010) mentioned that the weight of the palm-tree root is erect higher than the weight of the palm-tree root that is sloping and falling on the peatland. This shows that root weight is very influential on plant growth. Upright plants will support plant physiology and metabolism so that the growth is more optimal. This is in line with the research of Gholami *et al*. (2013) that the giving of humic acid to *Plantago ovate* in the saline soil can reduce the crop stress through the mechanism of the nutrients absorption enhancement and the changes of plant physiology.

The wet weight of coffee seedlings is shown in Figure 2. It is seen that the fresh weight of the stem increased with the addition of humic acid dose, coffee pulp compost, and manure. This indicates that the addition of these three materials gives a positive response. However, the response is very visible on the coffee stems applied with humic acid, this is due to the fact that the weight is different with the control in addition of humic acid by 10 g and 30 g. Coffee pulp compost and manure also able to rise the fresh weight of the stem but not as high as the weight of the humic acid materials. This suggest that humic acid is better at improving the fresh weight of coffee seedlings compared to coffee pulp or manure compost. The increase of fresh weight of the stem is very useful because it describes the formation of the plant tissue that is useful for plant metabolism. Vaughan & Malcom (1985) stated that the effect of humic acid is generally more noticeable in the growth of roots in comparison with the growth of shoot.

Based on Figure 2c which shows the fresh weight of coffee leaves after five months of application of humic acid, coffee pulp compost, and manure, it can be seen that humic acid and manure can increase the weight of fresh leaves compared to the controls. However, coffee pulp compost by 10 g has generated a decline in number of leaves. This is because the treatment of coffee pulp compost by 10 g has caused a fall in coffee leaves. Nevertheless, as seen from the type of materials (humic acid, coffee pulp compost, and manure), it appears that a dose of 30 g coffee pulp compost has produced more leaves than other materials.

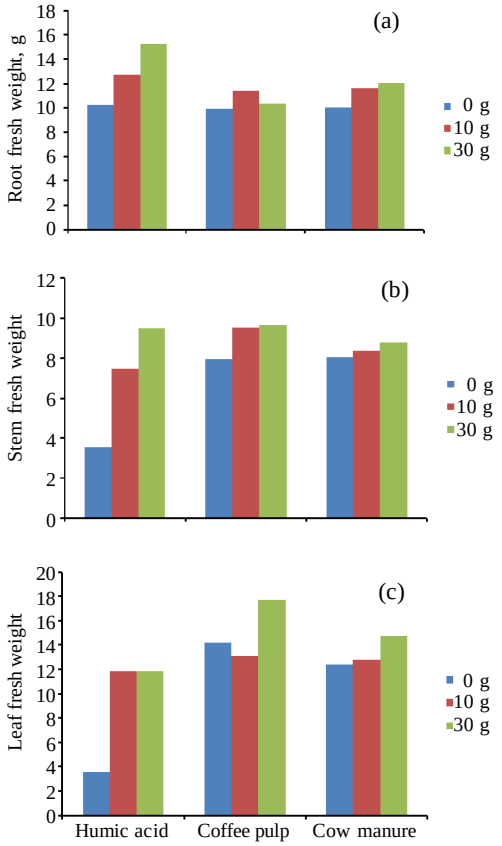

Figure 2. Root (a), stem (b), and leaf weights (c) of coffee seedlings after 5 months application of humic acid

Baskoro (2010) reported that humic acid tends to improve the growth and production of cassava better than plant residue even though both of the materials seem to have significant growth and production. This proves that humic

acid can be an alternative for better organic manure. Setyowati *et al*. (2007) also added that humic acid in the optimum pH of 6 can absorb 72,90% aluminum ion. This showed that the optimum pH of humic acid can help to boost the absorption of ions in the soil.

The results of soil analysis after the treatment of humic acid are shown in Table 3. It appears that the application of humic acid, coffee pulp compost, and cow manure in the dose of 10 g and 30 g could increase the organic C of soil. The increase in the organic C of soil is obtained in the highest humic acid treatment at a dose of 10 g. Thus, it shows that the dose of 10 g humic acid can increase the organic C of soil effectively.

Humic acid can increase the nutrient content of the soil. The content of N is increased with the addition of 10 g humic acid and is declined in the dose of 30 g and coffee pulp compost of 10 g. The application of cow manure in the dose of 10 g and 30 g could increase the nitrogen in the soil. The results showed that the increase in soil nutrients still not significant, however, it appears that the addition of humic acid by 10 g is able to increase the nitrogen in the soil. Unlike the case with organic C and nitrogen in the soil, the phosphor is increased due to the application of 10 g humic acid and coffee pulp compost and cow manure by 10 g and 30 g. A decline in phosphor content happened in the treatment of humic acid by 30 g. This decline may occur presumably due to more phosphor is absorbed for the plant because the fresh weight of the roots shows a higher value than other treatments. The result of soil analysis of potassium is different from other nutrients. This appears that the application of humic acid by 30 g which able to increase the potassium in the soil. Utami *et al*. (2007) argued that one of the roles of humic acid is to increase the cation exchange capacity so that more nutrients could be available for the plant. Therefore, the dose of 30 g of humic acid in this study is suspected to contribute to the availability of potassium in the soil. Potassium is a highly volatile nutrient element. In contrast with the addition of 30 g of humic acid in the soil, the ionic bond is getting stronger thus increasing the available potassium in the soil. Humic acid is a stable compound and resistant to microbial degradation (Stevenson, 1982). The pH of humic acid, coffee pulp compost, and cow manure are not much different from the control at 6.3 to 6.5 because the organic materials are functioned as a buffer so that an addition of organic materials will not affect any changes in soil pH. In this study, the range of pH is good for coffee plants because it can absorb the nutrients in the soil optimally. Thus, the material in this research is good to produce soil pH. Humic acid seems to be better because it significantly increased the plant height. Humic acid response is better than coffee or manure compost because humic acid is more stable and resistant to microbial degradation. Unlike the case with coffee pulp compost or manure which are the organic material that could be destroyed by microbe easily.

Table 3. Soil analysis after humic acid application

Treatment (Dose/2 kg tanah)	Organic C, %	N, %	Available P, mg/kg	Available K, cmol/kg	pH H_2O
Control	1.18	0.22	87	1.03	6.4
Humic acid 10 g	1.28	0.24	96	0.66	6.5
Humic acid 30 g	1.22	0.21	79	1.6	6.5
Coffee pulp 10 g	1.20	0.20	100	0.85	6.3
Coffee pulp 30 g	1.24	0.23	96	0.7	6.4
Cow manure 10 g	1.25	0.23	101	0.77	6.4
Cow manure 30 g	1.19	0.23	99	0.62	6.4

CONCLUSIONS

Humic acid in amount of 30 g could improve the growth of coffee significantly. In addition, humic acid in the dose of 10 g and 30 g could produce better fresh weight of root, stem, and leaves than the coffee pulp compost and manure. The organic C of soil increased after the addition of humic acid by 10 and 30 g. Potassium content increased by the addition of 30 g of humic acid. Humic acid, coffee pulp compost, and manure are able to stabilize the soil pH.

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