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Improvement of Ultisol soil fertility under pineapple plantation using banana Cavendish rotation in Central Lampung, Indonesia

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Abstrak: The rotational planting was applied as the result of decreasing the number of pineapple production. The decreased pineapple production is influenced by soil fertility measured from the chemical, physical, and biological aspects. This research was conducted to comprehend the potential of rotational planting. This research was conducted by taking samples from three different locations: PC pineapple (the first plant), RC Pineapple (Ratoon Plant), and bananas after harvest. Samples were taken at a depth of 0-20 cm and 20-40 cm. The research was conducted from November 2015 until February 2016 at Central Lampung. This research found that rotating the planting between the pineapple and the banana can improve soil fertility. After harvest, bananas' location has soil pH, total nitrogen, C-organic, phosphorus available, and potassium available is higher if compared to PC pineapple and RC Pineapple location. This was based on the fact that the soil of the harvestable banana (4.74) has better pH compared to the two locations, PC pineapple (4.54) and RC pineapple (4.09). This resulted from a larger amount of dolomite given to the harvestable banana's soil than those from the PCs and the RC's. Its pH can also influence its OH^- and other nutrients within the soil. From the explanation above, it can be concluded that the soil of harvestable banana (ex-banana) has a better quality to increase the production of pineapples.

1. Introduction

Pineapple production in Lampung has decreased in 2013 (722,621 t), 2014 (560,036 t) and 2015 (534,774 t). One factor that influences the decline of the production of pineapple is the decrease in soil fertility. Decreased soil fertility is suspected because of the intensive use of chemical fertilizers and pineapple plants planting every year [18]. Ramadhani and Nuraini [1] explained that the panting of pineapple plant monoculture every year had lower nutrient availability (C-organic (2.38%) and pH (4.62)) compared to planting polyculture plant (C-organic (4.03%) and pH (5.8)). Besides, the decrease in soil fertility is also caused by Lampung province has Ultisols soil type. Ultisol pH of topsoil is 4-6.5, poor content of P, Ca, Na, K, Mg, and high saturation of aluminum (>60%) [1,3]. This acidic soil pH lowers soil fertility and health. The efforts to increase soil fertility at PT. Great Giant Pineapple is the use of chemical fertilizers, the addition of cow dung compost, and the return of pineapple leaves to the land. Rahman and Zhang [2] explained the longterm use of inorganic fertilizers can cause soil degradation and can reduce crop productivity. The use of inorganic fertilizers can reduce soil biological activity and can cause environmental pollution [3].

PT. Great Giant Pineapple has added cow dung compost to improve soil fertility. However, the problem is the low availability of compost that cannot be full fill by the company's. One solution provided that it does crop rotation. The crop rotation applied is the Cavendish banana plant. Supriyadi [4] explained that the effort to increase the biomass in the soil can be conducted by rotating crops. Thirdyawati et al [5] explained that the crop rotation can increase crop yields, maintain soil quality, control diseases, pests, weeds, and insects, increase soil biota nutrition, increase organic matter, and increase nutrients in the soil. One of the company of choice is, rotation with cavendish banana crop can increase the company's revenue. Santos et al [6] reported that the banana weevils can be used as organic fertilizers because it contains nutrients for plants. The banana weevil has nutrients and microbes that plants need to supply nutrients. The banana weevil has *Azospirillium* sp, *Aspergillus nigger* dan *Azotobacter* sp to improve plant roots, therefore affecting nutrient absorption. Inrianti et al [7] explained that the banana weevil containing microbes decomposing organic matter. These decomposing microbes are located on the outer and inner banana weevil. Species of microbes that have been identified in banana weevil include *Bacillu*s sp, *Aeromonas* sp, and *Aspergillus nigger*. This is the microbes decomposer organic matter. Banana weevil amounted to 66,2% carbohydrates of 100 g of material. High carbohydrate will stimulate the development of microorganisms. Therefore, it is necessary to conduct research related to Cavendish banana plants' rotation potential to improve soil fertility in ultisols at PT. Great Giant Pineapple.

2. Materials and Methods

The study was conducted in November 2015 at PT. Great Giant Pineapple, Terbanggi Besar of Central Lampung. Soil chemical analysis is carried out in the cogen laboratory in PT. Great Giant Pineapple. The analysis performed are pH (*a glass electrode*), Total N (*Kjeldahl*), C-organic (*Walkley and Black*), Available P (*Bray* 1), and Available K (*Ammonium Acetate* 1 N). This research uses a survey method using a free grid method. This research was conducted by taking samples from three different locations: PC pineapple (the first plant), RC Pineapple (Ratoon Plant), and bananas after harvest. Samples were taken at a depth of 0-20 cm and 20-40 cm. Pineapple locations are taken based on production with ranges 50 – 65 t ha^{-1}. Processing of data results using boxplot charts. This is because it is to determine the distribution of nutrient content between locations. The use of the boxplot can determine the lowest average of data and the highest average of data.

3. Results and Discussion

3.1. Soil pH

The data results show that the bananas after harvest locations have a higher soil pH than the two locations. Budiyani et al [8] explained that the location of bananas has sourced microorganisms local in banana weevil. Ole [9] explained that banana weevil has a high nutritional content with carbohydrates (66%) and protein content (4.35%); it is an organic matter source. Anwar et al [10] explained that the increase in soil pH is associated with the presence of microbial activity that produces organic acids during biodegradation. Rosalina and Kahar [11] reported that the organic matter in soil comes from plant and animal residues. Ogbomo and Osaigbovo [12] state that the organic matter can balance nutrients and reduce soil acidity. Carbohydrate content can be used as a substrate for microorganisms. The substrate can increase the activity of microorganisms. The microbial activity produces citric acid with a charge $COOH^-$, which indirectly increases soil pH [1].

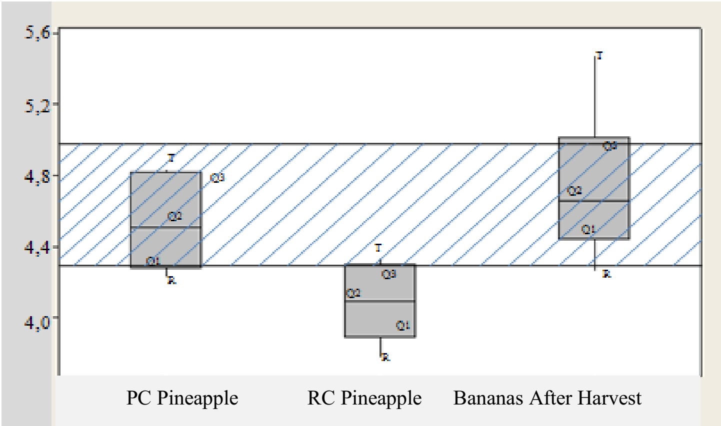

Figure 1. Diagram of soil pH between locations

Information : Q1 = *Quartile* 1, Q2 = *Quartile* 2, Q3 = *Quartile* 3, T = highest value, R = lowest value,
= standard for pineapple needs

3.2. Total Nitrogen

The data results show that bananas after harvest locations have higher total nitrogen than the two locations. This is because the bananas after harvest location have a higher pH than other locations. Ramadhani and Nuraini [1] explained that the nutrient availability in the soil is influenced by soil pH. Organic matter can balance nutrients and reduce soil acidity [12]. The microbes that have been identified in banana weevils include *Bacillus sp*., *Aeromonas sp*., and *Aspergillus nigger* [7]. Broto et al [14] explained that the bacteria in banana weevil can bind N_2 from the air and converting it to ammonia so that nitrogen in the soil is maintained and fertile. Ramadhani and Nuraini [1] reported that the increased nitrogen in the decomposition process by microorganisms changes in organic matter into CO_2 + H_2O + nutrients + hummus + energy. During the decomposition process, CO_2 evaporates, causing carbon to decrease, and nitrogen in the soil increases.

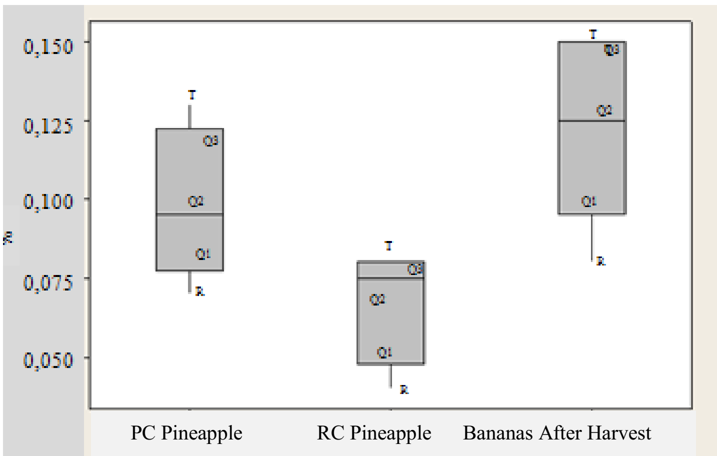

Figure 2. Diagram of soil Total N between locations

3.3. C-organic

The data results show that the bananas after harvest locations have a higher organic carbon than the two locations. This is because banana weevils have microorganisms that can help the process of decomposition. Inrianti et al [7] explained that the microbes that have been identified in banana weevils include *Bacillus sp*., *Aeromonas sp*., and *Aspergillus nigger*. This is common microbes decompose organic matter [13]. Organic material is a natural substrate used by microorganisms and can provide nutrients for plants [1]. Banana weevils can be used as organic fertilizers because it contains nutrients for plants [6]. The banana weevil has nutrients and microbes that plants need to supply nutrients.

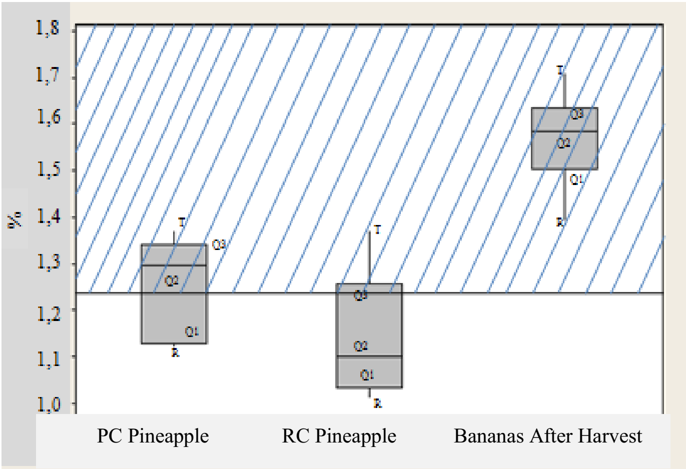

Figure 3. Diagram of soil organic C between locations

3.4. Available P

The data shows that the highest phosphorus available is at the bananas after harvest locations. This is because bananas after harvest locations have a higher soil pH compared to the two locations. The acid soils have high Fe and Al, so phosphorus is very easy to form complex bonds and is difficult to available [15]. Sharma et al [16] reported that the organic acids produced from microorganisms then react with the phosphate bonds of Al^{3+} and Fe^{3+}, which form organic bonds so that they can dissolve the phosphate. Other than that, Banana weevil has nutrients and microbes that plants need to supply nutrients [6]. Inrianti et al [7] reported that the banana weevil has phosphorus (60.0 mg), carbohydrates (11.60 g), and calcium (15 mg). Banana weevil containing microbes decomposing organic matter. Aini et al [17] state that the banana weevil is the main ingredient to accelerate the composting of organic material into compost to provide nutrients for plant.

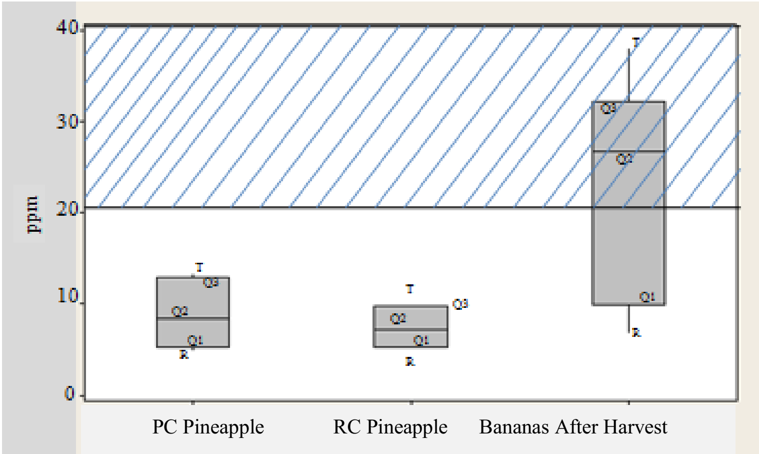

Figure 4. Diagram of soil available P between locations

3.5. Available K

The highest soil potassium content is found at the bananas after harvest locations. The increased potassium in soil is caused by soil pH. On acid soils will make the concentration of K^{+}, Na^{+}, Ca^{2+}, and Mg^{2+} to be low [15]. Bananas after harvest locations had a higher soil pH than the two locations, so that bananas after harvest locations have a higher potassium content if the compared two locations. The addition of organic matter can increase K^{+}, Ca^{2+}, and Mg^{2+} [12].

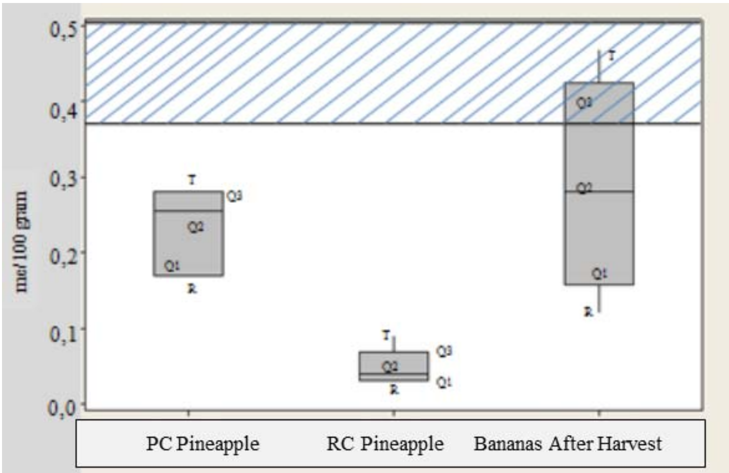

Figure 5. Diagram of soil available k between locations

4. Conclusion

The results showed that the bananas after harvest locations had higher nutrient (soil pH, total nitrogen, organic carbon, available P and available K) if PC pineapple (the first plant) and RC Pineapple (Ratoon Plant) location. Bananas after harvest locations had soil pH (4.74), total nitrogen (0.13 %), organic carbon (1.57%), available P (23.24 ppm), and available K (0.29 me/100 g). PC pineapple (the first plant) had soil pH (4.54), total nitrogen (0.1%), organic carbon (1.26%), available P (8.79 ppm) and available K (0.24 me/100 g). RC Pineapple (Ratoon Plant) had soil pH (4.09), total nitrogen (0.08 %), organic carbon

(1.14%), available P (7.34 ppm) and available K (0.05 me/100 g). Therefore, crop rotation with the Cavendish banana plant was able to increase soil fertility at PT. Great Giant Pineapple. Besides being able to increase soil fertility, crop rotation can reduce the use of chemical fertilizers at the next planting time.

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