The Utilization of Liquid Smoke and Ameliorant From Empty Palm Bunches on Soil Chemical Properties, Growth, and Production of Hiyung Cayenne Pepper in Swamp Land

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Abstract. The growth of oil palm land area causes an increase in palm oil waste produced. The potential of EFB waste has significant economic value, one of which can be used as a material for making liquid smoke and ameliorant to overcome soil fertility problems, especially soil in swamplands. This research aims to examine the interaction effect of the application of liquid smoke and TKKS waste ameliorant on changes in soil chemical properties, growth, and production of hiyung cayenne pepper in swamp land. The method used in this research is the Divided Plot Design. Main Plot (A) is a liquid smoke pesticide that consists of five levels (concentrations), namely ao = 0 m L L $^{-1}$, a1 = 10 m L L $^{-1}$, a2 = 15 m L L $^{-1}$, a3 = 20 m L L $^{-1}$ water, and a4 = 25 m L L $^{-1}$. Subplot (B) of the best TKKS ameliorant from phase one research which consists of five levels (measures), namely bo = 0 t ha $^{-1}$, b1 = 5 t ha $^{-1}$, b2 = 10 t ha $^{-1}$, b3 = 15 t ha $^{-1}$, and b4 = 20 t ha $^{-1}$. The combination of treatments tried was 25 treatments, each treatment was repeated 3 times, so that in this study there were 75 experimental units. The results of the research showed that the interaction effect of the application of liquid smoke and TKKS waste ameliorant was on the parameters of plant wet weight, plant dry weight, root wet weight, and root dry weight of hiyung cayenne pepper. Treatment a1b2 (5 mL liquid smoke + 10 t ha $^{-1}$ ameliorant EFB) best increases plant wet weight, a2b2 treatment (10 mL liquid smoke + 10 t ha $^{-1}$ ameliorant EFB) best increases plant dry weight, treatment a1b3 (5 mL liquid smoke + 15 t ha $^{-1}$ ameliorant TKKS) best increases the wet weight of the roots and the dry weight of the roots of hiyung cayenne pepper in swamp land.

Keywords: Land Amelioration; Suboptimal Land; Sustainable agriculture; Eco-Friendly Agriculture

1. Introduction

Over the last five years (2014-2018), the area of oil palm plantations in Indonesia has continued to increase with an average growth rate of 7.89% except in 2016 the area of oil palm plantations experienced a slight decrease of 0.5% or decreased by 58,811 h

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a. From 2014 to 2018, the total area of oil palm land increased by 3,571,549 ha (Directorate General of Plantations, 2020). With the growth in oil palm land area, there has been an increase in the production of Fresh Fruit Bunches (FFB) and Crude Palm Oil (CPO), which has resulted in a high potential for development of the palm oil industry. However, on the other hand, it can lead to an increase in palm oil waste that has not been utilized as a commodity with economic value. The problem that arises from the palm oil industry is the abundance of factory waste. Each factory with a capacity of 60 t at ^{1} o'clock can process FFB up to 1000 t day $^{-1}$ (Rahardjo, 2009). Processing FFB into CPO produces waste including 23% empty oil palm bunches (TKKS); 6.5% shell and 13% fiber (Directorate General of Plantations, 2020). Processing one t of FFB will produce EFB of 22-23% or 220-230 kg (Haryanti *et al*., 2014). EFB is a solid waste that is discarded from separating boiled bunches from the fruit (Kamal, 2014) whose amount continues to increase, and is still not utilized properly (Sari *et al* ., 2018). TKKS contains quite high levels of nutrients and organic material which can be used as fertilizer and materials that can increase soil fertility by improving the physical, chemical, and biological conditions of the soil (Toiby *et al* ., 2015). The benefits of EFB include increasing cation exchange capacity, and soil pH, containing the nutrients N, P, K, and Mg, and can act as mulch and increase soil microbial activity (Gandahi & Hanafi, 2014).

The potential of EFB waste has significant economic value, one of which is that it can be used as an ameliorant material to overcome soil fertility problems, especially soil in swamplands (Aryanti *et al*., 2017). Ameliorant is a material that can increase soil fertility by improving the physical and chemical conditions of the soil, by adding ameliorant materials such as compost, manure, lime, and natural phosphate (Armani *et al*., 2018). Providing ameliorant will impact increasing fertilizer efficiency and soil pH because synergistically it will affect improving plant growth (Istina *et al*., 2014) such as improving the root environment. Providing EFB ameliorant to soil is an effective way to improve fertility levels. The nutrient content contained in EFB as a soil ameliorant is 1.44 N-total (classified as very high); 41.0 C-organic (classified as very high); 28.5 C/N ratio (classified as very high) and is classified as better when compared to lime, rice husks, chicken manure, and palm oil ash (AJKS) (Aryanti *et al* ., 2017). Utilization of EFB can be a potential product when used for plant cultivation (Trisakti *et al* ., 2017). Several studies have applied EFB in plant cultivation and production, such as EFB compost enriched with sea mud and rice husk biochar as an ameliorant for rice plants (Andayani & Hayat, 2019). The use of EFB waste as an ameliorant has a significant effect on the growth of mustard greens (Armiyarsih *et al* . , 2020). *et al* ., 2020), a combination of EFB and cocopeat as an organic ameliorant that can increase plant height, tuber diameter, number of leaves, and leaf area in the growth of oil palm seedlings (Alfian *et al*., 2017).

Apart from being an ameliorant, TKKS can replace the use of chemical insecticides with pesticides for pest control so that it is environmentally friendly through liquid smoke (Sari *et al* ., 2018). Liquid smoke usually contains water and around 200 types of chemical components (Karima, 2014). The content of liquid smoke from TKKS is acid and phenol which can be an insecticide (Indrayani *et al* ., 2011). So far, the use of

TKKS to make liquid smoke, especially in South Kalimantan, is still very rare. Liquid smoke is used for cultivating fruit, flower, and vegetable plants, liquid smoke is sprayed on plant leaves to make the leaves healthier, liquid smoke can also shift the use of chemical fertilizers which are 100% natural, and can reduce the smell when added to manure with quality fertilizer better (Basri, 2010). Thus, the use of TKKS can be applied to the process of cultivating plants such as cayenne pepper.

The Indonesian people are the biggest fans of cayenne peppers in the world, resulting in a high demand for cayenne peppers for cooking spices, the food industry, and medicines, which means that this commodity is never short of enthusiasts. Cayenne pepper is an important product in Indonesian food (Nathania *et al* ., 2016). High market demand automatically causes the price of cayenne pepper to rise. It can be said that the profits obtained from cultivating cayenne pepper are generally higher compared to cultivating other vegetables (Muhaimin *et al* ., 2018). One type of cayenne pepper that is quite well known is hiyung cayenne pepper. The name hiyung cayenne pepper is taken from the name of a village in Tapin Regency which has potential as a producer of cayenne peppers, a product of natural local wisdom that has economic value. This cayenne pepper is cultivated in Hiyung Village which is located in Tapin Tengah District (Tapin Regency Central Statistics Agency, 2019). Hiyung cayenne peppers have a spiciness level that is 17 times that of ordinary cayenne peppers. Based on research results from the Testing Laboratory of the Center for Postharvest Research and Development belonging to the Indonesian Ministry of Agriculture, the capsaicin level in these cayenne peppers even reached 2,333.05 ppm (Hayati & Hardarani, 2019). Apart from being known for its spicy taste, another advantage of this cayenne pepper also lies in its durability which lasts up to 8-10 days. These advantages may be due to the land conditions in Hiyung Village which are dominated by lowland swamp land which provides efficiency in the cultivation of cayenne pepper. According to Subagyo (2006), the chemical properties of lowland swamp soil show high to very high C-organic and N contents, while the C/N ratio varies from 9 to 16 depending on the level of decomposition of the organic material. Soil CEC also varies between 23 to 48 me 100 g $^{-1}$. Base cations also vary from low to very high. The available P content also varies from medium to high and the soil pH is acidic (4.5-5.5). Lebak swamp land has a great opportunity to be developed as agricultural land through proper management.

Therefore, this research aims to examine the effect of the interaction between the application of liquid smoke and TKKS waste ameliorant on changes in soil chemical properties including pH, P-available, K-dd, Ca-dd, Mg-dd, and KTK, growth of hiyung cayenne pepper plants. , namely: plant height (cm), number of primary and secondary branches, and production of hiyung cayenne pepper plants, namely: age from flowering (days), number of flowers (flowers), number of flowers to fruit (fruit), percentage of flowers to fruit (%), weight of 25 fruits per plant (g), weight of fruit per plant (g), three harvests, and cumulative.

Research on the cultivation of Hiyung cayenne pepper will be carried out in lowland swampland in Hiyung Village to optimize the use of lowland swampland in South Kalimantan. The use of TKKS waste as an ameliorant and pesticide in the form

of TKKS liquid smoke is also expected to influence the development of hiyung cayenne pepper in lowland swampland.

2. Materials and Methods

The method used in this research is the Divided Plot Design. Main Plot (A) is a liquid smoke pesticide that consists of five levels (concentrations), namely ao = 0 mL L^{-1}, a1 = 10 mL L^{-1}, a2 = 15 mL L^{-1}, a3 = 20 mL L^{-1} water, and a4 = 25 mL L^{-1}. Subplot (B) of the best TKKS ameliorant from phase one research which consists of five levels (measures), namely bo = 0 t ha^{-1}, b1 = 5 t ha^{-1}, b2 = 10 t ha^{-1}, b3 = 15 t ha^{-1}, and b4 = 20 t ha^{-1}. The combination of treatments applied was 25 treatments, with repetition 3 times, so in this study, there were 75 experimental units.

The parameters observed to determine the liquid smoke content in this study were Ethylene glycol, Acetic Acid (acetic acid), Phenol (phenol), Benzensulfone, acid/Carbamic acid, Acetone (acetone), and Butyrolactone. After producing liquid smoke from the EFB, continue sowing the hiyung chili seeds. Before the hiyung chili seeds are sown, their quality is first tested by soaking them in water. Good quality seeds are seeds that are below the water surface and are used as seeds for sowing. Sowing is carried out in seedling tanks using soil mixed with TKKS that has been taken previously. Seeding is carried out for one month or until four leaves appear. When sowing, three beds were also made with a trial bed measuring 1x100 m. Each bed will be divided into 5 main plots and each main plot will be further divided into 5 subplots. The distance between main plots is 1 m, and the distance between subplots is 50 cm.

After the plotting is complete, the TKKS ameliorant application will then be carried out according to the treatment, namely, 0 t ha^{-1}, 5 t ha^{-1} is equivalent to 150 g plot $^{-1}$ (25 g plants $^{-1}$), 10 t ha^{-1} is equivalent to 300 g plot $^{-1}$ (50 g plants $^{-1}$), 15 t ha^{-1} is equivalent to 450 g plot $^{-1}$ (75 g plants $^{-1}$), 20 t ha^{-1} is equivalent to 600 g plot $^{-1}$ (100g plant $^{-1}$). Incubation is carried out for one month before planting so that the ameliorant material reacts with the soil and decomposes completely. Planting is carried out by planting one perforated cayenne pepper plant with a planting distance of 50 cm with a plot area of 3 m2 ^{to} obtain 6 planting holes in one plot. The number of plots required for the research was 75 plots, so 450 cayenne pepper plants were needed.

Pesticide application with treatment doses, namely 0 m LL^{-1}, 10 m LL^{-1}, 15 m LL^{-1}, 20 m LL^{-1}, and 25 m LL^{-1} given 4 times a day starting at the age of 10 HST until the first harvest so that you get 25 gifts. Spraying is carried out on all parts of the plant. Maintenance is carried out by watering in the morning and evening, but if it rains, watering is not carried out. Weeding is very important to do so that there is no competition for nutrients with the main plant which can disrupt plant growth and attract pests. Harvesting is done three times once a week. Harvesting is done in the morning by picking hiyung cayenne peppers.

Observations made in this research include (1) Changes in soil chemical properties, including pH, P-available, K-dd, Ca-dd, Mg-dd, and CEC, (2) Growth of hiyung cayenne pepper plants, namely: plant height (cm), number of primary and secondary branches. (3) Production of hiyung cayenne pepper plants, namely: age from flowering (days), number of flowers (flowers), number of flowers to fruit (fruit), percentage of flowers to fruit (%), weight of 25 fruits per plant (g), weight fruit crop (g), three harvests, and cumulative. Before carrying out the analysis of variance, homogeneity of

variance was first carried out using the Bartlett test. If the error variance is homogeneous, then continue with the analysis of variance. On the other hand, if the error variance is not homogeneous, data transformation is carried out until the assumption of homogeneity of variance is met. The results of the analysis of variance showed a real effect followed by using the Duncan Multiple Range Test at the 5% level.

3. Results and Discussion

3.1 Changes in Soil Chemical Properties

P_2O_5 - available. The results of the analysis of variance showed that the application of TKKS had no significant effect on the P_2O_5 content of the soil (Figure 1a). Even though the content of each treatment is different, this is not influenced by the treatment but comes from the soil itself. The average P-available content in hiyung chili cultivation land ranges from 6 – 15.2 mol kg^{-1}. The maximum availability of phosphorus in most soils is in the pH range 6 - 6.5, while the research land has an acidic pH so that availability is thought to be bound by Al and Fe. Table 1 below is an analysis of data on the chemical content of liquid smoke from empty oil palm fruit bunches (TKKS).

Table 1. Results of Chemical Content Analysis of TKKS Liquid Smoke

No	Parameter	Results Test (%)	Test Method
1	Silane, (3-chloropropyl) trimethyl	15,203	
2	Benzenamine (CAS) Aniline	1,370	
3	Benzenecarbothioic acid (CAS)	5,185	
4	Thiobenzoic	1,855	
5	1-HYDROXY-2-BUTANONE	5,914	
6	Pyridine (CAS) Azin 3,199 79.00	1,885	
7	8924706 9859100	0.364	GC-MS
8	Cyclopentanone (CAS) Dumasin	0.462	
9	Methanol, (methyl-onn-azoxy)-, acetate	4,065	
10	Propane, 2-methoxy- (CAS) Methyl	9,061	
11	isopropyl	3,341	
12	Propanoic acid (CAS) Propionic acid	8,195	
13	Butanoic acid, 2-hydroxy-, methyl ester	6,894	
14	2-Cyclopenten-1-one (CAS)	26,586	
15	Cyclopentenone	9,619	
	2-Furanmethanol (CAS) Furfuryl alcohol		
	2(3H)-Furanone, dihydro- (CAS) Butyrolactone		
	2-Furanmethanol, tetrahydro- (CAS) Tetrahy		
	Phenol (CAS) Izal		

Ca–dd. The results of the analysis of variance showed that giving TKKS had no significant effect on changes in soil Ca (see Fig. 1b). It is suspected that EFB has not yet decomposed in the soil so it does not affect the availability of calcium in the soil. Moreover, the TKKS used is natural TKKS without any additional ingredients in it

which causes it to decompose slowly into the soil and has a very low value. However, based on the results of laboratory analysis, it show that the Ca content of the soil after incubation varies from very low to very low. One of the factors that caused TKKS to not affect the K given to the soil was also thought to be because the decomposition process in the soil was slow. After all, rain rarely fell at the time of the research.

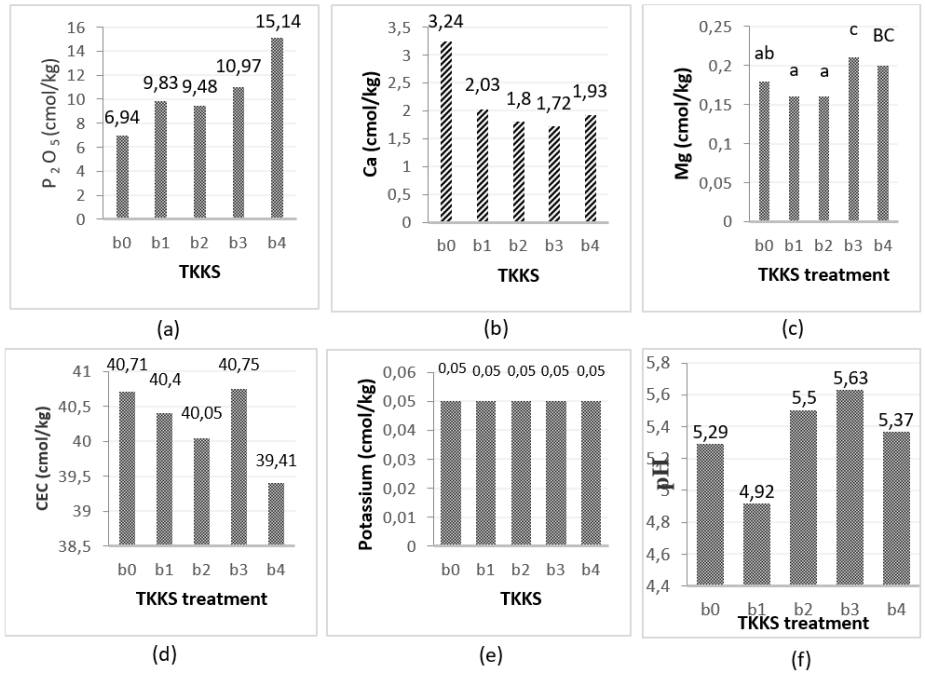


Fig. 1. Average content of (a) P_2O_5, (b) Ca-dd, (c) Mg, (d) CEC, (e) pH of the soil where the TKKS ameliorant was applied. Note: bo = 0 t ha $^{-1}$, b1 = 5 t ha $^{-1}$, b2 = 10 t ha $^{-1}$, b3 = 15 t ha $^{-1}$, and b4 = 20 t ha $^{-1}$. The same letter indicates the same effect based on the Duncan test at the 5% level.

Mg – dd. The results of the analysis of variance show that giving TKKS has a significant effect on Mg availability (see Fig. 1c). Based on further tests, showed that the TKKS dose treatment had a significant difference in soil Mg content. Treatment b0= control, b1=5 t ha $^{-1}$, b2=10 t ha $^{-1}$ is significantly different from b3=15 t ha $^{-1}$, and b4=20 t ha $^{-1}$. In this case, TKSS affects the amount of Mg in the ground. If you look at the analysis results, it shows that the B3 treatment a dose of 15 t ha $^{-1}$ is the best treatment in increasing the Mg content in the soil. Mg is one of the micronutrients contained in EFB, the Mg contained in EFB is around 0.9% (Haryanti *et a*., 2014). As for treatment b4 (20 t ha $^{-1}$) Mg content in the soil was not higher than in the b3 treatment (15 t ha $^{-1}$) is thought to be caused by several factors that influence Mg absorption in the soil. The soil texture where the research was carried out is clay but there is sand in it at several points. According to Gransee & Führs (2013), the availability of Mg in the soil is influenced by several factors, such as low soil pH and

easy leaching so the Mg content is generally found to be higher in clay soil than sandy soil.

CEC. The results of the analysis of variance show that giving TKKS has no significant effect on soil CEC (Figure 1d). Although based on the results of soil analysis, shows that the CEC of the research land is high, even very high, namely ranging from 39, 41 – 40.75 cmol. kg $^{-1}$. High CEC is thought to occur because soil CEC is not only influenced by the organic material content in the soil but is also influenced by soil texture, this opinion was expressed by Asih *et al.* (2019) where the CEC on soil with a higher clay content tends to be greater than sandy soil, because the outer surface area of clay is higher than sand or dust particles.

K–dd. The results of the analysis of variance showed that the provision of TKKS had no significant effect on soil K content (Fig. 1e). Soil potassium in treatment b0 (0 t ha $^{-1}$), b1 (5 t ha $^{-1}$), b2 (10 t ha $^{-1}$), b3 (15 t ha $^{-1}$) and b4 (20 t ha $^{-1}$) which has an average of 0.05 which is classified as very low. Based on the analysis results, the potassium content in TKKS compost is very low, so the results of the analysis of soil where TKKS is applied are also very low.

pH. The results of the analysis of variance showed that the application of TKKS had no significant effect on changes in soil pH (Figure 1f). Soil acidity in the research soil ranged from 4.92 to 6.63. The soil on the research land is acid soil, where the land used is elevated land with a surjan system. Elevated soil is soil taken from surrounding land so that the lower soil that is raised upwards oxidizes and causes the soil to become acidic. The process of decomposing organic matter in the soil can also cause soil acidity to increase because the soil decomposes organic matter by bacteria and produces acid (Saidy, 2018). In this case, it is suspected that the TKKS decomposition process is still ongoing. This is by the results of the analysis of the C-organic content of TKKS applied to the soil which is 34.64% which is still considered high, so it still needs to be reformed to make it available to plants.

3.2 Growth of Hiyung Cayenne Pepper Plants

Plant height. The TKKS treatment showed no effect on plant height from the first week to the eighth week (Figure 2), presumably because the N content of TKKS had not been decomposed and absorbed by the plants. Generally, TKKS has a high lignin content so it is difficult to decompose even though it has undergone natural decomposition, as evidenced by the C/N content of the TKSS used which is still high, which is one of the factors in the lack of nutrient availability for plants. Apart from C/N, soil pH and EFB are also classified as acid, even very acid, so nutrients that depend on pH, such as P, will be difficult to provide to plants, plus the presence of Al, Fe and SO_4 which are classified as very high causes nutrients to become deficient.

Figure 2 shows the growth of hiyung chili plants up to the 11th week, showing that growth has increased every week, but up to the 8th week the increase was not due to treatment, it is thought to have come from the research soil used. Plant height ranges from 34.42 cm to 57.97 cm.

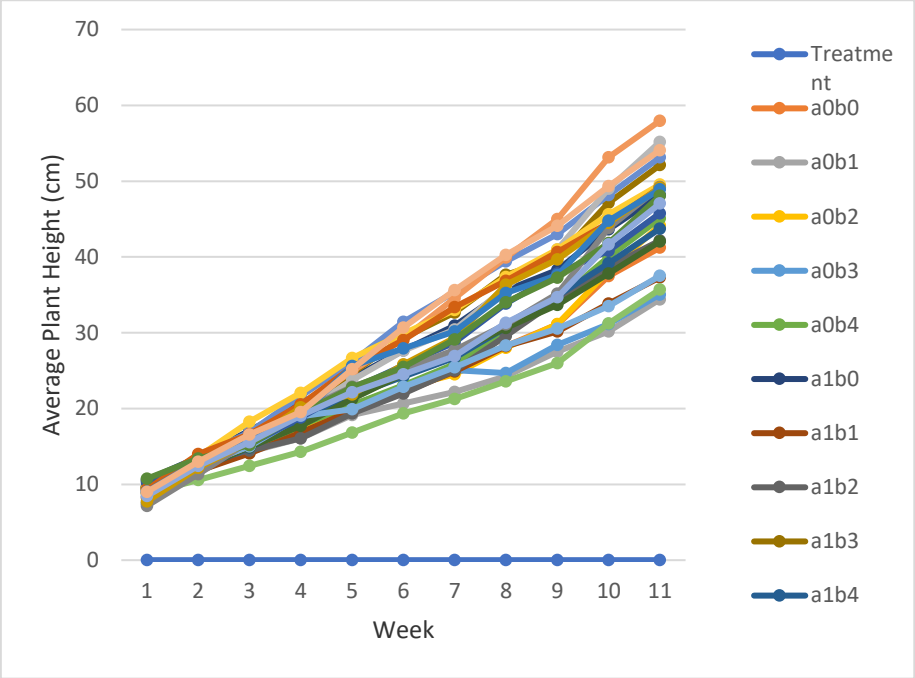
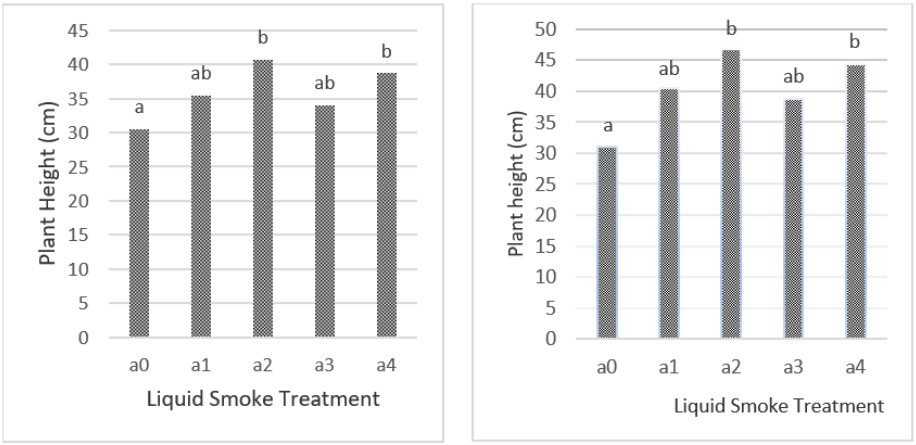


Figure 2. Average height of hiyung chili plants applied liquid smoke and TKKS ameliorant

Fig. 3a and 3b show plant growth in the 9th and 10th weeks which is influenced by the single factor of liquid smoke. Based on further tests, it show that the treatments a2=10 m L and a4=25 m L of liquid smoke are significantly different from the a0= control. It is suspected that with the application of liquid smoke, the plant growth process is not disturbed by pests or diseases so that plants can grow well without damage to plant organs such as roots, stems, or leaves.



(a) (b)

Figure 3. The average height of hiyung chili plants (a) 9 WAP (b) 10 WAP when TKKS liquid smoke was applied. Note: bo = 0 t ha $^{-1}$, b1 = 5 t ha $^{-1}$, b2 = 10 t ha $^{-1}$, b3 = 15 t ha $^{-1}$, and b4 = 20 t ha $^{-1}$. The same letter indicates the same effect based on the Duncan test at the 5% level.

components of liquid smoke such as acetic acid function to accelerate plant growth and prevent plant disease. Methanol functions to accelerate plant growth, while phenol and its derivatives function to prevent pest attacks and plant diseases. Basri (2010) also stated that ethanol functions to accelerate plant growth, while phenol and its derivatives function to prevent pest attacks and plant diseases. In previous research, liquid smoke played a role in accelerating plant growth, because liquid smoke contains acetic acid. Other research results state that liquid smoke with a concentration of 2% can increase the growth of rice plants and can increase the production of harvested dry grain by 33% (Sari *et al*., 2018).

The results of this research are also in line with research conducted by Tavassoli & Galavi (2011) which states that the methanol component functions to accelerate leaf growth, as a carbon source, and inhibit photorespiration thereby increasing plant growth, as well as water use efficiency. The phenol component functions as a disinfectant and inhibitor so that liquid smoke can be used as a biopesticide (Yatagai, 2002). These chemical components are influenced by the raw materials and manufacturing process. Apart from that, liquid smoke is considered an alternative to synthetic ZPT which tends to be expensive.

Number of Branches. The treatment of liquid smoke and EFB ameliorant showed no effect on the number of hiyung chili branches (Figures 4 and 5), this is thought to be because the EFB that was applied to the soil had not completely decomposed. The elements N, P, and K are elements that are essential macronutrients for plants, including chilies. All three function in the metabolic and biochemical processes of plant cells (Havlin *et al.*, 2005). The absorption of N, P, and K nutrients by plants is influenced by nutrient availability. Nutrient absorption by chili plants continues as long as the plants still need these nutrients for plant growth and development (Dubey *et al* ., 2016). Apart from that, the quality of nutrients in organic fertilizer depends on the raw materials such as a mixture of manure, straw, litter or animal feed remains and other materials (Amir

et al ., 2017) determining the nutrient content in it which can support plant growth, especially hiyung chili plants.

Providing organic fertilizer through immersion in the soil will influence growth during the vegetative and generative periods. The nutrient content of N, P, and K in each organic fertilizer has a big influence on plant fruit growth. The elements N and P are mobile nutrients in plant tissue so if there is a nutrient deficiency, they will immediately be allocated to young plant tissue. The N element during the vegetative period is quite balanced in plants. This is different from the element P which plays a more important role in the generative period. This element is very important in the process of forming flowers, fruit, and seeds (Viveros, 2010). In this case, the nutrients from EFB are not enough to support the growth of hiyung chili plants so they do not influence branch growth, both primary and secondary.

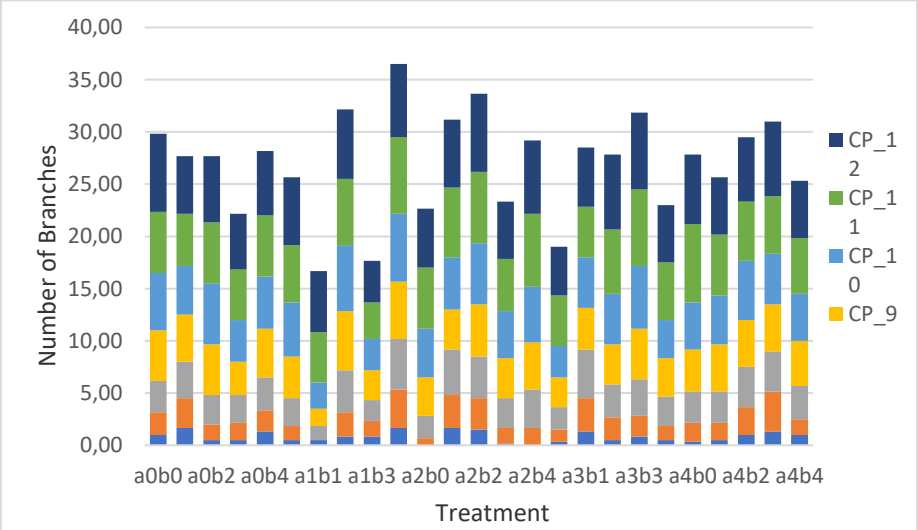


Figure 4. An average number of primary branches of hiyung chilies were applied with liquid smoke and TKKS ameliorant. The same letter indicates the same effect based on the Duncan test at the 5% level.

The high nutrient content makes fruit production quite good. So, with the availability of nutrients for plants, the uptake of nutrients by plants will increase and affect plant growth and production. The effect of organic fertilizers not only plays a role in plant growth but can be seen in the physical condition of the soil both on the surface and around plant roots. The increase in growth and yield of red chilies is caused by organic fertilizer not only adding nutrients to plants but also creating suitable soil conditions for plants by improving area, facilitating root penetration into the soil, improving water holding capacity, increasing soil pH, cation exchange capacity. and nutrient uptake, reducing Al-dd which is toxic to plants, the soil structure becomes crumbly without the accumulation of toxic compounds in land and groundwater (Vlahova-Vangelova & Dragoev, 2014). Unfortunately, in this research, no research has been carried out regarding post-harvest soil, so the long-term effects of organic materials applied to the soil have not yet been seen.

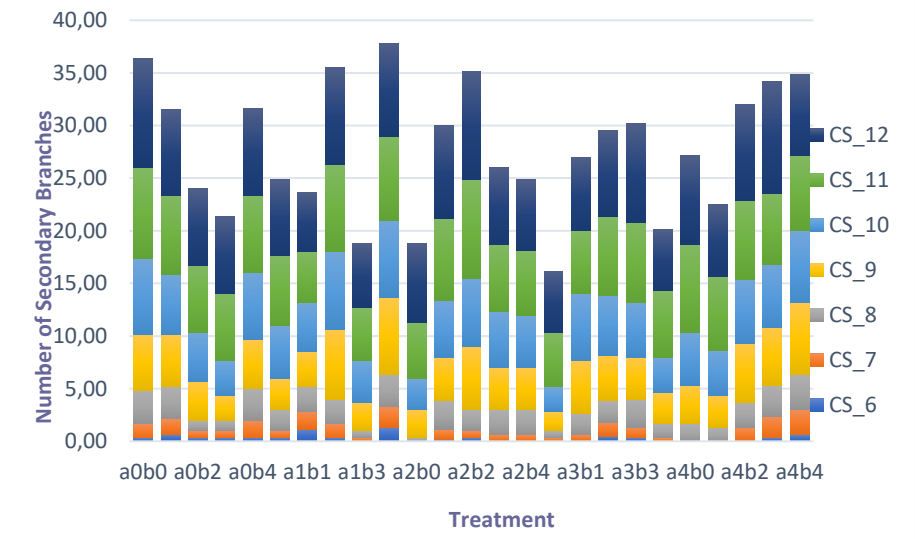


Figure 5. The average number of secondary branches of hiyung chilies that were applied with liquid smoke and TKKS ameliorant. The same letter indicates the same effect based on the Duncan test at the 5% level.

Wet and Dry Weight of Plants. The liquid smoke and EFB treatments had a very significant effect on the wet weight and dry weight of hiyung chili plants (Figures 6 and 7). Based show that the treatments are significantly different if seen from the highest wet weight, namely in the a1b2 treatment, namely a combination of giving 5 mL of liquid smoke with 10 t ha $^{-1}$ EFB, but statistically, it shows that the a1b1 treatment has the same effect as the a1b3, a2b2 treatments , a2b3, a3b4, a4b1, a4b2, a4b3, and a4b4. The highest wet weight was found in the a1b2 treatment, namely 29.58 g.

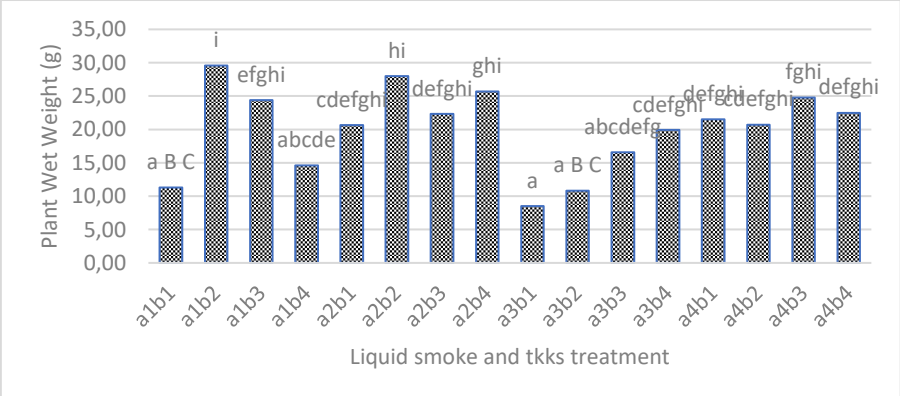


Figure 6. Average wet weight of hiyung chili plants applied with liquid smoke and TKKS ameliorant. The same letter indicates the same effect based on the Duncan test at the 5% level.

Based on the analysis of variance, it shows that the interaction between liquid smoke and EFB has a very significant effect, and based on further tests it shows that the best interaction is the a2b2 treatment, namely 10 mL of liquid smoke and 10 t ha $^{-1}$ EFB, although it is not much different from the a1b2, a1b3, a2b3 treatments. a2b4, a3b4, and a4b4. If seen in terms of efficiency of use, the a2b2 treatment is the ideal treatment to use for cultivating chili plants, because, in terms of quantity, 10 mL of liquid smoke and 10 t ha $^{-1}$ EFB can affect the water content of chili plants.

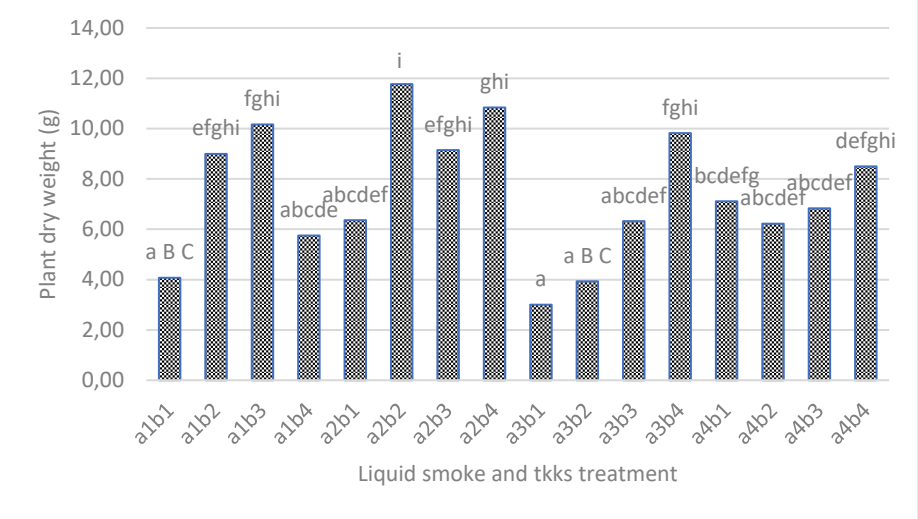


Figure 7. The average dry weight of hiyung chili plants that were applied with liquid smoke and TKKS ameliorant. The same letter indicates the same effect based on the Duncan test at the 5% level.

Wet Weight and Dry Weight of Roots. The results of the analysis of variance showed that the interaction treatment of liquid smoke and EFB had a very significant effect on the wet weight of the roots and the dry weight of the roots (Fig, 8 and 9). Based on further tests, showed that the treatments were significantly different, where treatments a1b3 and a2b3 had the same effect and had almost the same wet root weight. Where the wet weight of a1b3 is 14.38 g and a2b3 is 14.35 g. Root wet weight is used to determine the plant's ability to absorb water. To determine the total biomass of roots in the soil, observing the wet weight of the roots is an appropriate observation variable. The ability of roots to absorb water by maximizing the root system is one of the main approaches that is usually used to see the adaptability of plants to water shortages that occur (Efendi, 2009). Plants that have a high root volume will be able to absorb more water so they can survive conditions of water shortage (Palupi & Dedywiryanto, 2008). Increasing root length and root volume is an important morphological response in the process of plant adaptation to water shortages (Budiasih, 2009). Root wet weight is used to determine the plant's ability to absorb water. Plants' need for water can be met by absorption by the roots. The water content in the soil and the ability of the roots to absorb water greatly influence the amount of water absorbed by the roots so the ability of the roots to absorb water greatly influences the wet weight of the roots (Jadid, 2007).

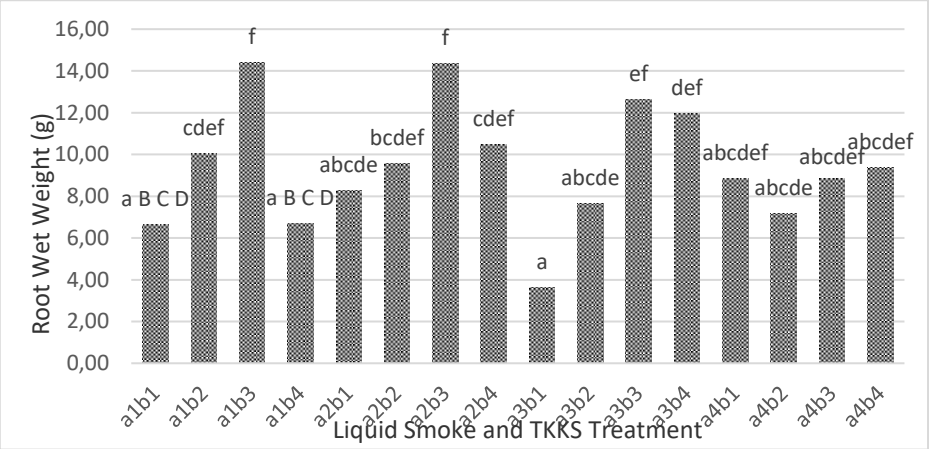


Figure 8. Average wet weight of hiyung chili plant roots applied with liquid smoke and TKKS ameliorant. The same letter indicates the same effect based on the Duncan test at the 5% level.

Root dry weight indicates a plant's ability to absorb water because plants that have a high root dry weight have larger roots and have a higher level of tolerance to drought compared to plants with a low root dry weight (Kurniasih & Wulandhany, 2009). Providing organic material that has sufficient N content when planting can maintain good early plant growth, thereby increasing the number of roots. Roots are one of the plant organs that are used to store water and biomass which will be distributed to the plant and will later be used for metabolic processes in the plant itself. If the roots grow well, the growth of other parts of the plant will develop well too, because the roots can absorb the nutrients the plant needs (Roidi, 2016).

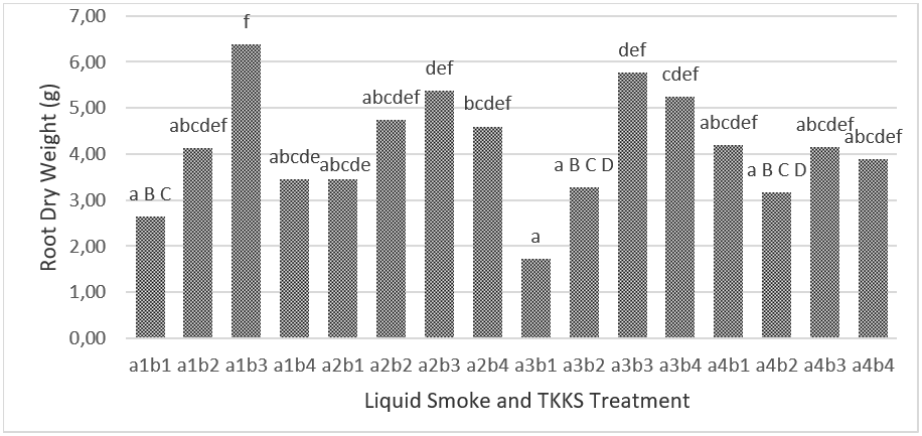


Figure 9. The average dry weight of hiyung chili plant roots applied with liquid smoke and TKKS ameliorant. The same letter indicates the same effect based on the Duncan test at the 5% level.

4. Conclusion

The interaction effect of the application of liquid smoke and EFB waste ameliorant is found on the parameters of plant wet weight, plant dry weight, root wet weight, and root dry weight of hiyung cayenne pepper. Treatment a1b2 (5 mL liquid smoke + 10 t ha $^{-1}$ ameliorant EFB) best increases plant wet weight, a2b2 treatment (10 mL liquid smoke + 10 t ha $^{-1}$ ameliorant EFB) best increases plant dry weight, treatment a1b3 (5 mL liquid smoke + 15 t ha $^{-1}$ ameliorant TKKS) best increases the wet weight of the roots and the dry weight of the roots of hiyung cayenne pepper in swamp land.

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