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Application of Biochar and Liquid Smoke From Biomass Waste Management to Increase Yields and Raise Farmers' Income

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***Abstract*. Corncobs and rice straws are the types of biomass waste in farmland that has yet to be optimally managed. The farmland waste management using perfect combustion technologies produced liquid smoke and biochar. The analysis of the production process of biochar and liquid smoke through perfect combustion signified a high accuracy. Biochar and liquid smoke were proven well-functioning for soil amendment. The study aimed to expose the interaction between liquid smoke and biochar in cayenne pepper crops' growth. It used two factors, including Factor I: biochar dose and Factor II: liquid smoke dose. The findings concluded the result of interaction between liquid smoke and biochar based on the observation of the number of leaves and weight of fruits of cayenne pepper crops. The combination of 20 g of biochar and 60 ml/l of liquid smoke resulted in more numbers of leaves, reaching 76.50 stands. The combination of 30 g of biochar and 80 ml/l of liquid smoke yielded heavier fresh fruits of cayenne crops, reaching 304.17 g. The utilization of 80 ml/l of liquid smoke affected the crops' height, number of leaves, and weight of fruits. Meanwhile, the utilization of 30 g of biochar averagely resulted in higher crops with more numbers of fruits and heavier fruits. The application of both biochar and liquid smoke could potentially increase the yields of cayenne pepper crops and raise the farmers' income.**

Keywords: application, technology, biochar, liquid smoke, waste, biomass, increase, income, farmer

INTRODUCTION

The increasing awareness of the importance of land resource management and soil quality improvement in the last few decades has allowed the application of biochar (bio-charcoal) into the soil for land amendment purposes. Land degradation occurs due to the absence of nutrient supply to maintain soil fertility. The condition indicates a low rate of soil physical and chemical properties. The utilization of land amendment is targeted to sustain land structure and productivity [1], [2].

Biochar technology derives from the complete combustion process of agricultural waste in farmland. Agricultural waste for biochar combustion material consists of crop waste and corncobs. The application of biochar is expected to increase soil fertility, primarily through the fulfilment of urgent nutrients, such as nitrogen, pH, CEC, and organic carbon. The nutrient improvement of the soil occurs in the 0-10 cm layer, which serves to minimize the leaching nutrients, especially potassium and nitrogen [3]-[6].

The application of biochar and liquid smoke function is to restore the loss of soil fertility which is caused by excessive utilization of inorganic fertilizers and chemical pesticides. Biochar functions to restore the composition of soil nutrients in enhancing crops' productivity. Meanwhile, the utilization of liquid smoke as a natural pesticide will help to eradicate pests in cayenne pepper crops. Both of these materials can facilitate farmers in yielding crops with a high rate of productivity in terms of quantity and quality [7], [8].

The effectiveness of biochar for soil amendment is in accordance with the content and composition of relatively stable carbon compounds. Biochar has a high affinity to cations and is useful in reducing the rate of soil degradation, thus can boost sustainable food production. In addition to biochar, another supporting material to maintain soil composition and fertility that contains no chemicals is liquid smoke (wood vinegar), which derives from the condensation of direct and indirect combustion of materials containing lignin, cellulose, hemicellulose, and carbon compounds. Most of the raw materials include various types of wood, oil palm blocks, coconut shells, husks, pulp, sawdust, etc. [9], [10].

Liquid smoke functions to improve soil quality; neutralize soil acids; eliminate pests; control crops' growth; repel insects; as well as accelerate growth in roots, stems, tubers, leaves, flowers, and fruits. It can replace chemical pesticides which are considered harmful for health and the environment. It is necessary to develop naturally-degradable pesticides. Such types of pesticides should be toxic to microorganisms, yet non-toxic to humans and animals; produce no pollutants to the environment, and contain no harmful substances to human health. The alternative pesticides can be produced either from crops' bioactive materials, condensation results of wood drying (dry distillation) process, or fibrous substances that contain cellulose lignin. The bioactive materials from crops possess allelopathy feature, which is described as the ability of organisms to produce and release environmental biomolecular compounds (allelochemical) to affect the development and growth of other organisms surrounding [4], [11], [12].

The current business opportunities for cayenne pepper are constrained by the deteriorating land condition due to the continuous utilization of chemical fertilizers and pesticides over a long period. Soil cultivation for chilli crops at a certain time will result in the damage of soil composition, pH, and mineral contents, which will lead to dryness and the loss of appropriate nutrients for cayenne pepper [13].

The failure in the yields of cayenne pepper is also influenced by various factors, such as crop diseases due to microbes. Various types of fungi can cause diseases and attack cayenne pepper crops, causing losses in sales. Meanwhile, various attempts for crop disease control are normally initiated through the utilization of inorganic pesticides. The type of pesticides can reduce the losses of agricultural products due to pests and improve production targets. Even if inorganic pesticides are effective in dealing with pests and crop diseases, they contain negative and toxic impacts for long-term use. They are synthesized from non-renewable materials, such as coal and petroleum, that can harm the sustainability of crops and living environment [4][13][8].

The study aimed to analyze the growth and yields of cayenne pepper crops based on the treatment combination using liquid smoke and biochar.

METHOD

The study was organized in Pandesari Village, Pujon District, Malang Regency in February 2019. It used cayenne pepper varieties; biochar and liquid smoke made from crop waste and corncobs; soil, compost, and manure. It implemented Randomized Block Design (RBD) based on factorial arrangement, which consisted of two factors for three times of repetition. Factor I: the biochar dose, which consisted of three levels, including B_0 = without biochar, B_1 = 10 g of biochar, B_2 = 20 g of biochar, and B_3 = 30 g of biochar. Factor II: the liquid smoke dose, which consisted of three levels, including A_0 = without liquid smoke, A_1 = 40 ml/l of liquid smoke, A_2 = 60 ml/l of liquid smoke, A_3 = 80 ml/l of liquid smoke.

Meanwhile, the observation parameters included the crop height (cm), number of leaves (strands), number of fruits (fruits), the weight of fresh fruits (g), as well as the effectiveness of liquid smoke and rice husk biochar (%). The study used statistical analysis and real difference test to find out the differences.

RESULT & DISCUSSION

Based on the observation, the cayenne pepper crops used in this study with ages ranging from 14 to 49 days signified various improvements in height after the application of biochar. In contrast, the application of liquid smoke indicated no significance in height.

Table 1. Average Height (cm) of Cayenne Pepper Crops After The Treatment with Liquid Smoke (A) and Biochar (B) in Various Crop Ages

Treatment	Crop Height at The Age of...... (HST)					
	14	21	28	35	42	49
Liquid Smoke (A)						
A_0 (without liquid smoke)	14.55	20.68 a	30.56	41.79	61.05	79.36
A_1 (40 ml/l of liquid smoke)	14.68	20.99 a	29.19	39.58	60.09	77.02
A_2 (60 ml/l of liquid smoke)	15.32	22.26 ab	33.13	45.31	65.74	82.34
A_3 (80 ml/l of liquid smoke)	16.13	23.14 b	33.53	44.66	62.05	78.05
LSD (5%)	tn	1.611	tn	tn	tn	tn
Biochar (B)						
B_0 (without biochar)	14.18	17.73 a	26.70 a	36.61 a	49.57 a	68.87 a
B_1 (10 gr of biochar)	15.11	21.61 b	30.12 a	39.37 a	55.96 a	76.80 ab
B_2 (20 gr of biochar)	14.93	22.33 b	34.43 b	46.27 b	69.70 b	83.84 b
B_3 (30 gr of biochar)	16.44	25.40 c	35.16 b	49.10 b	73.68 b	87.27 b
LSD (5%)	tn	1.611	3.824	4.914	8.199	8.211

Note: Numbers per column with the same letters signify no difference at the LSD test (5%); tn = no difference at the LSD test (5%).

The result was consistent with the study which concluded that the application of biochar could increase the crops' growth. There is a tendency that the greater the biochar dose is given; the better the crops' height will be. It indicates that crops are adaptable with their growing media, as the roots absorb nutrients from the media. In addition, biochar can boost the fertility of the soil as the crops' growing media [8], [13], [12].

The pores of biochar can bind and store water and nutrients for crops. The positive impacts of biochar to enhance the biological fertility of soil are proven by the activities of the soil microelements in increasing its composition, biomass, and nitrogen fixation [11], [14], [15].

The provision of biochar combined with liquid smoke affected the number of leaves and weight of fruits. It happened due to the impact of biochar that caused crops to obtain sufficient quantities of nutrients and water in accordance with the increasing number of leaves and the size of fruits. The combination of liquid smoke and biochar that affected the number of fruits was supported by two synergistic treatments in the yields of cayenne pepper crops.

Table 2. Average Numbers of Fruits per Crop After the Treatment with Liquid Smoke (A) and Biochar (B)

Treatment	Number of Fruits
Liquid Smoke (A)	
A_0 (without liquid smoke)	21.08 a
A_1 (40 ml/l of liquid smoke)	20.29 a
A_2 (60 ml/l of liquid smoke)	21.21 a
A_3 (80 ml/l of liquid smoke)	21.04 a
LSD (5%)	tn
Biochar (B)	
B_0 (without biochar)	17.54 a
B_1 (10 g of biochar)	19.96 b
B_2 (20 g of biochar)	21.71 b
B_3 (30 g of biochar)	24.42 c
LSD (5%)	2.059

Note: Numbers per column with the same letters signify no difference at the LSD test (5%).

The provision of liquid smoke containing phenol and formaldehyde compounds functioned as bacteriocide and fungicide. The availability of sufficient nutrients and water together with the protective compounds could also protect the crops from pests and diseases. Such a function would boost the optimum growth of crops and produce high yields [4].

Table 3. Average Weight of Fresh Fruits per Crop (g) After the Treatment with Liquid Smoke (A) and Biochar (B)

Treatment	Liquid Smoke			
Biochar	A_0 (0 ml/l)	A_1 (40 ml/l)	A_2 (60 ml/l)	A_3 (80 ml/l)
B_0 (0)	168.33 a	183.33 abc	178.33 ab	195.00 abc
B_1 (10 g)	199.17 abc	215.00 bc	218.33 cd	201.67 abc
B_2 (20 g)	234.17 d	225.83 d	238.33 d	220.83 cd
B_3 (30 g)	214.17 bc	236.67d	277.50 e	304.17 e
LSD (5%)	37.917			

Note: Numbers per column with the same letters signify no difference at the LSD test (5%).

Table 3 shows that the highest average weight of fresh cayenne pepper was obtained from the addition of 30 g of biochar combined with 80 ml/l of liquid smoke, reaching 304.17 g per crop. Based on the data, the combination treatment provided soil amendment with various nutrients, such as C, H, O, N, P, and K which could be absorbed by crops and improve the yields of the cayenne pepper.

The application of biochar for soil amendment material could increase soil productivity by improving the chemical, physical, and biological properties of the soil. Productive soil which was cultivated with liquid smoke could keep the crops away from pests and diseases, in addition, to sustain the crops' optimal growth. Liquid smoke could help farmers to get rid of viruses, diseases, and pests from cayenne pepper crops. Meanwhile, the addition of biochar in soil cultivation could increase groundwater storage capacity to provide crops with a sufficient amount of water. With the increasing soil fertility, crumb soil structure, as well as sufficient macro- and micro-nutrients, the production of cayenne pepper crops could increase [13][10][16].

A number of studies signified that the utilization of biochar could increase soil productivity through the improvement of the chemical, physical, and biological properties of the soil [17][13][18]. The addition of biochar will lead to increasing pH, CEC, and nitrogen fertilization. The improvement of soil structure can also enhance groundwater storage capacity. With these functions, crops can grow better due to the sufficient fulfilment of water as well as good aeration and drainage system that will allow crops to grow properly result in high quality of yields. Thus, farmers will possibly raise their income. The soil cultivation with biochar and liquid smoke for soil amendment purposes can improve soil fertility [19].

CONCLUSION

Based on the results of this study it can be concluded that the application of biochar and liquid smoke from biomass waste to increase production and farmer income: (1) The application of biochar and liquid smoke for soil amendment could improve the physical and chemical properties of the soil. (2) The utilization of biochar affected the crops' height, number of fruits, and weight of fruits. The treatment with 30 g of biochar averagely resulted in higher crops with more and heavier fruits to yield. (3) The combination of 30 g of biochar and 80 ml/l of liquid smoke produced heavier fresh fruits, reaching 304.17 g and was more effective to boost the yields of cayenne pepper crops.

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