Application of Cocoa Pod Extract Compost with the Addition of Biochar and Pleurotus sp to Shallots on Sandy Clay Land

Iradhatullah Rahim(✉), Sukmawati, Nur Ananda, Muh. Rustan, Rahmat Muda, Irninthya Nanda Pratami Irwan, Suherman, and Muh. Iqbal Putera

Faculty of Agriculture, Animal Husbandry, and Fisheries, Universitas Muhammadiyah Parepare, Parepare 91132, Indonesia
iradhat76@gmail.com

Abstract. The utilization of sandy clay is done by adding organic materials to minimize excessive chemical input. The purpose of this study was to determine the soil's characteristics after applying cocoa husk compost and Pleurotus sp to 2 types of biochar, namely rice husk and corn cob biochar. Furthermore, the application of them can reveal the growth and production of shallots. The field research was arranged using a factorial design with 3 factors, namely factor 1 was the application of 2 types of biochar, namely rice husk biochar and corncob biochar. Factor 2 was the adding the Pleurotus sp inoculant, namely, without and with the adding of Pleurotus sp. The third factor is the application of cocoa pod husk compost, including 1 kg.m^2 and 2 kg.m^2. Soil nutrient characterization was carried out before and after application. The results showed an increase in the soil water content by up to 30% after applying organic matter, and the highest was in the application of rice husk biochar, which was 17%. The organic C, P, and K percentage increased in all treatments and corn cob biochar having the highest. Meanwhile, adding compost and Pleurotus increased the N content by 80%. Pleurotus and compost were added to the highest plant tissue of biochar husk at a dose of 2 kg/m, while the highest wet weight was rice husk. In general, the finding of this study indicated that to increase shallot production, we can process plant biomass, both as compost or as biochar, with the addition of Pleurotus sp in sandy clay soils.

Keywords: Sandy Clay, Biochar, Pleurotus Sp

1 Introduction

Sandy clay textured soils cannot hold water and nutrients properly because their unstable aggregates. It has a reasonably fast permeability reaching 89.82 cm/hour with a very loose consistency (Tewu, Theffie, & Pioh, 2016), so cultivating plants, will require quite a large amount of input. The utilization of this land can be done with shallot plants whom high economic value. Shallots fertilized with excessive N can increase the vegetative growth and reduce tuber weight. So it is recommended to combine it with organic fertilizers such as agricultural waste, manure, and mulch which will support the

M. Setiyo et al. (eds.), *Proceedings of the 4th Borobudur International Symposium on Science and Technology 2022 (BIS-STE 2022)*, Advances in Engineering Research 225,
https://doi.org/10.2991/978-94-6463-284-2_43

advantages of shallot cultivation (Askari-Khorasgani & Pessarakli, 2020; Gu et al., 2019).

Cocoa pod husk is one of the agricultural wastes that can be composted and used as organic fertilizer. Composting is a green method that convert organic waste into organic fertilizer and soil conditioner through biological processes [3]. Rahim, Meriem, & Abdallah (2022) used cocoa pod husk compost with the addition of fungi proven to be able to improve the shallots performance. It is because cocoa pod husk compost contains nutrients, hormones, and organic acids (I. Rahim, Nasruddin, Kuswinanti, Asrul, & Rasyid, 2018; I Rahim & Nasruddin, 2019). Compost can improve the physical properties of the soil, as well as biochar.Biochar can be used to improve the physical properties of sandy clay to shallots cultivation. Biochar is a carbon-rich biomass obtained from thermochemical conversion (pyrolysis or gasification) in an oxygen-limited environment. Agriculture biomass waste such as straw, peanut shells, rice husks, wood chips, corn cobs, tree bark, and switch grass [7] can be a solution for improving soil fertility, adsorption potential toxic elements, and climate change mitigation [8]. Application of biochar can stimulate leaf number and increase lettuce biomass, increase total N, P, and C content, and microbial community [9].

Biochar positively affects on plant growth and soil quality, indicating that using biochar is one way to overcome nutrient deficiencies, soil stability, and promote plant growth [10]. This study also included the addition of Pleurotus sp inoculant. Pleurotus sp is a fungus from the division Basidiomycota, which has a fruiting body and is edible. Pleurotus sp could produce 1,794 µg/l IAA and 2,554 µg/l GA3, and the compost inoculated by Pleurotus had levels of 6.70% P_2O_5, 0.71% K_2O, 0.28% Mg, and 0.19% S [11]. This paper monitors the application of compost, biochar, and Pleurotus sp to increase the growth and production of shallots on sandy loam soils.

2 Materials and Methods

2.1 Study area

The research took place at the end of February to May 2022 which is the dry season on farmer's land in Ciro-ciroe Village, Watang Pulu District, Sidrap Regency, South Sulawesi. Located at 3°43'- 4°09' South Latitude and 119°41'-120° East Longitude, with an altitude between 10 m - 150 m above sea level (Figure 1) with daily temperatures ranging from 23-33 oC (https:// www.accuweather.com/id/en/ciro-ciroe/3480733/may-weather/3480733?year=2022)

Soil sampling was done twice: once at the start of the study, before the application, and once at the end. Soil samples were collected in a composite manner by taking soil samples at 5 points diagonally and then mixing them. Composite soil samples were collected in small quantities at several sampling points but represented an area considered homogeneous in a specific stretch of land [12].

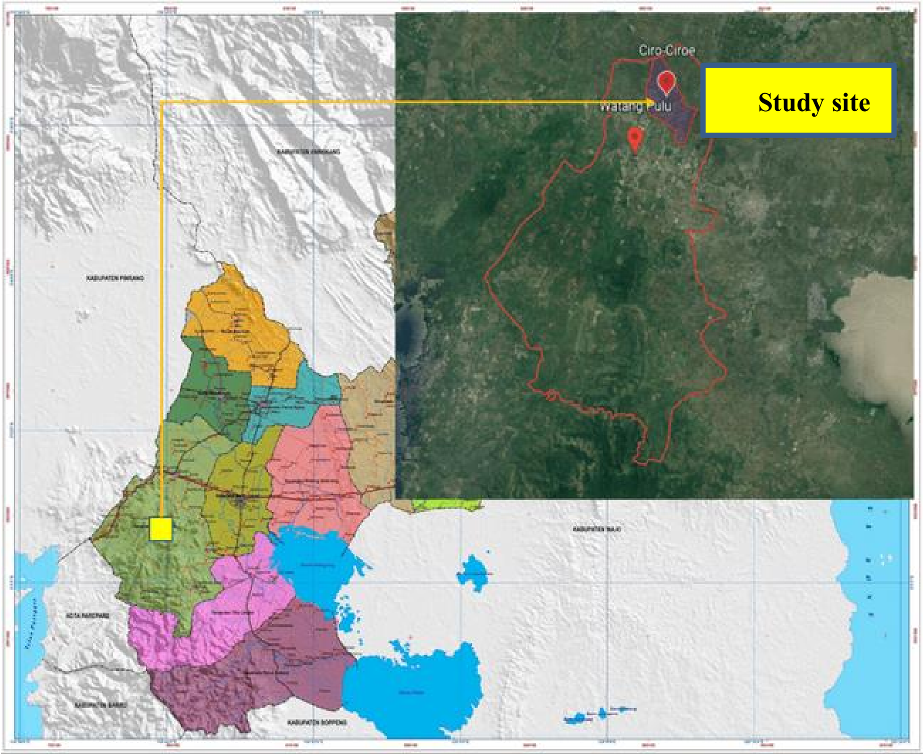

Fig. 1. Locations of sampling sites in Ciro-ciroe Village, South Sulawesi, Indonesia. The Map is modified from Google Maps Platform.

2.2 Propagation of Pleurotus sp

Pleurotus sp was obtained from cocoa plantations and propagated on PDA media and identified morphologically and in vitro [13]. Pleurotus sp in cocoa, missellium, and hyphae plantings is presented in Fig. 2. Pleurotus sp inoculant in a petri dish containing PDA media was taken with a Bohrer cork as many as 9 points, put into fine corn media which was soaked for 24 hours and was sterilized using an autoclave for 25 minutes. The corn media was then stored for 7-9 days at room temperature until it was filled with Pleurotus sp. mycelium.

Fig. 2. Pleurotus sp in cocoa (a), misellium (b), and hyphae (c) plantations (private collection)

2.3 Application of biochar, Pleurotus sp, and cacao compost

The biochar used is corn cobs and rice husks which are burned without smoke at a temperature ranging from 200 - 300 oC. While the compost used is compost from cocoa pod skin fermented with superior rotting fungi for 40 days. A week before planting, biochar is applied to the land together with compost and Pleurotus a week before planting, by mixing it evenly with the top soil in the land.

2.4 Experiment setup

The field experiment was arranged using a 3-factor factorial design based on a randomized block design. Factor 1 was the application of 2 types of biochar, namely rice husk biochar and corncob biochar. The second was the adding of Pleurotus sp inoculant, namely without and with added of Pleurotus sp. The third factor was the application of cocoa pod husk compost, including 1 kg.m-2 and 2 kg.m-2. Shallot tuber seeds were planted in plots measuring 1 m x 7 m with a spacing of 20 cm x 25 cm. The final results in the form of diameter, fresh weight, and dry weight of shallot bulbs were measured at harvest, which was 55 days after planting.

2.5 Plant tissue analysis

Plant as a sample from the field were washed thoroughly with ion-free water before drying in the oven at 70 oC. The dried plant samples were ground with a 0.5 mm grinder and then put in tightly closed plastic bottles [14]. The sample plants were then analyzed for N using the Kjeldahl method, while the analysis for P and K content was determine by wet ashing using a mixture of concentrated acids HNO3 and HClO4. The levels of macro and micro elements in the extract were measured using an atomic absorption spectrophotometer (AAS), a flame photometer, and a spectrophotometer [15].

3 Results and Discussion

3.1 Characteristics of the land applied biochar and compost

The biochar used as a treatment in this study has a different performance (Figure 3). Rice husk biochar is dark black and very crumbly. Likewise with corncob biochar which is dark black and dry (Figure 3, P2). The biochar that was given Pleurotus was black but not thick, and white fungus mycelium was seen covering the entire surface of the biochar (Figure 3, P3 and P4). Figure 3 also shows rice husk biochar mixed with cocoa pod husk compost which is denser and forms granules compared to rice husk biochar alone.

Fig. 3. Performance of rice husk biochar (P1), corncob biochar (P2), rice husk biochar + Pleurotus (P3), corncob biochar + Pleurotus (P4), and husk biochar + compost (P5).

Table 1. Soil characteristics before and after the application of 2 types of biochar, cocoa pod husk compost, and Pleurotus

Variety of biochar and Pleurotus	Water content	Texture class	pH	Organics matter (%)		P_2O_5	K	Cation ex-change capacity
	%			C	N	ppm	(cmol (+)kg-1)	
Before application	12.8	sandy clay loam	6.15	1.54	0.10	9.09	0.13	17.09
Rice husk biochar	17.0	sandy loam	6.25	1.89	0.19	11.38	0.19	18.79
Rice husk biochar + Pleurotus + compost	13.6	sandy clay loam	6.35	2.02	0.13	10.14	0.18	23.60
Corncob biochar	14.6	sandy clay loam	6.65	2.38	0.23	12.18	0.23	22.87
Corncob biochar + Pleurotus + compost	15.6	sandy clay loam	6.74	2.32	0.28	11.19	0.22	24.77

Table 1 shows the land characteristics before and after the application the organic matter was different. It is indicated by an increase in soil water content from 12.8% before application to 13 - 17% after application. The increase of water content about 30% and the highest was in biochar rice husk. The results of the study [16] showed an increase in soil water holding capacity by applying biochar up to 33% - 45% on coarse-textured soils. Straw biochar was also reported to have a higher water holding capacity than woody plants [17], so that it was in line with this study that the highest water content was in rice husk biochar.

Biochar application raises soil pH slightly, but not significantly. The soil pH before applying biochar was 6.15, and it increased to 6.74, which is close to neutral. A study by [18], biochar significantly reduced the relative net production of NO and N_2O from denitrification in two acid soils, resulting in a trend toward lower NO and N_2O emissions. An increase in soil pH with the addition of biochar was identified as the main factor mediating the suppression.

There was an increase in soil nutrient levels with the addition of biochar and Pleurotus-enriched compost. The percentage of organic C content increased in all treatments and was highest in corn cob biochar. After application, the water that enters the pores of the biochar dissolves organic and mineral compounds dissolved on the surface of the biochar. These solutes then increase dissolved organic C, cations, and anions in the soil solution [19]. Corn cob biochar has larger pores than rice husk biochar, so it has the highest organic C compared to other treatments. The addition of compost and Pleurotus sp reduced the biochar pores so that the dissolved organic C content was lower. The highest P and K levels were also found in the soil applied with corncob biochar. It happens because these elements enter the biochar's pores and water into the larger pores of the corncob biochar. The opposite happened to the soil nitrogen content. Compost and Pleurotus addition to the land increased N content to 0.28% after application from 0.10% before application, or an increase of 180%. Biochar can increase microbial activity, accelerate nutrient cycles, and reduce nitrogen leaching and evaporation [20].

Interaction with substrate when composting can increase the nutrient load, including N but changes the surface properties of the biochar. The surface area of biochar decreases during the composting process due to the blockage of micro pores because absorbed compost derivatives [21].

3.2 Yield of Shallot by application with Biochar, Pleurotus, and compost

Analysis of shallot tissue that has been applied to various treatments of biochar, Pleurotus, and compost is shown in Table 2.

Table 2. N.P,K uptake in shallot tissue which treated with biochar, compost, and Pleurotus

Organic matter	Nutrient uptake (% per plant)		
	P	K	N
Corn cob biochar + compost 1 kg.m^{-1}	0.83	0.74	1.13
Corn cob biochar + compost 2 kg.m^{-1}	1.13	0.63	1.11
Corn cob biochar + Pleurotus + compost 1 kg.m^{-1}	1.05	0.43	1.41
Corn cob biochar + Pleurotus + compost 2 kg.m^{-1}	1.08	0.57	1.63
Rice husk biochar + compost 1 kg.m^{-1}	1.13	0.84	1.21
Rice husk biochar + compost 2 kg.m^{-1}	1.01	0.92	1.52
Rice husk biochar + Pleurotus + compost 1 kg.m^{-1}	1.18	0.87	1.71
Rice husk biochar + Pleurotus + compost 2 kg.m^{-1}	1.4	0.76	1.63

Table 2 shows the highest levels of P absorbed by shallots by rice husk biochar added with Pleurotus and 2 kg.m-1 compost. In addition to genetic characters and agroclimatological factors, shallot growth and production are also strongly influenced by cultivation methods. Cultivation methods consist of plant spacing, planting time, planting materials, and agricultural management such as fertilization and addition of growth hormones [1]. Nutrient absorption in shallots is influenced by the presence of cocoa pod husk compost with Pleurotus sp added to the planting medium in this research.

This is in line with research [22] which 9000 kg.ha-1 of livestock manure composted with Trichoderma biofertilizer, has a stronger positive impact on plant productivity and inhibits the negative effects of excessive use of organic and synthetic fertilizers. Other reports that the highest yield of shallot bulbs is obtained by applying 50% of the dose of N combined with 5 ton.ha-1 vermicompost [23], which can also reduce N leaching into groundwater and runoff to surface water, reducing N2O emissions, promoting N uptake through N2 fixation and soil health [24].

In this study, the absorption of N in shallot bulb tissue was also highest in the combination of biochar with Pleurotus and compost, corn cob biochar as well as rice husk biochar. However, according to reports [25], the compost given to shallots has a more significant effect than biochar. Giving 1 $kg.m^{-1}$ of municipal waste compost was more effective in increasing the yield of the Super Philip variety over the Bima Brebes and Medan varieties than just giving biochar. It is also proven by adding 2 kg/m of cocoa pod husk compost, which can increase shallot production by adding biochar alone or by adding Pleurotus (Table 3).

Table 3. Shallot yield with the addition of cocoa pod husk compost combined with biochar and Pleurotus sp

Organic application with 2 kg/m cacao compost	Bulbs wet weight	Bulbs dry weight	Bulbs diameter
	g/plot		cm
Rice husk biochar	103.44[a]	69.89[a]	54.13[a]
Rice husk biochar + Pleurotus sp	96.14[a]	66.83[a]	52.60[a]
Corncob biochar	80.8[b]	57.28[a]	48.40[a]
Corncob biochar + Pleurotus sp	94.50[a]	68.28[a]	54.50[a]

The addition of Pleurotus sp increased the shallot bulbs dry weight compared if only being given biochar alone. Sulfiani, Rahim, & Ilmi, 2020, reported that the combination of corn cob biochar treatment with Pleurotus sp increased the wet weight of shallot bulbs. It shows that composting cocoa pod husks, biochar, and Pleurotus sp are effective treatments to increase shallot production on sandy clay-textured land.

Acknowledgement. The authors would like to thank the Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia for funding this activity. Thanks a lot also for Wahyuddin, SP with kindly assistance in the field.

References

1. O. Askari-Khorasgani and M. Pessarakli, “Evaluation and cultivation methods and sustainable agricultural practices for improving shallot bulb production–a review,” *J. Plant Nutr.*, vol. 43, no. 1, pp. 148–163, 2020, doi: 10.1080/01904167.2019.1659329.
2. X.-B. Gu, H.-J. Cai, Y.-D. Du, and Y.-N. Li, “Effects of film mulching and nitrogen fertilization on rhizosphere soil environment, root growth and nutrient uptake of winter oilseed rape in northwest China,” *Soil Tillage Res.*, vol. 187, pp. 194–203, Apr. 2019, doi: 10.1016/j.still.2018.12.009.
3. S. P. Gautam, P. S. Bundela, A. K. Pandey, M. K. Awasthi, and S. Sarsaiya, “Diversity of Cellulolytic Microbes and the Biodegradation of Municipal Solid Waste by a Potential Strain,” vol. 2012, 2012, doi: 10.1155/2012/325907.
4. I. Rahim, S. Meriem, and E. H. Abdallah, “Organic Acids from Cocoa Pod Waste Inoculated by Basidiomycota Fungi to Enhance the Performance of Shallots,” *AGRIVITA J. Agric. Sci.*, vol. 44, no. 3, pp. 549–558, 2022.
5. I. Rahim, A. Nasruddin, T. Kuswinanti, L. Asrul, and B. Rasyid, “Utilization of Cocoa Pod Husk Waste Composting by Tremella Sp and Pleurotus Sp as A Medium to Growth of Cocoa

Seedling," in *IOP Conference Series: Earth and Environmental Science*, 2018, vol. 156, no. 1. doi: 10.1088/1755-1315/156/1/012012.
6. I. Rahim and A. Nasruddin, "The Ability of Rot Fungi From Cocoa Plant In Producing Lignocellulosic Enzymes The Ability of Rot Fungi From Cocoa Plant In Producing Lignocellulosic Enzymes," 2019, doi: 10.1088/1755-1315/270/1/012037.
7. S. P. Sohi, E. Krull, E. Lopez-Capel, and R. Bol, "A review of biochar and its use and function in soil," *Adv. Agron.*, 2010, doi: 10.1016/S0065-2113(10)05002-9.
8. C. J. Ennis, A. G. Evans, M. Islam, T. K. Ralebitso-Senior, and E. Senior, "Biochar: Carbon Sequestration, Land Remediation, and Impacts on Soil Microbiology," *Crit. Rev. Environ. Sci. Technol.*, vol. 42, no. 22, pp. 2311–2364, Jan. 2012, doi: 10.1080/10643389.2011.574115.
9. D. Trupiano *et al.*, "The effects of biochar and its combination with compost on lettuce (Lactuca sativa L.) growth, soil properties, and soil microbial activity and abundance," *Int. J. Agron.*, vol. 2017, no. i, 2017, doi: 10.1155/2017/3158207.
10. J. Rawat, J. Saxena, and P. Sanwal, "Biochar: A Sustainable Approach for Improving Plant Growth and Soil Properties," in *Biochar - An Imperative Amendment for Soil and the Environment*, IntechOpen, 2019. doi: 10.5772/intechopen.82151.
11. I. Rahim, A. Nasruddin, T. Kuswinanti, L. Asrul, and B. Rasyid, "Utilization of Cocoa Pod Husk Waste Composting by Tremella Sp and Pleurotus Sp as A Medium to Growth of Cocoa Seedling," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 156, no. 1, 2018, doi: 10.1088/1755-1315/156/1/012012.
12. U. Kurnia, F. Agus, A. Adimihardja, and A. Dariah, *Sifat Fisik Tanah dan Metode Analisisnya*. Balai Besar Litbang Sumberdaya Lahan Pertanian, Departemen Pertanian, 2006.
13. I. Rahim and A. Nasruddin, "Biodegradation of Cocoa Pod Husk Waste used Rot Fungi Consortium at Various Storage Times," 2019, doi: 10.4108/eai.2-5-2019.2284691.
14. W. Horwitz, "Official Methods of Analysis of AOAC International.," in *Agricultural Chemicals, Contaminants, Drugs.*, 17 th edit., W. Horwitz, Ed. Maryland: AOAC International, Maryland USA., 2000.
15. Sulaeman, Suparto, and Eviati, *PETUNJUK TEKNIS ANALISIS KIMIA TANAH , TANAMAN , AIR , DAN PUPUK*. Bogor: Balai Penelitian Tanah, Departemen Pertanian, 2005.
16. I. G. Edeh, O. Mašek, and W. Buss, "A meta-analysis on biochar's effects on soil water properties – New insights and future research challenges," *Sci. Total Environ.*, vol. 714, p. 136857, Apr. 2020, doi: 10.1016/j.scitotenv.2020.136857.
17. D. Laird, P. Fleming, B. Wang, R. Horton, and D. Karlen, "Biochar impact on nutrient leaching from a Midwestern agricultural soil," *Geoderma*, vol. 158, no. 3–4, pp. 436–442, 2010, doi: 10.1016/j.geoderma.2010.05.012.
18. A. Obia, G. Cornelissen, J. Mulder, and P. Dörsch, "Effect of Soil pH Increase by Biochar on NO, N2O and N2 Production during Denitrification in Acid Soils," *PLoS One*, vol. 10, no. 9, p. e0138781, Sep. 2015, doi: 10.1371/journal.pone.0138781.
19. A. Silber, I. Levkovitch, and E. R. Graber, "PH-dependent mineral release and surface properties of cornstraw biochar: Agronomic implications," *Environ. Sci. Technol.*, vol. 44, no. 24, pp. 9318–9323, 2010, doi: 10.1021/es101283d.
20. L. Johannes and J. Stephen, Eds., *Biochar for Environmental Management*. London: Earthscan, 2012.
21. S. Joseph *et al.*, "How biochar works, and when it doesn't: A review of mechanisms controlling soil and plant responses to biochar," *GCB Bioenergy*, vol. 13, no. 11, pp. 1731–1764, 2021, doi: 10.1111/gcbb.12885.

22. F. Zhang *et al.*, “Trichoderma Biofertilizer Links to Altered Soil Chemistry, Altered Microbial Communities, and Improved Grassland Biomass,” *Front. Microbiol.*, vol. 9, Apr. 2018, doi: 10.3389/fmicb.2018.00848.
23. Yohannes GK, Kebede W, Arvind C, Fikreyohannes G, “Effect of integrated nutrient management on growth, bulb yield and storability of onion (Allium cepa L.) under irrigation at Selekeleka, Northern Ethiopia. Int J Life Sci 5(2):151–160,” vol. 5, no. 2, pp. 151–160, 2017.
24. O. Askari-Khorasgani, H. Hatterman-Valenti, F. B. Flores, and M. Pessarakli, “Managing plant-environment-symbiont interactions to promote plant performance under low temperature stress,” *J. Plant Nutr.*, vol. 42, no. 16, pp. 2010–2027, Oct. 2019, doi: 10.1080/01904167.2019.1648682.
25. D. A. Luta, D. S. Hanafiah, and T. Sabrina, “Increasing the Productivity of a Few Varieties of Onion (Allium Ascalonicum L.) With the Aplication of Ameliorant,” *J. Community Res. Serv.*, vol. 1, no. 2, p. 49, 2018, doi: 10.24114/jcrs.v1i2.9335.
26. S. Sulfiani, I. Rahim, and N. Ilmi, “Perbuhan Dan Produksi Bawang Merah (Allium cepa) Pada Media Tanam Biochar Dan Pleurotus sp Parepare Sulawesi Selatan Prosiding Seminar Nasional SMIPT 2020 Sinergitas Multidisiplin Ilmu Pengetahuan dan Teknologi ,” in *Prosiding Seminar Nasional SMIPT 2020 Sinergitas Multidisiplin Ilmu Pengetahuan dan Teknologi ,* 2020, vol. 3, pp. 128–131.