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EFFECTIVENESS OF BIOCHAR AS SOIL AMELIORANT TO INCREASE SMALL SHALLOT BULBS YIELD FROM TRUE SHALLOT SEED (TSS) IN DRYLAND AGROECOSYSTEM

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ABSTRACT

The decline in soil fertility, characterized by extremely low organic matter content, isa common occurrence in agricultural land due to the intensified practices of crop production. These practices often involve the unwise application of chemical fertilizers and a lack of recycling agricultural waste as organic fertilizers. This study aimed to investigate the impact of biochar on the yield of small shallot bulbs grown from true shallot seed (TSS) in a dryland agroecosystem. The experimental trial was conducted using a randomized block design, incorporating two factors: organic amendments (biochar, manure, and biomass) and TSS varieties (Tuk-tuk, Sanren, and Trisula). The results demonstrated that the use of biochar, particularly in the Trisula variety, resulted in the highest production of mini-tubers, with an average of 4.5 tubers per seed. In comparison, the Sanren variety yielded 1.8 bulbs per seed, while the Tuk-Tuk variety yielded 1.2 bulbs per seed. Furthermore, the application of biochar had a positive influence on soil properties, such as increased levels of organic carbon (C-organic), availability of phosphorus (P-available), and cation exchange capacity (CEC) in dry soils. The utilization of biochar as an organic amendment demonstrated its potential to enhanceshallot bulb yield, particularly in the Trisula variety, within a dryland agroecosystem.

Keywords: Biochar, Shallot, Dryland Agroecosystem.

INTRODUCTION

The Indonesian government has set ambitious targets for shallot development, aiming for self- sufficiency by 2020 and even aspiring to become one of the exporting countries for shallots by 2024. To achieve these goals, various strategies are being implemented. One strategy involves the utilization of True Seed of Shallot (TSS) or seeds from seeds in shallot cultivation. Additionally, efforts are being made to develop new shallot production areas outside of existing centers. However, due to farmers' limited familiarity with using TSS seeds in shallot cultivation, the strategy of cultivating mini-shallots has emerged as a viable solution. Mini-shallots are intentionally produced as seeds from TSS propagation and are characterized by their small size (3-4g). The cultivation of mini-shallots involves planting the direct seeds (*tabela*) in close proximity to each other. When growing shallots using TSS seeds, this can be achieved either through seedlings obtained from TSS nurseries, typically aged between 40-45 days, or by utilizing mini-shallots.

The cultivation of shallots is expanding into new areas in West Nusa Tenggara, primarily focusing on dry land regions such as Empang District (Sumbawa Regency), Sakra District, East Sakra District, Pringgabaya District, Labuhan-Lombok District (East Lombok Regency), Tanjung District, and Bayan.

District (North Lombok Regency). One of the main challenges faced in these areas is the limited availability of organic matter in the soil. To address this issue, technological interventions are required, with one effective approach being the incorporation of soil improvers. Soil improvers can take various forms, including plant waste returned to the soil, shell charcoal (biochar), compost, and others. These additives have been reported to significantly enhance soil fertility and reduce the need for external inputs, thereby providing substantial benefits to soil quality and overall agricultural production. By utilizing soil improvers, the development of shallot cultivation in these new areas can overcome organic matter deficiency and improve the soil conditions for optimal plant growth. This intervention promotes sustainable farming practices by reducing dependency on external inputs while simultaneously enhancing soil fertility, which ultimately contributes to increased productivity and improved overall soilquality.

Biochar, a soil improvement material, is produced through the high-temperature pyrolysis of organic matter in a low-oxygen environment. Numerous studies have demonstrated the various benefits of adding biochar to improve soil quality. For instance, biochar can enhance soil physical and chemical properties and reduce the release of greenhouse gases, such as CO2 and CH4, into the atmosphere. The specific benefits of biochar application can vary depending on soil type (Laird D, et,al.,2010). Several studies have highlighted the significant role of biochar in improving soil properties.

Biochar has been found to positively impact soil physical and chemical characteristics (Major J, et, al., 2010, Karhu K, et, al., 2011, Lehmann J, et, al., 2009). Its application can lead to substantial reductions in fossil energy use in agricultural activities, ranging from 41% to 64% (Gaunt J L and Lehmann J, 2008), making it an important contributor to climate change mitigation efforts. The direct effects of biochar on soil properties have implications for crop productivity. Major et al. (2011) reported that maize yields can increase by up to 140% after four years of biochar application (Major J, et, al., 2010). However, the impact of biochar on crop productivity can vary significantly based on factors such as application method, application rate, and soil type. In general, biochar has been found to have a positive effect on crop productivity (Jeffery S, et, al., 2011). Moreover, the use of biochar in crop cultivation has been shown to increase soil organic carbon content and reduce methane (CH4) emissions, highlighting its importance in mitigating climate change (Feng Y, et, al., 2012, Whitman T, et al., 2009). These findings underscore the significant potential of biochar as a sustainable soil management tool that can enhance agricultural productivity while contributing to climate change mitigation efforts.

The impact of biochar on crop productivity is influenced by factors such as application method, application rate, and soil type. Generally, biochar has been found to have a positive effect on area productivity (Jeffery S, et, al., 2011)). Its utilization in crop cultivation has demonstrated the ability to increase soil organic carbon levels and decrease the release of methane gas (CH4), which contributes significantly to mitigating climate change (Feng Y, et, al., 2012, Whitman T, et al., 2009). Different types of biochar can affect the quality of soil amendment and its capacity to enhance soil quality, particularly in terms of (1) nutrient availability, (2) nutrient retention, and (3) water retention (Glaser B, Lehmann J and Zech W 2002). The objective of this study is to examine different soil amendment formulations, specifically biochar derived from peels, compost, and plant residues, when applied to the soil. The aim is to identify a soil improvement formula that can enhance the quality of dryland soil and improve both plant performance and shallot bulb yield.

MATERIALS AND METHODS

This study aimed to compare different soil amendment formulas (rice husk biochar, manure, and plant biomass/corn cob biochar) and their effects on shallot minituber yield in three TSS cultivars under dryland conditions. The experimental design employed a randomized block design with two factors: soil amendment formula (biochar, manure, and biomass) and TSS varieties (Tuk-tuk, Sanren, and Trisula), with four replicates. The study was conducted from April to July 2019 in Regency East Lombok, specifically on dryland with Inceptisol soil type. The parameters measured included the number of tubers/clumps, the average weight of tubers, and the weight of tubers/clumps. Additionally, data on precipitation, cultivation patterns, and soil quality were collected both with and without soil improvement to determine the research site's profile. The obtained outcome parameter data and result quality were subjected to analysis of variance with a significance level of 5%. Soil quality and precipitation data were analyzed descriptively

For minituber production, the TSS cultivars were directly planted (no-till) with narrow spacing of 4- 5 cm between seeds (TSS) and 10 cm between rows, resulting in a TSS requirement of approximately 10 kg/ha. TSS was initially grown in shaded beds for the first two weeks after sowing, following which the shade was removed and the plants were cared for in an open outdoor environment. Plant care practices included weeding, irrigation, controlling plant-disrupting organisms, and fertilization with NPK 16:16:16 up to 450 kg/ha, applied three times at 2 weeks, 1 month, and 2 months after planting, with a ratio of 20:40:40%. Tubers were harvested at 92 days after TSS application.

RESULTS AND DISCUSSION

Characteristic of dryland and soil properties at the research site

The study area for this research was characterized by Inceptisol soil type, which is typical for dryland conditions. In the years prior to the study, the region had an annual rainfall amount of less than 1000 mm. However, in 2019, when the study was conducted, there was a higher than usual amount of rainfall, measuring 1445 mm/year. This increase in rainfall was accompanied by a prolonged distribution period, which was attributed to climate anomalies. In such soil conditions, shallot cultivation can only be carried out once a year, specifically at the beginning of the rainy season, while waiting for the rice seedlings to reach the appropriate age for planting. This period, locally referred to as the "Selak Ampar" period, follows the traditional pattern of planting shallots after rice cultivation. However, due to the climate anomaly and the extended precipitation period in 2019, the cultivation pattern was altered to a shallot-rice-shallot sequence.

Table 1 shows that several soil improver formulations have different qualities, it can be seen that the soil improver in the form of rice husk *biochar* has lower water content, nutrient content of P and K and higher pH but lower C/N ratio as liquid manure and biochar from corn cobs. In general, biochar has a higher organic C content than manure, manure *has* a relatively higher moisture content and the highestC/N ratio.

Soil quality before and after applying the soil improver.

The results showed that the effect of differences in the form of the soil amendment formula was seen inC organic, P total, P available and CEC, while pH, N total were not affected by the form of the soil amendment formula (Table 2).

According to Table 2, the biochar formulations derived from rice husk and corn cobs demonstrated superior soil quality improvement compared to the manure-based formulations. Specifically, the biochar formulas resulted in higher yields due to their positive effects on various chemical properties of the soil, such as organic carbon content (C organic), phosphorus (P), total potassium (K), and cation exchange capacity (CEC). These properties were relatively higher when compared to the soil conditioners in the form of manure. In addition to the chemical properties, the application of soil conditioner also enhanced soil quality through its biological properties. This was indicated by higher microbial respiration parameters observed in the three tested formulations when compared to the soil without any soil conditioner. This increase in microbial activity is likely attributed to the rise in organic carbon content in the soil, which in turn stimulates the activity of microorganisms. Consequently, this leads to higher levels of phosphorus, total potassium, and CEC in the soil.

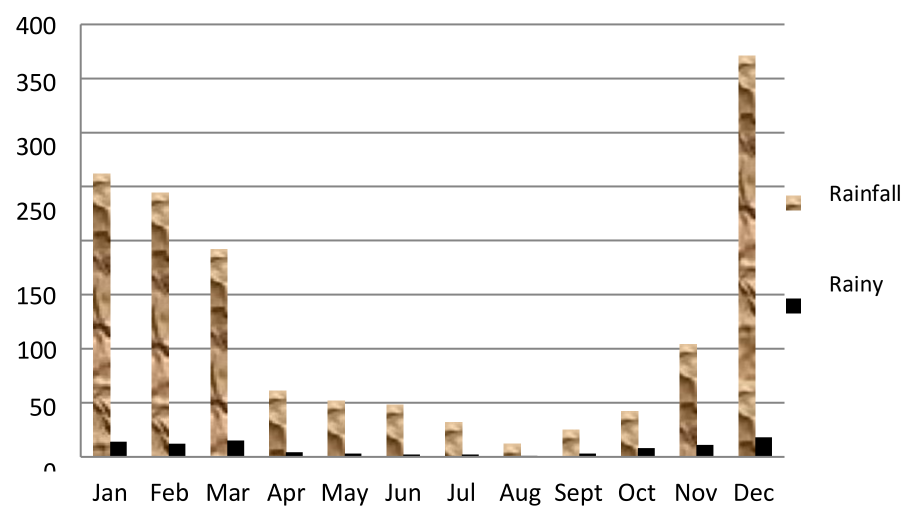

Figure 1. Distribution of precipitation in the district of Sakra in 2019.

Table 1. Soil improvement quality in different formulas in East Lombok Regency, 2019.

Parameter	Rice Husk Biochar	Fertilizer	Corn cob biochar
PhH2O	7.20	6.80	6.70
NA (%)	6.10	12.30 p.m	8.90
C - Org (%)	27.14	25.32	26.42
C/N (%)	21.00	24.00	22.00
P2O5 (%)	1.12	0.78	1.04
K2O (%)	1.48	0.76	0.88

Table 2. Soil Quality Before and After Soil Amendment Deployment.

Parameter	Before yougive floor repairs	After administration ofBiochar Husk	After spreading liquid manure	After the administration ofCorncob Biochar
PhH2O	6.8	7.2	6.8	6.7
C - Org (%)	0.74	0.91	0.88	0.87
P-total (mg/100 gr)	5.42	5.43	5.42	5.44
K-total (mg/100 gr)	2.90	6.48	5.76	5.88
P-available (ppm)	3.40	11.22	8.14	9.62
CEC (cmol(+)/kg)	5.10	5.45	5.20	5.20
Respiration of microorganisms (mg CO_2/kg soil/day)	9.88	11.92	10.70	10.70

Table 3. Average yield of cultivar treatments and several soil improvement formulas on bulb number, average bulb size and bulb yield in East Lombok Regency.

Treatment	Number of shallots (bulbs/clumps)	Average bulb size (gr/tube)	Bulb yield (tons/ha)
Diversity (V)	S	S	S
Formula (F)	S	NS	S
V x F. Interaction	NS	NS	NS
Tuktuk	1.1	7.8	9.8
Sanren Trisula	1.6	4.3	8.4
LSD 0.05	4.6	4.2	10.2
Biochar from rice husks	3.6	7.9	9.7
Fertilize	2.1	4.3	6.7
Biochar from corn cobs	2.4	4.3	10.1
LSD 0.05			

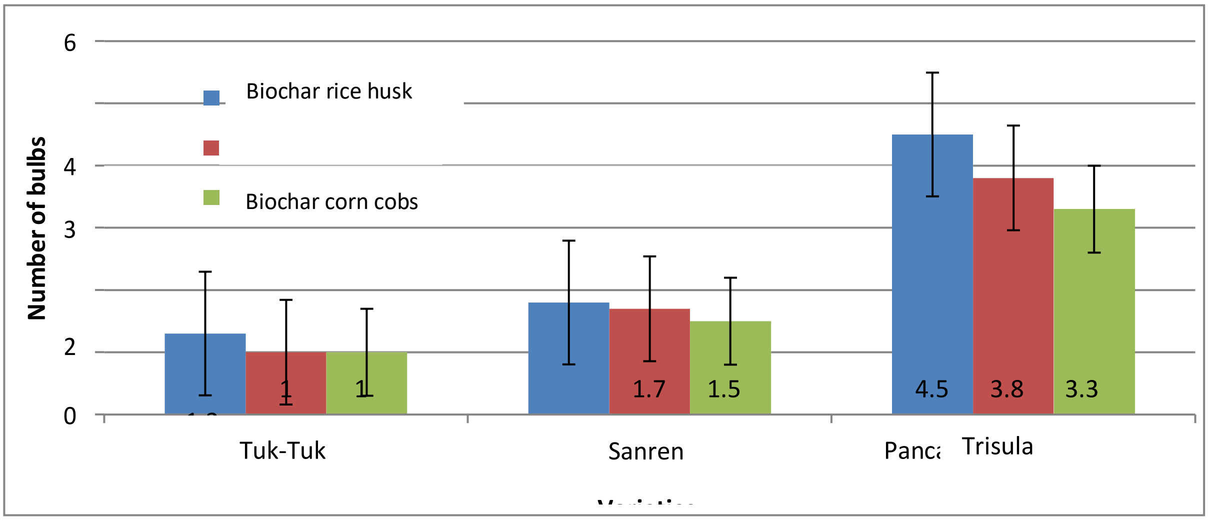

Figure 2. Results of bulb propagation by TSS.

The soil improvement results, particularly in the case of biochar formulations, also revealed a low carbon-to-nitrogen (C/N) ratio, which is indicative of a high organic carbon content. A low C/N ratio suggests that microorganisms readily utilize the soil conditioner as an energy source [10]. Thus, the high C-organic content resulting from the application of biochar formulations positively influenced soil quality by improving various chemical properties and enhancing microbial activity.

Propagation of True Seed of Shallot (TSS) in bulbs, yield and yield components

The TSS to bulb propagation ratio represents the relationship between one TSS grain and the number of bulbs produced by shallot plants. For mini bulb production, TSS is directly planted with a no- till approach, utilizing a very narrow spacing. The study results indicated that both the variety factor and the soil formula factor individually had a significant impact on the yield of shallot tubers.

However, the interaction between these two factors did not show a significant difference, as indicated by the findings in Table 3.

The targeted mini-bulb size of 3-4 grams per bulb, as mentioned by Rini Rosliani in 2016, was not achieved in this study. Instead, the average size of the mini-tubers ranged from 4-7 grams. Although the achieved bulb size falls within the small category, it should be noted that the cultivar used in this study naturally produces larger tubers compared to the defined mini-bulb size. Therefore, despite being classified as mini-tubers, the achieved sizes are relatively larger. Among the tested varieties, TukTuk Ariettas exhibited the largest bulb size, reaching 7.8 grams per bulb.

The larger size of the mini-tubers can be attributed to the application of additional soil conditioners in varying compositions for all varieties. As described in the section on resulting soil quality, the incorporation of biochar in the soil formulation improved soil quality in terms of both chemical and biological properties. This enhancement allowed plant roots to efficiently access soil nutrients, ultimately leading to optimal growth and increased yield.

The combination of Trisula cultivar treatment with the application of soil conditioner in the shell charcoal biochar formula resulted in the highest number of tubers produced from a TSS seed. Specifically, the Trisula cultivar with the shell charcoal biochar formula treatment yielded an average of 4.5 bulbs per clod. This implies that the propagation ratio for this particular treatment combination is 1:4.5, as shown in Figure 2.

CONCLUSION

The application of the rice hull biochar formula as a soil conditioner proved effective in enhancing soil quality on dry land, particularly in terms of chemical properties such as increased organic carbon content (C-organic), improved availability of phosphorus (P) and potassium (K), and an increase in cation exchange capacity (CEC). Furthermore, it also positively influenced the biological properties of the soil by promoting increased microbial respiration.

The TSS variety had a significant impact on determining the overall yield and yield components, with the exception of bulb size, which did not show any significant difference among the varieties. However, when considering the interaction between the TSS variety and the soil treatment, no substantial effects or differences were observed.

Among the various treatment combinations, the application of biochar derived from rice hulls in conjunction with the Trisula variety resulted in the highest plant and bulb propagation ratio of 1:4.5. This indicates a favorable outcome in terms of propagating new plants and achieving a higher number of tubers per clod.

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