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Abstract - *The agricultural area has continued to shrink and is a huge issue for agriculture-based countries, such as Indonesia. Contrary, the coastal sandy land area of Indonesia is large enough, but it has low productivity due to dominant soil constituent material of sand (>80%) so that it affects the availability of water and plant nutrient negatively. To improve the water-holding capacity, an applied technology is urgently needed so that it can be used as a growing material of sesame. A novel technology through the use of activated coconut shell charcoal was proposed. Due to its functions in optimizing growing medium, improving soil properties physically, chemically, and biologically as well as in holding water and providing nutrients, the used biological charcoal would work as biological soil amendments. The experiment was factorial design laid out in Randomized Complete Block Design involved 14 treatments with three replications consisting of combinations of seven biochar applications and two sesame varieties. The data were subjected to analysis of variance and Tukey's Honestly Significant Difference test were used as a post-hoc analysis (α = 5%). The experimental results showed that the highest oil content obtained from the application of coconut shell charcoal at a dose of 10 ton/ha combined with chicken manure at a dose of 30 ton/ha. The application of biochar more or less than 10 ton/ha combined with chicken manure decreased oil content. The significant effect on oil content was not found when the plant was treated only with the biochar at any dose level.*

***Key Words**: Coastal land, Biological soil amendments, Sesame varieties.*

1. INTRODUCTION

The background of this study was the continuous shrinkage of agricultural area because of change of function. It means that fertile soils as a home base for agriculture is getting lesser. Coastal sandy land area is one of alternatives, but it is classified as marginal land. Up to now, coastal sandy land has not been used yet by coastal society for agricultural activities because it is not suitable for growing plant. In fact, the use of marginal or impotent land, such as coastal sandy land for crop production actually becomes the innovation of natural land resources empowerment as well as society empowerment. The society around the coast is generally a part of poor society that socio-economically depends on coast or sea resources and commonly uses the land for certain crop, viz corn, coconut, and papaya. Meanwhile, the waste of coconut shell is only used for household need (dried for gasoline) instead of using it as an activated biological charcoal (biochar). As an industrial crop which is potent economically and highly nutrient, per 36 grams of seed contains 206.2 kal; copper 1.48 mg; Mn 0.88 mg; tryptophan 0.12 g; Ca 351 mg; Mg 126.36 mg; Fe 5.24 mg; P 226.44 mg; Zn 2.8 mg; B1 vitamin 0.28 mg; and fiber 4.24 g [1]. Sesame oil contains oil that ranges between 40 to 50% that is edible and has long shelf life more than one year without any deterioration due to its content of sesamol antioxidant, rich in unsaturated fats (especially oleic acid and linoleic acid [2].

Indonesia is export and import country for sesame either for dry sesame or oil. Meanwhile, the increased life quality of society is followed by the increased healthy life impact on food and industry need so that the prospect of sesame development showed high potency [3]. In 2007, the import value of sesame seed was as high as 2,862 ton with an economic value of US$1.28 million and of sesame oil in amount of 550 ton with an economic value of US$ 598 thousand [4].

The low content of clay, silt, and nutrient as well as low level of organic matter resulted the water to flow as fast as 150 cm/hour. In turn, the low level of saving water (1.6-3% of available water). The high speed of salty wind which is up to 50 km/hour. At day, high level of light intensity (109.960 lux), low level of moisture content which increase air temperature. The faster the speed of salty wind affects the plant evapotranspiration to increase. Daily soil temperature varies from 26.9 to 31.5 °C and sometimes exceeds up to 33.1 °C, loose texture of soil, high infiltration, high evaporation, and low soil fertility [5] so that naturally the coastal sandy land is not suitable for plant due to low level of fertility physically, chemically, and biologically. That is why the sandy land needs an important treatment if it is used to for plant production, especially for sesame.

As a way to cope that marginal land, the rehabilitation is needed through the application of biochar [6]. It was believed that an improvement or remediation of growing material through the application of biochar can turn marginal land into productive land. In order to obtain suitable growing medium to optimize sesame productivity, biochar is needed as it provides good environment for soil microbes, but it cannot be consumed by the microbes, retain and supply water and nutrient so that it is more available for the plant [7]. The use of biochar significantly affected root growth and plant biomass of *Rauvolfia serpentina* Benth. [8].

Charcoal is a porous solid state produced by pyrolysis of carbonated materials [9]. Some of porous charcoal is enclosed by hydrocarbon or another organic compound. The activation of charcoal is to remove the carbon so that it produces activated charcoal. Activated charcoal can be differentiated from common charcoal based on characteristics of outer surface. Outer surface of common charcoal is still covered with deposit hydrocarbon that inhibited its activation, whilst outer surface of activated charcoal relatively free from deposit and can absorb due to large surface and opened pores [10]. Activated charcoal is mostly used for cigarette, mask, drink, pharmaceutical, cooling machine industries [11]. Recently, this activated charcoal is developed as a soil conditioner for horticultural crops production [12].

Organically grown sesame will have a high value on the international market. The study about optimization of sesame production through amelioration by using organic fertilizers were done. In 2002—2004, an experiment was conducted involving four regions in India where the treatments tested were combination of organic fertilizers wood ash 75 ka/ha, manure 3.75 t/ha, compost of nimba 900 kg/ha, fish bone 75 kg/ha, Sulphur 20 kg/ha, phosphorus enriched with bacteria 5 kg/ha, azotobacter 5 kg/ha, and *Trichoderma viridae* (0.4%) yielded high BC ratio and net money return (NMR) [13]. The pot experiment about nutrient balance has been proved where the application of inorganic fertilizer (NPK) 25% and cow manure 75% on sesame grown under sandy soils increased number of pod [14]. The experimental result reported by [15] also reported that cow manure as high as 7.5 t/ha was able to increase mustard as many as 3.2 kg/m^2. [16] informed that cow manure of 15 t/ha produced onion bulb as many as 15.4 t/ha. Treatment with neem oil (2%) sprayed on sesame at 3.30 PM for 45 days yielded average of 782 kg/ha for all location with the peak amount was 786 kg/ha. [17] contributed to solve sandy land issues by the application of organic fertilizer and soil amendments as well as slow-release fertilizer in order to improve the availability of water and nutrient, to increase water holding capacity, faster aggregation, and reduce nutrient leaching because of available organic fertilizer found around the land. [18-19] stated that fertilizer applied at a dose of 22.5 to 45.0 kg N/ha on dry land, whereas fertilizer applied at a dose of 45.0 to 67.5 kg N/ha on paddy field; in fact, farmer at Nganjuk fertilized the sesame varied at a dose of 90-135 kg N/ha or equivalent to 200-300 kg urea/ha.

Besides, the use of organic ameliorant directly affect agroecology, oil content, soil health, and human health. The use of organic resources reduce the dependency of chemical fertilizer and pesticide. The experimental result showed that chicken manure at a dose of 30 ton/ha on sandy land productively increased yield [20] and the application of cow manure 10 ton/ha combined with NPK (100:100:50) caused total oil content more than 40% [21]. As well as the experiment conducted on Egypt recommended that the importance of bio fertilizer was to improve soil condition physically, biologically, and chemically and in long terms will show significant result on sesame growth, including its yield [22].

Near the coastal sandy land, leaf litter is still seen as a waste so it is burn. Consequently, the combustion will result CO and other gases and will increase greenhouse gas emission. Leaf litter can be used as mulches or processed as a compost so that it may serve as soil organic matter. However, the carbon inserted to the soil in form of compost and mulch will depleted as microbial activity in decomposing and producing CO and CH released to atmosphere. As a result, C-organic will decrease [23]. Therefore, in order to maintain soil organic carbon, the addition of organic matter in greater amount is needed every season. This such practice will increase greenhouse gas emission. There is another alternative to manage leaf litter to become organic matter stably, which is processing it to be a biochar [24]. Basic principle of producing biochar is combustion (pyrolysis) minimally with or without oxygen so that the carbon inside biomass tissue is not perfectly burnt and turned into biochar instead of ash and volatile CO. Biochar is organic matter that is resistant with microbial decomposition, so that its presence beneath the soil will last longer. The application of biochar is able to improve soil quality. Some crucial benefit after applying the biochar are to retain water holding capacity so that it saves irrigation, increase soil CEC, and restore soil acidity so that soil becomes more fertile. By the application of biochar, it meant that it saves more carbon beneath the soil and emission gas will be reduced. It also support the fixation

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and retention of nitrogen so that it reduces nitrogen leaching and emission of NO. In acid soil and toxic soil, biochar is able to decrease Al toxicity and other soil pollutant. Biochar is also able to increase number of beneficial soil microbes. Therefore, biochar will help farmer from the dependency with commercial fertilizer and it increases the growth and yield of plant [25-33]. This technology has been done by sugarcane farmer to manage sugarcane litter and turned it into biochar. They did that to restore the function of the land, to reduce carbon emission because CO fixed by leaf during photosynthesis will be stored in soil (sequestration) instead of releasing back to the air, and this technology is adaptive with climate change issue.

Sesame is an annual plant that is adaptively grown in dry land with harvest time of 2.5 to 5 months. During the growth, it needed rainfall between 400 to 650 nm [34]. Sesame is well known for farmers and widely grown at dry lands especially. The production of sesame is relatively easy with low risk, small inputs, easily grown with staple crop or industrial crop, and free from mammals so that it is suitable to grow at forest area [35]. Related to growing requirement, to obtain high production, high-yielding variety and high—quality seeds are needed, besides the land preparation, planting time, optimum population, perfect dose of fertilizer, well-maintained pest control, and good irrigation. The seeds used must have certification to warranty its purity and quality. The use of specific variety needs to concern with climate and growing condition as well as its habit and age. The seed requirement of monoculture production is 3-8 kg/ha and 2-3 kg/ha for polyculture production. In 1997, Sumberejo 1 (Sbr 1), Sbr 3, Sbr 4 with branching habit were released. Sbr 1 and Sbr 4 are suitable to grow at paddy land after growing rice, whereas Sbr 2 and Sbr 3 are suitable to grow at dry land [36].

Sesame is importantly one of oil producing plant from sub tropic to tropic region as well as source protein for arable land [37]. The importance of sesame value lays on the high productivity of sesame, such as oil content, protein, calcium, iron, and methionine. It indicated the increase of sesame production in Nigeria which exceeded more than 15,000 metric tons [38]. The oil is obtained by the extraction of pressed seeds. The resulting oil is highly influenced by growth condition and sesame variety. Sesame is suitable to grow around tropic area, at 1 to 1,200 meter above sea level, sensitive to low temperature, high rainfall, cloudy when flowering, optimally grown at 25-30 ^{o}C with full light, is classified as short plant with light length around 10 hours per day. The day length affects the production and the delay of planting will lower the production.

Sesame is optimally grown at any soil whether it is fertile and unfertile and best grown at fertile sandy clay soil with pH of 5.5. to 8.0, shallow soil. Besides, sesame requires good drainage and cannot be submerged so that the excess of water must be removed [39].

The description of two tested sesame varieties are shown in Table 1.

Table-1: Description of sesame varieties Sumberejo 1 and Winas 1

No.	Characteristics	Sumberejo 1	Winas 1
1.	Type	White sesame	White sesame
2.	Flower color	Purple	Pink
3.	Leaf color	Old green	Green
4.	Habit	More branches	Branches
5.	Plant height	120-160 cm	116-146 cm
6.	Harvest time	90-110 days	100-103 days
7.	Number of loculi	8	4
8.	Oil content	56%	50%
9.	Productivity potency	1-1.6 ton/ha	1-1.4 ton/ha

2. MATERIALS AND METHODS

This study was to determine the effect of the application of coconut shell charcoal on sesame yield grown on coastal sandy land area in Bantul, Indonesia. The materials prepared were seven types of biochar addition (control, P0; biochar at a dose of 5 ton/ha, P1; biochar at a dose of 10 ton/ha, P2; biochar at a dose of 15 ton/ha, P3; biochar at a dose of 5 ton/ha combined with chicken manure at a dose of 30 ton/ha, P4; biochar at a dose of 10 ton/ha combined with chicken manure at a dose of 30 ton/ha, P5; and biochar at a dose of 15 ton/ha combined with chicken manure at a dose of 30 ton/ha, P6), while two sesame varieties were M1 ('Sumberejo 1') and M2 ('Winas 1'). The equipment used were water sprinkler, thermo-hygrometers, tube solar meter type ELE 505-070, and the apparatus for laboratory analysis for oil content. The experiment were done at sandy land of coastal of Bantul during May to August 2017. A Randomized Complete Block Design (RCBD), were chose to the 7x2 factorial experiment, with three replications. The individual crops were planted in land. The observation were done on agronomic aspects (number of flowers, seed yield per plant, and oil content). The data were analyzed using analysis of variance (ANOVA) and Tukey's Honestly Significant Test (α = 5%) as a post-hoc analysis.

3. RESULTS AND DISCUSSIONS

The results in the following section are based on the order of statistical significance, which ranges from the highest level interaction to the main effects of treatments. From Table 2, the statistical analysis showed that type of biochar with sesame varieties interaction were not occurred in number of flowers, seed yield per plant, and oil content (P>F-value <0.05). Thus, the results are presented in a format corresponding to these significant interactions.

Table-2: P>F-value of main effects of types of biochar (C), sesame varieties (V) and their possible 2-way interactions for number of flowers (FLO), seed weight per plant (SWP), and oil content (OIL)

Source	d.f.	P > F-value		
		FLO	SWP	OIL
C	6	<0.0001	<0.0001	<0.0001
V	1	0.014	0.026	0.423
C×V	6	0.556	0.107	0.807
CV (%)		2.79	1.78	1.83

d.f., degree of freedom; CV, coefficient of variation

Significant interactions between types of biochar and sesame varieties were not found. It meant that either the addition of activated coconut shell charcoal and sesame varieties had independent effect so that it did not interact each other to affect the observed variables.

Table-3. Number of flowers in response to 2-way interaction of types of bio char and sesame varieties

Type of Biochar	Number of flowers		Mean
	Sumberejo 1	Winas 1	
P0	49.00	51.67	50.33 c
P1	50.33	50.33	50.33 c
P2	51.00	54.00	52.50 c
P3	58.67	60.33	59.50 b
P4	59.67	60.33	60.00 b
P5	63.00	63.67	63.33 a
P6	60.00	60.33	60.17 b
Mean	55.95 y	57.24 x	56.60 (-)

Means on each variable were subjected with Tukey's Honestly Significant Difference Test (α=0.05)

Number of flowers in response to types of biochar and sesame varieties can be seen in Table 3. The interaction between sesame varieties and types of biochar was not significantly found. Number of flowers of 'Winas 1' was greater than number of flowers of 'Sumberejo 1'. Meanwhile, the addition of types of biochar showed certain effects. Plant treated with biochar at a dose of 10 ton/ha added with chicken manure had most flower compared to other treatments, followed by charcoals at a dose of 15 ton/ha, biochar at a dose of 5 and 15 ton/ha added with chicken manure, whereas control plant and biochar at a dose of 5 and 10 ton/ha gave the least flowers.

Table-4. Seed weight per plant in response to 2-way interaction of types of charcoal and sesame varieties

Type of Charcoal	Number of flowers		Mean
	Sumberejo 1	Winas 1	
P0	9.17	9.20	9.18 f
P1	9.63	9.53	9.58 e
P2	9.77	10.20	9.98 d
P3	10.27	10.63	10.45 c
P4	10.77	10.90	10.83 b
P5	11.17	11.33	11.25 a
P6	10.83	10.73	10.78 bc
Mean	10.23 y	10.36 x	10.30 (-)

Means on each variable were subjected with Tukey's Honestly Significant Difference Test (α=0.05)

Seed weight per plant in response to types of charcoal and sesame varieties can be seen in Table 4. The interaction between sesame varieties and types of charcoal was not significantly found. Seed weight per plant of 'Winas 1' was heavier than those of 'Sumberejo 1'. The addition of biochar resulted various effects. Plant treated with biochar at a dose of 10 ton/ha added with chicken manure yielded heaviest seed weight per plant compared to other treatments, followed by biochar at a dose of 5 ton/ha added with chicken manure, and biochar from the highest to the lowest dose level. In fact, the addition of biochar at a dose of 15 ton/ha added with chicken manure showed similar results compared to biochar at a dose of 5 ton/ha added with chicken manure and biochar at a dose of 15 ton/ha. The lightest seed weight per plant was obtained from untreated plant.

Table-5. Oil content in response to 2-way interaction of types of biochar and sesame varieties

Type of Biochar	Number of flowers		Mean
	Sumberejo 1	Winas 1	
P0	40.00	39.83	39.92 d
P1	40.33	40.50	40.42 cd
P2	40.83	40.67	40.75 b-d
P3	41.33	41.17	41.25 b-d
P4	41.17	41.67	41.42 bc
P5	44.00	44.17	44.08 a
P6	41.50	42.50	42.00 b
Mean	41.31 x	41.50 x	41.40 (-)

Means on each variable were subjected with Tukey's Honestly Significant Difference Test (α=0.05)

Number of flowers in response to types of biochar and sesame varieties can be seen in Table 5. The interaction between sesame varieties and types of biochar was not significantly found. Oil content of 'Winas 1' did not significantly differed with that of 'Sumberejo 1'. The highest oil content obtained from the application of coconut shell biochar at a dose of 10 ton/ha combined with chicken manure. The application of biochar more or less than 10 ton/ha combined with chicken manure decreased oil content. The significant effect on oil content was not found when the plant was treated only with the biochar at any dose level.

3.1. General Discussions

The growth of sesame grown on coastal sandy soil, especially in the upcoming research stage was started with the germination. The development of sesame was slower at the beginning of observation until the first week after planting (WAP) and initiated into linear phase at 5 to 7 WAP, mainly at white sesame variety. The trend was also happened for productive variables, such as number of flowers, nitrate reductase activity, net assimilation rate, number of pods per plant, and oil content gave significant effect to some observed variables. The significant interaction effect also found for some observed variables. Most sesame varieties are an indeterminate type which was marked by the blooming of the flower. Leaves are the sole plant organ playing a main work in photosynthesis due to chlorophyll content which is absorbing the light. The increasing concentration of chlorophyll content is able to produce more assimilates in order to support the plant growth and development [40]. Oil producing plant, such as sesame can be developed by its metabolism activity and nutrient status. The composition of fatty acid from any seed of oil producing plant is mostly affected by its genetic status, but some is affected by nitrogen content because of its importance as an essential nutrition for oil producing plant as well as its seed development [41], whereas [42] stated that the increased N followed by the increased unsaturated fats and the decreased saturated fat in oil content of Flax seed. However, manure can supply nutrient that plant needed, improve soil structure, increase microbe population that lastly can increase the quality of production [43].

4. CONCLUSIONS

The highest oil content obtained from the application of biochar at a dose of 10 ton/ha combined with chicken manure at a dose of 30 ton/ha. The application of biochar more or less than 10 ton/ha combined with chicken manure decreased oil content. The significant effect on oil content was not found when the plant was treated only with the biochar at any dose level.

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