

Reducing Soil Strength and Increase Growth and Results of Paddy (*Oryza Sativa* l.) on Acid Sulphate Soil

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Abstract. The purpose of this research was to determine the effect of rice husk of biochar combined with inorganic and organic amendments on soil strength, growth and yield of rice plants on acid sulphate soils. The research phase was to identify the physical properties of soil in both regions and the measurement of field penetration resistance. Furthermore, conducting field research using a randomized block design (RBD), with the treatment consisting of; control soil (B0), rice husk biochar 6 t.ha-1 (B1), rice husk biochar 8 t.ha-1 (B2), rice husk biochar 10 t.ha-1 (B3), rice husk biochar 12 t.ha-1 (B4), recommended inorganic fertilizer package (B5), recommended inorganic fertilizer package and rice husk biochar 10 t.ha-1 (B6), 10 t.ha-1 (B7) manure fertilizer 10 t. ha-1 and rice husk biochar 10 t.ha-1 (B8). The research observations consisted of several physical properties of soil in BPTP land and farmer's land. Field penetration resistance is measured by determining the value of soil strength (DAIKI). Observation of growth variables in the maximum vegetative phase, consisting of; plant height and a number of tillers, while the yield variable is; a number of panicles per clump, and dry grain weight per clump. The results showed that the strength of the soil in the Experimental Field of BPTP West Kalimantan was 470 kPa and the farmer's land was 500 kPa. This condition indicated high soil compaction in paddy-based acid sulphate fields in the West Kalimantan Sungai Kakap.

Keywords: acid sulphate soil, biochar, soil strength, growth and result, paddy

INTRODUCTION

One of the land that is still available and has the potential for food development is acid sulphate soil,

which has a total area of 6.7 million ha spread across Sumatra, Kalimantan and Papua [1]. This soil has high levels of iron sulphate minerals with dominant pyrite content, and when drainage is carried out, it can release sulfuric acid, which in turn releases Fe, Al and other heavy metals that are harmful to plants and other living organisms.

In addition to this, the soil has unfavourable physical properties, including poor drainage, unstructured and immature soil. Poor soil drainage in acid sulphate soils is caused by high clay and soil organic matter in fulfilled conditions which will further inhibit the development of soil structure in the inner soil horizon. The relatively high clay content causes the macropores to become small so that it can cause soil strength (soil strength) to be high. From the physical aspect of the soil, one indicator of soil damage is the occurrence of soil compaction, which has an impact on soil strength. Soil compaction arises as a result of continuous intensive tillage which can result in accelerated decomposition of soil organic matter [2].

On the other hand, transportation of all plant biomass often occurs without the return of organic matter into the soil. In addition, the condition of acid sulphate soils which are in the tidal area allows an increase in soil DHL due to irrigation water during periods of dry seawater intrusion. The high DHL reflects the high Na⁺ ion so that it can trigger soil dispersion during processing. As a result, soil compaction will occur so as to inhibit the growth and development of rice plants.

To overcome physical obstacles in acid sulphate soils related to high soil strength is through the provision of soil amendments. One of the amendments that has the potential to reduce the strength of the soil is biochar combined with other organic management. The results of an incubation study in the laboratory reported by Masulili showed that soil strength decreased from 500 N.cm⁻² to 393.34 N.m⁻² in the

administration of rice husk biochar [2]. Thus, rice husk biochar has the potential to decrease soil strength. In line with this, a decrease in soil strength due to biochar amendments was also found by Chan et al. [3] on hard soil in Australia.

The nature of biochar is difficult to decompose so that it can last long in the soil or have a relatively long effect. At this time, the most potential crop residue for biochar production is rice husk [4]. Lehmann et al. added that residues from processing grains such as rice husk could be used to make biochar that can increase C-organic so that it can increase the growth of corn plants [5]. This increase in organic C will directly affect soil aggregation and decrease soil strength. In this connection, research by Masulili [2] has found that rice husk biochar can be used as an effective soil amendment to address acid soil problems in West Kalimantan, which can increase rice crop production. Masulili et al., also found that biochar coconut waste in acid sulphate soils in West Kalimantan could increase rice growth and yield [6].

METHOD

This research was conducted in the Experimental Field of the Agricultural Technology Assessment Center (BPTP) of Pal IX and Sungai Kakap farmer land in West Kalimantan Province with a time of 4 months. The initial phase of the study was to identify the physical properties of the soil in the two regions, then to conduct field research using a randomized block design (RBD). The treatment consists of; control soil (B0), biochar rice husk 6 t.ha-1 (B1), biochar rice husk 8 t.ha-1 (B2), biochar rice husk 10 t.ha-1 (B3), biochar rice husk 12 t .ha-1 (B4), recommended inorganic fertilizer package (B5), recommended inorganic fertilizer + rice husk biochar package 10 t.ha-1 (B6), manure 10 t.ha-1 (B7) manure 10 t. ha-1 + biochar rice husk 10 t.ha-1 (B8).

Field research was carried out by clearing weeds, ploughing, hoeing, destroying and piling soil. Then 1 x 2 m plot boundaries were made, 0.5 m plot spacing. Then each dose of soil amendment is mixed with the soil until it is evenly distributed at a depth of 0-10 cm. 20-day-old nursery seedlings are planted 1 month after granting the soil amendment, with a distance of 25 cm x 25 cm. During this experiment, the plants are maintained, and the water level is maintained 5-10 cm from the ground level until the primordia phase, then the water level is slowly reduced until harvest.

Observations of the study consisted of several physical properties of land in BPTP land and farmers' land. Observational data were presented descriptively in tabular form. Observation of soil penetration resistance is measured by determining the value of soil strength (DAIKI). Furthermore, the measurement

results are presented in soil strength profile drawings at depths of 0-10 cm, 10-20 cm, 20-30 cm, 30-40 cm and 40-50 cm.

In addition, the growth variable was observed in the maximum vegetative phase, consisting of; plant height and number of tillers, while yield variables are; number of panicles per clump, and weight of dried grain per clump. The data obtained were analyzed for variance at the 5% and 1% levels, and to find out the difference in mean values between treatments was carried out the smallest significant difference test (LSD) at the 5% significance level ($\alpha = 0.05$).

RESULTS & DISCUSSION

1. Soil Strength (Soil Strength)

In connection with soil strength (soil strength), intensive management of acid sulphate soils and the continuous transportation of plant biomass can have negative impacts, including soil compaction in the soil layer between 0-10 cm [2]. Therefore, land amendments are needed that can prevent soil compaction. The condition of the area in the tidal land at a certain period (dry season), irrigation water intruded by sea water which can increase salinity. In the dry season there is a salinity problem that can reach 10 ds / m. This condition can trigger an increase in soil dispersion during tillage (puddling) which allows an increase in soil compaction that can cause increased soil strength (soil strength) which in turn will affect the growth and production of rice. The results of the study in Table 1 show that soil compaction measured as resistance to acid sulfate penetration in the Kakap River in West Kalimantan was 470 Kpa on BPTP land and 500 Kpa on farmer's land.

Table 1. Some of the physical properties of the land in the BPTP Pal IX and farmers' landat Sungai Kakap West Kalimantan

Soil Phsycal Properties	BPTP Land	Farmer's Land
BI (gr/cm ³)	1,38	1,32
Soil Strength (kPa)	470	500
Total pore space (%)	44,36	45,19
Texture		
Sand (%)	1,36	1,85
Dust (%)	34,91	42,36
Clay (%)	63,73	55,79

As a result of applying rice husk biochar and its combination with organic and inorganic amendments to the penetration resistance of acid sulphate soil in Table 2, the strength of the control soil is no different than that of the soil given the recommended package

inorganic fertilizer (500 N.cm-2), due to the absence of supply organic matter. A decrease in soil strength has occurred in the treatment of 6 tons of rice husk biochar. ha-1 (450 N.cm-1) and decreases again when the biochar dose is increased.

Table 2. Effect of rice husk biochar and its combination with organic and inorganic amendments to the resistance of acid acid sulphate penetration in the month 1 month after incubation

Treatment	Penetration Resistance (N.cm ⁻²)
Soil Control	500 c
Biochar 6 t.ha ⁻¹	450 bc
Biochar 8 t.ha ⁻¹	450 bc
Biochar 10 t.ha ⁻¹	400 ab
Biochar 12 t.ha ⁻¹	400 ab
Ppk inorganic (N,P,K) recommended	500 c
Ppk inorganic (N,P,K)+biochar 10 t.ha ⁻¹	450 bc
Ppk manure 10 t.ha ⁻¹	450 bc
Ppk manure 10 t.ha ⁻¹ +biochar 10 t.ha ⁻¹	350 a

Note: Numbers followed by the same letter in the same column do not differ at the BNT test level of 5%.

The lowest soil strength achieved in the 10 ton ha-1 biochar treatment combined with 10 ton ha-1 cow manure (350 N. cm-2) decreased 30% compared to the control (Table 2). This occurs because of the presence of organic acids that can form organo-mineral complexes resulting in soil aggregation, and the presence of functional components of organic material added to the soil. Thus, the provision of biochar combined with organic amendments provides an opportunity to reduce soil strength (soil strength).

Provision of rice husk biochar and some organic amendments can improve some soil physical properties [2]. This change in physical properties occurs because organic amendments can cause soil aggregation, which is characterized by increasing porosity and decreasing soil BI.

The high value of soil fill weight on acidic, dry land causes soil compaction [7], and can increase soil strength. Related to the effect of biochar application and organic amendments, Widyantika and Prijono [4] have found that a decrease in the value of soil fill weight followed by an increase in the dose of rice husk biochar given to the soil. Furthermore, Melo et al. reported that the application of biochar is very beneficial to improve physical quality by improving soil weight that has an impact on reducing soil strength [8]. Furthermore, Kusumaet al. rice husk biochar has

a high lignin content so that it has an impact on the length of time of biochar decomposition [9].

The results of the measurement of soil strength profile (Figure 1), at a depth of 0-10 cm, the soil that was given inorganic fertilizer had higher soil strength than that which was given rice husk biochar, and the lowest soil strength reduction was achieved in the treatment of rice husk biochar combined with fertilizer cowshed. This means that the opportunity for soil compaction can occur if intensive rice farming only relies on the use of synthetic fertilizers. The effect on the strength of acidified acid sulfate soils is only found in the depth range of 0-20 cm.

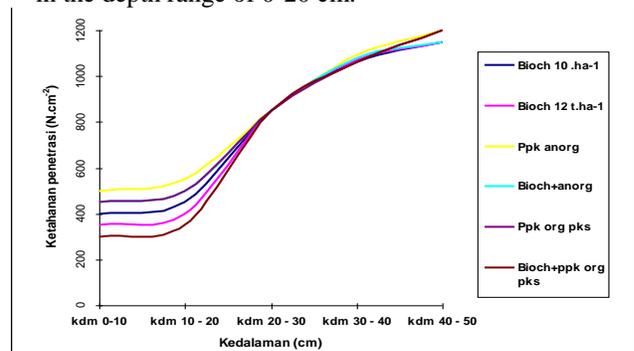


Figure 1. Field strength profile on various amendments soil

In line with the results of research by Wahyunie et al. also showed that penetration resistance in intensive tillage systems was higher when compared to the application of conservation tillage [10]. Therefore, the use of single or combined biochar combined with organic amendments is a good alternative in controlling soil penetration resistance. The results of WidyantikadanPrijono's research [4], giving rice husk biochar soil amendment with different doses have been able to improve the physical properties of the soil to optimize the growth of maize plants compared to soils not given biochar.

2. Growth and Yield of Rice Plants

The provision of biochar rice husk both single and combined with organic or inorganic fertilizers has an impact on increasing growth and yield of rice plants, which is indicated by an increase in plant height, number of tillers, number of panicles per clump and dry grain weight per hectare (Table 3).

The statistical test results are shown in Table 3, the growth and yield of rice plants increase with increasing single biochar dose, where the dry weight of rice in the biochar treatment of rice husk 12 t.ha-1 4.34 t.ha-1 is not different from biochar rice husk 10 t.ha-1 which reached 4.29 t.ha. The highest plant growth was achieved in the treatment of 10 t.ha-1

Table 3. Effects of rice husk biochar and its combination with organic and inorganic amendments on the growth and yield of rice in acid sulphate soils in the field.

Treatment	Plant Height (cm)	Amount of the tillers	Number of tassels per clumps	Weight of dried grain (t.ha ⁻¹)
Soil control	77.16 a	13.93 a	9.20 a	2.56 a
Biochar 6 t.ha ⁻¹	88.16 a	18.40 b	12.66 b	3.12 b
Biochar 8 t.ha ⁻¹	90.13 b	18.86 b	12.80 b	3.50 b
Biochar 10 t.ha ⁻¹	93.83 b	20.00 b	13.00 b	4.29 c
Biochar 12 t.ha ⁻¹	93.83 b	20.66 b	13.40 bc	4.34 c
Ppk inorganic (N,P,K) anjuran	90.20 b	21.00 bc	13.00 b	3.96 c
Ppk inorganic (N,P,K)+biochar 10 t.ha ⁻¹	95.83 c	22.26 c	13.86 c	4.66 d
Ppk manure 10 t.ha ⁻¹	85.76 b	19.40 b	12.00 b	3.82 bc
Ppk manure 10 t.ha ⁻¹ +biochar 10 t.ha ⁻¹	94.53 bc	20.00 b	13.33 b	4.50 cd

Note: The numbers followed by the same letters in the same column do not differ at the BNT test level of 5%.

biochar combined with recommended package inorganic fertilizer (120 kg N ha⁻¹, 90 kg P ha⁻¹ and K₂O 50 kg ha⁻¹), as well as rice yield, increased from 2.56 t.ha⁻¹ in the control soil to 4.66 t.ha⁻¹ in this treatment and was the highest yield, not significantly different from the results in the biochar treatment combined with cow manure which reached 4.50 t.ha⁻¹. Furthermore, the yield of rice plants in the recommended inorganic fertilizer treatment (120 kg N ha⁻¹, 90 kg P ha⁻¹ and K₂O 50 kg ha⁻¹) reached 3.96 t.ha⁻¹ was not significantly different from cow manure 10 t.ha⁻¹ which reached 3.82 t.ha⁻¹.

This indicates that the yield of rice plants increases with the treatment of rice husk biochar, and the increase in yield will be higher when biochar is given together with inorganic and organic fertilizers. This increase in growth and yield occurs because the treatment given has an effect on improving the nature of the soil, among which a decrease in soil strength (Table 1). Soil strength, as measured through soil penetration resistance, is one of the physical constraints of acid sulphate soils that can inhibit the growth and yield of rice plants. This is related to the inhibition of soil from the root range, which in turn can inhibit the growth and yield of rice plants. A decrease in soil strength will affect the development of plant roots. Zulkarnaen argues that root development will be hampered by the presence of mechanical soil barriers namely the higher strength and compaction of the soil which is determined by the amount of pore space and weight of soil contents [11].

In connection with this, Gani also found that the administration of biochar 20 t.ha⁻¹ caused the physical properties of the soil to be good, thereby increasing the ability of plants to absorb nutrients [12]. As a result, the growth and yield of rice plants increases.

CONCLUSION

1. The results of the study show that the strength of the land in the West Kalimantan BPTP Experimental Land is 470 kPa and 500 kPa farmers. This condition indicates the high level of soil compaction in rice-based acid sulphate land in the Sungai Kakap in West Kalimantan.
2. The lowest soil strength value achieved in the 10 ton ha⁻¹ biochar treatment combined with 10 ton ha⁻¹ cow 350 manure (350 N.cm⁻²) decreased 30% compared to the control.
3. In the field soil strength profile depth of 0-10 cm, soil that is given inorganic fertilizer has higher soil strength than that which is given rice husk biochar, and the lowest soil strength decrease is achieved in the treatment of rice husk biochar combined with cow manure (B8).
4. Increased growth and higher rice yield are achieved when biochar is given together with inorganic or organic amendments. Regarding rice yields, the best treatment was obtained on recommended inorganic fertilizer + biochar 10 t.ha⁻¹ (B6) to produce rice from 2.56 t.ha⁻¹ on the control soil to 4.66 t.ha⁻¹ but not different from organic fertilizer + biochar 10 t.ha⁻¹ (B8).

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