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The Functions of Biochar and Arbuscular Mycorrhizal Fungi to Increasing the Yield of Glutinous corn on sub-optimal land in a sustainability

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Abstract

This study aims to determine the role of biochar and mycorrhizal fungi in increasing soil fertility Inceptisols as suboptimal soil, which are poor in nutrients, low in carbon, and phosphorus, are suitable for planting of purple pulut corn (Zea mays ceratina Kulesh). This study used a randomized block design (RAK) with a factorial pattern of 3 replications, namely the dose of biochar (B) 0 t/h, 2 t/h, 4 t/h, and mycorrhizae (M) with a dose of 0 t/h, 0.2 t/h, 0.4 t/h. The data obtained were further tested with Duncan's multiple range test at a level of 5%. The application of biochar and mycorrhizae affected the number of leaves, days of flowering for males and females, and rows of This study aims to determine the role of rice husk biochar and mycorrhizal fungi in increasing soil fertility. Inceptisols, which are poor in nutrients, low in carbon, and phosphorus, are suitable for planting. There is an interaction in the administration of biochar 2 t/h + mycorrhiza 0.2 t/h on rows per row of purple pulut corn cobs. The application of biochar and mycorrhizae can overcome land infertility and provide the nutrients suitable for crops for supporting sustainable agriculture.

Keywords: Crops, Biochar, AMF, subobtimal land

1. Introduction

Marginal land or suboptimal land has the potential for agricultural development, especially food crops. Subobtimal land, has a low fertility rate and is sensitive to erosion causing low productivity. The low ability of sub-optimal lands either degraded due to exploitation of their use that does not heed the conservation aspects as well as the existence of both inherent constraints originating from the soil and its parent material, as well as external factors due to extreme climates (Mulyani et al, 2016)

Inceptisols are classified as marginal lands as immature soils with low pH (4.5-6.5), nutrients, and fertility as well as weak profile development with characteristics similar to the properties of the parent material. Utilization of Inceptisols in agricultural development is faced with obstacles such as the low element of Nitrogen and Phosphorus so that it is necessary to provide ameliorant and microorganisms that have an effect on improving soil characteristics that are environmentally friendly (eco-friendly) and sustainable. As stated by Nurmasyitah et al, (2013), Inseptisold Reuleut soil has low N and P elements, which are caused by intense leaching, as well as very low N elements from sources of organic metter.

In order to increase the quality and quantity of puffed corn yields on Inseptisol land, it is possible to use rice husk biochar and biotechnology applications with beneficial arbuscular mycorrhizal fungi (AMF).

Musafa et al. (2017) stated that the application of mycorrhizae to planting corn in Inceptisol soil was able to increase the available phosphorus by 16.94 ppm. Lack of Phosphorus can interfere with plant growth and root systems so that growth is stunted and stunted. Sufardi (2012) stated that P as a macro nutrient is needed in large quantities after nitrogen. Phosphorus plays a role in plant growth from the vegetative phase to the generative phase.

To increase soil fertility, Inceptisol Reuleut which is deficient in nitrogen and phosphorus nutrients (Rosnina et al., 2021) provides rice husk biochar which plays a role in improving soil aggregation and mycorrhizal fungi through their hyphae in mutual symbiosis by infecting the root system which allows nutrients to be in available form and can be used in the growth of purple pulut corn which is better than plants without treatment.

This research was conducted to improve the nutrient status of the Reuleut inceptisol soil as a subobtimal land with the addition of biochar and mycorrhizal fungi. The provision of rice husk biochar and AMF in increasing the absorption of essential nutrients needed by maize rice plants in an organic and sustainable manner.

2. Materials and Methods

This research was carried out in the Reuleut Inseptisol field in April-July 2021. The planting material used in this study was the USK 33 purple pulut corn strain, biochar, mycorrhizal fungi. While the equipment used is hoe, rake, pacak, raffia rope, meter, tugal, stake, hose, sprinkler, stationery and analytical scale).

This research was conducted using a factorial Randomized Block Design (RAK) method with two factors.

1. The provision of biochar (B) Consists of;
B0 : 0 t/h
B1 : 2 t/h
B2 : 4 t/h
2.Mycorrhizal (M) applications consist of:;
M0 : 0 t/h
M1 : 0,2 t/h
M2 : 0,5 t/h

Based on these treatments, 9 treatment combinations were obtained with 3 replications, so there were 27 experimental units. Biochar and mycorrhizal fungi were applied according to the dose on the surface of the beds spread 7 days before planting. Biochar application is done by sowing rice husk biochar evenly on the surface of the bed in accordance with a predetermined amount. Meanwhile, mycorrhizal application was carried out at 5g, 10g and 15g per planting hole, respectively.

Observation of the number of plant leaves by counting the number of leaves was carried out once a week until the 42nd day after planting (DAT). Days of flowering male and female flowers are determined after planting until the flowers have appeared 50% of the total population per bed.

The weight of the cob without the cob was determined after harvesting by removing the cob from the cob, then the cobs were weighed using a digital scale. The length of the cob without cob was measured after harvesting by removing the cob, measured using a ruler from the base to the tip of the cob. Observation of the number of rows per cob was carried out after harvest by counting the number of rows of seeds on each cob, along with the total weight of the cob

Observational data were analyzed statistically using a two-factor Randomized Block Design (RAK) analysis of variance and continued with the results of the variance if there were no significant different treatments, which showed F count < F table 5%, then no further test was carried out, but if it showed F count > F table then further test is carried out with Duncan's Multiple Range Test (DMRT) at 5% level.

3. Results and Discussion

The results showed that the administration of biochar 2t/h gave a significant to very significant effect on the variables, number of leaves, flowering days, length of cobs without cob, and overall weight of the cobs. According to Lelu et al. (2017) stated that this was presumably because biochar concentrated in the soil caused water and nutrient retention to increase so that the soil became fertile. Nutrient retention affects nutrients for plants, in addition it is suspected that the effect of biochar causes increased soil porosity, water holding capacity, organic C, and microbial activity in the soil.

The application of biochar with very high C-organic and P-available content in soils with moderate C-organic and high available P is thought to increase the soil organic matter content and available P-nutrients used by corn plants for their growth process.

In addition, the increase in plant growth is also influenced by mycorrhizae, this is presumably based on the results of research by Halis et al. (2008) stated that mycorrhizae can symbiotically with plant roots and play a role in increasing the absorption of phosphorus (P) and other nutrients, such as N, K, Zn, Co, S and Mo from the soil, increasing drought resistance, improving soil aggregates, increase the growth of soil microbes that are beneficial for plant growth.

Amount Of Leaves (Strands)

Based on the results of analysis of variance, it showed that biochar had a significant effect on the number of leaves at 7 and 14 DAP, but had no significant effect from 21 to 42 DAP. AMF application had no significant effect on the number of leaves

The administration of biochar as much as 0.2 t/h showed the highest average value of the number of leaves from the age of 7 to 42 DAP consecutively indicating an increase, the highest dose of biochar obtained the highest number of leaves, namely 10.93 leaves, but there was a significant difference in the level of 0 g/bed at 7 and 14 DAP, and the level of 4t/h at 7 DAP.

There was no interaction between biochar and mycorrhizae on the number of leaves. The effect of biochar and mycorrhizae on the number of leaves can be seen in Table 1.

The lowest number of leaves was found in untreated Inceptisol soil (control), which was 9.60 leaves, but from 21 to 42 DAP the presence of biochar did not give a significant difference.

The results of statistical tests showed that mycorrhizae alone did not give a significant difference at all ages of observation on the number of leaves, however, mycorrhizae at the level of 0 g/bed gave the highest average value of 7 DAP which was 3.48 strands, then from the age of 14 to 35 DAP, respectively. also gave the highest average value, namely 4.71, 6.08, 7.46, 8.92 strands, but the age of 42 DAP at the level of 240 g/bed which gave the highest average value of 10.46 strands.

Table 1. Average Amount of Leaves of Purple Pulut Corn Leaves USK 33 Line With Biochar and Mycorrhizae

Treatment	Amount Of Leaves (Strands)					
	7 DAP	14 DAP	21 DAP	28 DAP	35 DAP	42 DAP
Biochar (B)						
B0 (0 g)	3.04 b	4.22 b	5.40 a	6.57 a	8.08 a	9.60 a
B1 (1200 g)	3.74 a	5.02 a	6.30 a	7.57 a	9.25 a	10.93 a
B2 (2400 g)	3.17 b	4.51 a	5.84 a	7.17 a	8.62 a	10.06 a
Mycorrhizae (M)						
M0 (0 g)	3.48 a	4.55 a	5.62 a	6.68 a	8.22 a	9.75 a
M1 (120 g)	3.33 a	4.71 a	6.08 a	7.46 a	8.92 a	10.37 a
M2 (240 g)	3.14 a	4.48 a	5.83 a	7.17 a	8.82 a	10.46 a

Note : The numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test

Purple Maize Flower Day

Based on Table 2. It can be seen that the statistical test results for giving biochar alone 200t/h gave the best average value for the female flowering day variable, which was 52.68 DAP, not significantly different from the level of 2400 g/bed (0.4t/h) which was 53.82 DAP. , but significantly different to the level of 0 g/bed with an average value of 56.75 DAP. The results of the mycorrhizal statistical test alone did not give a significant difference to the female flowering day variable, but at the level of 1200 g/bed (0.2t/h) it gave the best value, namely 53.40 DAP.

In addition, the presence of AMF hyphae also plays a role in increasing the absorption of nutrients needed by plants such as N, P, K, and several microelements that can accelerate flowering days, respectively 4 and 7 days earlier, male flowers and female flowers appear on control corn plants.

The mechanism for increasing nutrients, especially phosphorus, which is needed throughout the growth

period of corn plants is related to the infection of AMF hyphae on the roots which is characterized by increased root hairs and root extension which allows absorption of nutrients in the soil to be maximally absorbed. This is in line with what was stated by Rosnina et al. (2021) found that the roots of the purple maize plant with mycorrhizal application had more root hairs than the roots of plants without mycorrhizae, thus enabling nutrients to be obtained to meet the needs of the generative phase with the emergence of early flowers than the untreated soil.

Table 2. Average Number of Several Parameters of USK 33 Strain of Purple Pulut Maize With Biochar and Mycorrhizae

Treatment	Male Flower(DAP)	Female Flower (DAP)	Cob without Shells(g)	Cob Length (cm)	Amount of Rows
Biochar (B)					
B0 (0 g)	54.55 a	56.75 a	126.03 a	18.47 b	14.88 b
B1 (2t/h)	51.82 a	52.68 b	165.90 a	21.30 a	16.51 a
B2 (4t/h)	52.08 a	53.82 b	153.46 a	21.26 a	14.93 b
Mychorrizae(M)					
M0 (0 g)	53.11 a	54.97 a	128.59 b	20.55 a	16.31 a
M1 (0.2t/h)	51.48 a	53.40 a	172.76 a	20.78 a	14.66 b
M2 (40t/h)	53.86 a	54.88 a	144.04 a	19.70 a	15.35 ab

Note : The numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test

Infection by AMF hyphae results in macronutrients, especially P being in available form, and good soil aggregation by the given biochar, macro elements such as Nitrogen and Phosphorus and some necessary microelements cause faster flowering days when AMF is given 0.2t/h, namely 51.48 days was the fastest compared to inceptisol soil without treatment, 54.55 days flower appeared as shown in Table 2. Flowering days on Inceptisol soil which was included in the sub-optimal land category that was nutrient-poor even though it had been treated with the addition of biochar and AMF was low when compared with flowering days for USK33 line purple pulut corn, which is approximately 49 days.

Cob Shells and Cob Without Shells

The results of the analysis of variance showed that biochar had a significant effect on the weight of cobs with cob. Mycorrhizae did not significantly affect the weight of the cobs with cabbage, nor did they show an interaction between biochar and mycorrhizae on the weight of the cobs and cob. The single application of biochar at the level of 1200g/bed gave the highest average value for the variable weight of cobs and cobs, which was 204.38 g, not significantly different from the level of 2400 g/bed, which was 194.72 g, but significantly different to the level of 0 g/bed with an average value. the lowest average is 155.28 g . The results of the mycorrhizal statistical test alone did not give a significant difference in the weight variable of cobs and cob, but at the level of 120 g/bed it gave the highest average value of 205.31 g as shown in Table 2. Biochar did not give a significant difference to the variable weight of cobs without cobs but the level of 1200 g/bed gave the best average value of 165.90 g while the level of 0 g/bed gave the lowest average value of 126.03 g. The results of a single mycorrhizal test at the level of 120 g/bed gave the highest average value of 172.76 g, not significantly different from the level of 240 g/bed which was 144.04 g, but significantly different to the level of 0 g/bed with an average value of 128.59 g.

The presence of biochar did not give a significant difference to the variable weight of cobs without cob, but the addition of 2t/h gave the best number, namely 165.90 g, while the lowest value was 126.03 g in the treated plant soil, while the highest value was 172.76 g in the AMF application of 0.2t/h, which was significantly different. with the weight of the cob without the control plant husk, namely 128.59 g

The presence of AMF hyphae can help the absorption of nutrients, especially phosphorus and resistance to drought. The mechanism of action of mycorrhizal hyphae occurs in plant roots by forming external hyphae that are able to provide the fixed P elements needed during the growth period, especially the generative phase, stimulate the photosynthesis process in the leaves so that the maize pulut plants can grow well on Inceptisol soils which are classified as land. marginal and increased yields even in conditions

of water shortage (Setiadi 1999; Talanca, 2010; Pangaribuan, 2014).

Amount Cob of Rows

The results of the analysis of variance showed that biochar and mycorrhizae had no effect on the number of rows per ear. Biochar alone did not give a difference in the variable number of rows per cob, but the level of 1200 g/bed gave the highest average value of 15.95. The mycorrhizal statistical test alone did not give a significant difference, but the level of 120 g/bed already gave the highest average value of 15.55 (data Table 2).

Cob Weight

The results of the analysis of variance showed that the application of biochar and mycorrhizae gave a very significant effect and there was an interaction on the weight of the corn cobs of pulut. As shown in Table 3.

Table3. Average Cob Weight of Beds Purple Maize Pulut Strain USK 33 With Biochar and Michorrizae

Treatment	Cob Weight of Beds (kg)	Ton/ha
Biochar (B)		
B0 (0 g)	4.90 b	8.17
B1 (1200 g/2t/h)	6.13 a	10.22
B2 (2400 g/4t/h)	5.70 a	9.50
Michorrizae (M)		
M0 (0 g)	4.60 b	7.67
M1 (120/0.2t/h)	6.80 a	11.33
M2 (240/0.4t/h)	5.20 b	8.67

Note : The numbers followed by the same letter in the same column are not significantly different according to the 5% DMRT test

Based on Table 3. shows that the results of a single biochar statistical test at the level of 1200 g/bed gave the highest average weight on the cob weight variable per bed, namely 6.13 kg, there was no significant difference with the level of 2400 g/bed which was 5.70 kg, but different. very significant at the level of 0g/bed, which is 4.90 kg. The results of a single mycorrhizal statistical test at the level of 120 g/bed showed the highest average value of 6.80 kg, significantly different from levels 0 and 240 g/bed with an average value of 4.60 and 5.20 kg. There was no interaction between biochar and mycorrhizae on number of rows per cob.

In Tables 1,2 and 3, mycorrhizal administration of 120 g/bed gave the highest value effect on all observed parameters. According to Pangaribuan's (2014) research, mycorrhizae can increase corn yields, even though they experience temporary drought in the vegetative and generative phases. Mycorrhizae have the ability to help roots to absorb nutrients, where the external hyphae of mycorrhizae that protrude into the soil will play a role in helping the plant root system. Nutrients absorbed by plant roots will be used to stimulate the process of photosynthesis in the leaves. The results of photosynthesis will be translocated to all parts of the plant for growth and development of maize plants.

The application of biochar 1200 g/bed gave the highest average value for the length of the cob without husks and the number of rows per ear. According to Chan et al. (2007) Biochar has micro pores that can be used as a habitat for microorganisms resulting in reduced competition between microorganisms so as to increase soil biological activity. The higher the activity of soil microorganisms, the higher the availability of nutrients in the soil so that plants can absorb nutrients properly and increase crop yields.

The presence of mycorrhizal hyphae also affects the length of the cob without corns and the number of rows per cob. This is in line with Erlita and Hariani (2017) in their research that mycorrhizae is a way to improve soil through a soil biotechnology approach by utilizing microorganisms. Biochar combined with mycorrhizae maximizes the work of the two soil-enhancing materials in improving and providing nutrients for plants.

pulut maize. Giving biochar 1200 g/bed + mycorrhiza 120 g/bed is the optimal dose in increasing the yield of purple pulut corn.

4. Conclusions

The application of Biochar and AMF on Inceptisol Reuleut soil can increase the growthand yield of purple

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