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Effect of Application of Sago Dregs and Rice Straw Biochar on Growth and Yield of Soybean (*Glycine max* L.) in Inceptisol

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Abstract. This research was conducted to determine the effect of giving sago dregs and rice straw biochar on growth and yield and to determine the correct dose of biochar for use in inceptisol soil. The research was conducted at the Experimental Garden of the Research Institute for Various Nut and Tuber Crops (BALITKABI) IP2TP Jambegede, Jl. Agriculture, No.6 Kemiri Village, Kepanjen District, Malang Regency – East Java. The design used was a Randomized Block Design (RBD), which consisted of 6 treatments and was repeated four times. There are 6 treatments, namely: P0 = without biochar; P1 = 100% rice straw biochar; P_2 = sago dregs biochar 100%; p_3 = sago pulp biochar 75% + rice straw biochar 25%; p_4 = sago pulp biochar 50% + rice straw biochar 50%; p_5 = sago pulp biochar 25% + rice straw biochar 75%. Observations included plant height, number of leaves, leaf area, seed weight per plant, and weight of 100 seeds. Data were analyzed using a variance test (Anova) by MS Excel. The results of this research show that the administration of sago dregs biochar and rice straw has a significant effect on yield and growth, where treatment (P3) with a mixture or combination of 75% sago dregs + 25% rice straw biochar, gave the best response compared to other treatments, with results reached 1.64 $t.ha^{-1}$. Thus, a mixture or combination of 75% sago dregs biochar + 25% rice straw biochar can be used in Inceptisol.

Keywords: biochar; sago dregs; rice straw

INTRODUCTION

Soybean (*Glycine max L Merril*) is a food commodity that plays an important role after rice, besides being a food ingredient and processed industry in Indonesia (Erlinda et al., 2019). Agricultural cultivation activities in Indonesia currently rely heavily on chemical fertilizer as a material that can increase land fertility and productivity. The use of chemical fertilizers over a relatively long period can cause the soil to harden quickly, be less able to store water, and promptly become acidic, which will ultimately reduce plant productivity (Amiroh et al., 2021; Purba et al., 2018)

Farmers still need to gain more knowledge in using production technology that supports sustainable agriculture, and fertile land resources are increasingly decreasing due to the continuous use of chemical fertilizers. This is because in previous activities, it was scarce for farmers to provide input from organic materials; some farmers even did not provide organic materials at all on their agricultural land; they were more confident that chemical fertilizers could provide better results than adding organic materials. The use of chemical fertilizers, which are expected to increase fertility, actually causes the quality of the soil to decrease, the soil texture to become hard, and the balance of nutrients is disturbed (Amin et al., 2019; Amiroh et al., 2021; Wulandari et al., 2023).

Agricultural land that is continuously cultivated, where there is no additional organic material or minimal input of organic material, will have low soil organic matter content (Yani Kamsurya & Botanri, 2022). Decreased soil fertility can be restored by adding organic material to the soil. No availability of nutrients within land because element Nutrients in the soil are used by microbes for the decomposition process of residues - previous crop residue. The stems and roots of plants that have not completely decomposed in the soil are utilized

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by microbes in the decomposition process to improve soil fertility so that it can be used for the following planting process (Siyum et al., 2022; Sukri et al., 2022).

Sago waste is the dregs of sago pith from which the starch has been removed, and sago farmers usually leave it on the land, as is the case on Papua Island (Wulandari *et al.*, 2023). In fact, sago dregs are very good for increasing soil and plant fertility (Amin *et al.*, 2019).This research aims to increase the growth and yield of soybeans and obtain the correct mixture ratio or dose by applying a mixture of biochar, sago dregs, and rice straw in Inceptisol soil.

METHODS

This research was carried out in May - August 2021 at the Jambegede Research Institute for Various Nuts and Tuber Crops (BALITKABI) Experimental Gardens, Jl. Agriculture, No.6 Kemiri Village, Kepanjen District, Malang District – East Java. The materials used are Anjasmoro variety soybean seeds, sago dregs biochar, rice straw biochar, Urea fertilizer, SP-36, KCl, and pesticides. The tools in this research include Pyrolysis equipment, analytical scales, a LAM (leaf area meter), stationery, an oven, and a camera.

This research used a Randomized Group Design (RBD) which consisted of 6 treatments, namely; P_0 = No biochar; P_1 = 100% Rice Straw Biochar; P_2 = Sago Dregs Biochar 100%; P_3 = Sago Pulp Biochar 75% + Rice Straw Biochar 25%; P_4 = Sago Pulp Biochar 50% + Rice Straw Biochar 50%; and P_5 = Sago Pulp Biochar 25% + Rice Straw Biochar 75%, which was repeated four times. Growth observations include Plant Height (cm), Number of Leaves (strands tan^{-1}), and Leaf Area (cm^2 tan^{-1}). Meanwhile, harvest components include Seed weight (g/plant) and 100 seed weight (g), and harvest yield (t/ha). Growth observations were performed 5 times since the plants were 14, 21, 28, 35, and 42 days after planting (DAP), with four samples from each treatment being observed.

Observations Leaf area was calculated using the estimation method (Widaryanto *et al.*,2019). The estimation method takes leaf samples and calculates the leaf area using LAM (As). Then, find the average leaf area ($\bar{A}$s) by dividing the total leaf area (As) by the number of leaves (n_s). The average value of leaf area ($\bar{A}$s) of the sample plant is used to calculate the leaf area of other plants (A_y) by counting the number of leaves of the sample plant (n_y), and multiplying it by the average value of leaf area ($\bar{A}$s).

Formula for calculating average leaf area:

$$\bar{A}s = \frac{As}{ns} \dots 1)$$

The formula for calculating plant leaf area:

$$Ay = ny \times \bar{A}s \dots 2)$$

Meanwhile, to calculate the yield of soybean plants, use the following formula;

$$\text{Harvest} = \frac{luas\ 1\ hektar\ (10.000m^2)}{luas\ petak\ panen\ (m2)} \text{x Weight of seeds per plot (g)} \dots 3)$$

Data analysis

Data were analyzed using a variance test (ANOVA) by MS Excel; if the test results show a significant difference, proceed with the Honest Significant Difference (BNJ) comparison test using a 5% level test.

RESULTS AND DISCUSSION

Plant height

The analysis of variance showed that the sago dregs and rice straw biochar treatments were significantly different at plant heights of 28, 35, and 42 DAP but were not significantly different at 14 and 21 DAP. The average plant height is presented in **Table 1**.

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Table 1. The average height of soybean plants given several biochar treatments

Biochar Treatment	Plant Height (cm tan $^{-1}$) at observation age (DAP)				
	14	21	28	35	42
P0	11.28	15.74	20.35 a	25.58 a	8.41 a
P1	10.89	14.06	21.98 ab	26.76 ab	30.27ab
P2	10.63	16.73	21.52 ab	27.22 ab	33.10 abc
P3	11.67	15.21	27.03 b	36.79 b	42.22 d
P4	10.19	14.89	21.50 ab	34.20 ab	38.74 cds
P5	11.07	14.66	22.64 ab	30.96 ab	36.45 bcd
BNJ (5%)	ns	ns	6.15	7.64	7.42
CV (%)	6.89	8.99	11.88	10.98	9.26

Note: Numbers adjacent to the same letter in the same column or the same age do not show significant differences in the 5% BNJ test; DAP: the day after planting; ns: nonsignificant; CV: coefficient of variation; P0: control (without biochar); P1: 100% rice straw biochar; P2: 100% sago dregs biochar; P3: sago dregs biochar (75%) + rice straw biochar (25%); P4: sago dregs biochar (50 %) + rice straw biochar (50%); P5: sago dregs biochar (25%) + rice straw biochar (75%)

The results showed that sago pulp biochar treatment, P3 sago pulp biochar treatment (75%), and rice straw biochar (25%) increased plant height (**Table 1**) when compared with other biochar treatment combinations. This is because sago dregs biochar has a high organic C content and C/N ratio. High organic C content can improve physical properties (water holding capacity and soil aeration). The ability to hold water and nutrients results in nutrients being absorbed and made available in the soil so that they can be absorbed by the roots and translocated to plant tissue in the vegetative formation of plants.

Table 2. The average number of leaves of soybean plants given several biochar treatments

Biochar Treatment	Number of Leaves (tan $^{-1}$) at observation age (DAP)				
	14	21	28	35	42
P0	3.81	5.13	6.44 a	9.31 a	12.41 ab
P1	3.69	4.81	6.69 ab	9.94 ab	12.68 a
P2	4.00	5.31	7.00 ab	10.06 ab	12.81 ab
P3	3.88	4.88	8.44 b	12.19 b	16.38 c
P4	3.63	5.00	7.24 ab	10.38 ab	13.55 BC
P5	3.81	5.19	7.56 ab	11.88 ab	15.25 ab
BNJ (5%)	Mr	Mr	1.89	3.01	2.63
CC (%)	6.63	6.05	11.35	12.27	8.27

Note: Numbers adjacent to the same letter in the same column or the same age do not show significant differences in the 5% BNJ test; DAP: the day after planting; tn: non-significant effect; CV: coefficient of variation; P0: control (without biochar); P1: 100% rice straw biochar; P2: 100% sago dregs biochar; P3: sago dregs biochar (75%) + rice straw biochar (25%); P4: sago dregs biochar (50 %) + rice straw biochar (50%); P5: sago dregs biochar (25%) + rice straw biochar (75%).

Apart from that, the support of rice straw biochar can increase the intake of high levels of organic material, providing additional nutrients that can support plant growth. This is in line with Gani (2009) who stated that adding biochar to the soil increases the availability of

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the main cations and available nutrients, acting as a soil conditioner that triggers plant growth by supplying and retaining nutrients. Furthermore, adding organic materials such as biochar to the soil can improve soil aggregates and increase the number of soil pores so that the soil becomes loose and ultimately, the absorption of nutrients by plants is better. The N, P, and K elements in the primary material of sago dregs biochar are very available. Soybean plants need the N element; soybean plants require nitrogen. In the growth process, especially during the vegetative growth (Aldave et al., n.d.; Kaza et al., 2018; Utami et al., 2020; Zewde & Purba, 2022).

Number of Leaves

The results of the analysis of variance showed that the sago dregs and rice straw biochar treatments were significantly different in the number of plant leaves at the ages of 28, 35, and 42 DAP but were not significantly different at the ages of 14 and 42 DAP. 21 DAP. The average number of leaves is presented in **Table 2**.

The results showed that P3 treatment (75% sago dregs biochar + 25% rice straw biochar) increased the number of leaves. This is because sago dregs biochar contains N, P, K, Ca and Mg nutrients. High nutrient content influences leaf formation. According to Sutiyoso (2008), the availability of nutrients, especially nitrogen, and Ca, influences cell division and elongation (elongation) and the formation of young leaves in general so that young leaves will form well and not curl or wavy. The Ca content in sago dregs biochar has a higher ratio than rice straw so the nutrient content is available in large quantities and can be optimized for faster growth of young leaves compared to other treatments. Apart from that, another important factor is the ability function of leaves to capture as much sunlight as possible as an energy source in the photosynthesis process. The greater the number of leaves allows more light energy to be captured in the leaves so that carbohydrates are produced for growth and yield production, such as the formation of a higher number of pods (Bohari et al., 2020; Kuboń et al., 2021; Purba et al., 2020).

Table 3. Average leaf area of soybean plants given several biochar treatments.

Biochar Treatment	Leaf area (cm ^{2} tons $^{-1}$) at maturity (DAT)				
	14	21	28	35	42
P0	16.25	38.16	45.80 a	59.99 a	91.29 a
P1	16.15	38.65	49.40 a	67.17 ab	118.00 ab
P2	16.55	47.05	52.22 ab	79.25 ab	112.64 ab
P3	18,20	40.71	67.51 b	118.9 c	175.05 c
P4	16.08	39.08	59.88 ab	86.95ab	136.30 b c
P5	16.60	43.88	1.04 ab	88.79 b	132.82 abc
BNJ (5%)	Mr	Mr	16.8	27.22	43.01
CC (%)	13,13	13.77	13.45	14,17	14.64

Note: Numbers adjacent to the same letter in the same column or the same age do not show significant differences in the 5% BNJ test; DAP: the day after planting; tn: non-significat effect; CV: coefficient of variation; P0: control (without biochar); P1: 100% rice straw biochar; P2: 100% sago dregs biochar; P3: sago dregs biochar (75%) + rice straw biochar (25%); P4: sago dregs biochar (50 %) + rice straw biochar (50%); P5: sago dregs biochar (25%) + rice straw biochar (75%).

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Leaf Area

The analysis of variance showed that the sago dregs and rice straw biochar treatments were significantly different in terms of plant leaf area at the ages of 28, 35, and 42 DAP but were not significantly different at the ages of 14 and 21 DAP. The average area of plant leaves is presented in **Table 3**.

Large leaf area is influenced by the adequacy of the nutrients N and P, which play an essential role in photosynthesis. The results showed that at 28 DAP, the P3 treatment (75% sago dregs biochar + 25% rice straw biochar) increased plant leaf area. The same thing was shown in the P4 treatment (sago dregs biochar (50 %) + rice straw biochar (50%). Meanwhile, at 35 - 42 DAP, the increase in leaf area was also influenced by the P3 treatment (75% sago dregs biochar + rice straw biochar 25%). This is because sago dregs biochar has a higher C-organic content and C/N ratio than rice straw biochar. The increase in organic C uptake in peanut plants due to biochar application is because the applied biochar material has the potential to conserve organic carbon, which can improve the physical, chemical, and biological properties of soil (Hamidi et al., 2021; Tando et al., 2017). Apart from that, the ratio of sago dregs, which is much higher compared to rice straw biochar, indicates that this biochar can provide more nutrients through its ability to retain water and high levels of nutrients in the soil so that the retained nutrients can be absorbed by the root hairs and in the soil. Translocated in plants in metabolic processes. The availability of nutrients, such as nitrogen, influences metabolic activity. Nitrogen is a constituent of all proteins and nucleic acids. The more nitrogen plants absorb, the wider the leaves will grow so that the photosynthesis process runs smoothly and the total plant biomass becomes greater. This is supported by (Erlinda et al., 2019); plants that receive sufficient N supply will form broad leaf blades with high chlorophyll content so that plants can produce assimilate in enough quantities so that they can support vegetative growth such as roots, stems, branches, fertile nodes, and soybean plant leaves.

Yield Components

Seed Weight, Weight of 100 Seeds, and Harvest Yield

The results of the analysis of variance on yield components showed that biochar treatment had a significant effect on seed weight (g tan^{-1}) and weight of 100 seeds (g) but had no effect on soybean yield (t.ha^{-1}). The average seed weight, weight of 100 seeds, and harvest yields of soybean plants given several biochar treatments are in **Table 4**.

Based on research, seed weight increased in the P3 treatment (75% sago dregs biochar + 25% rice straw biochar). This is due to the nature of biochar, which can retain water and nutrients in the soil, such as phosphorus nutrients, so that these nutrients are available in the soil, which help produce seeds and increase seed yields. This is supported by Anupong et al. (2022), who stated that adding biochar to the soil increases the availability of phosphorus, total nitrogen, and soil cation exchange capacity (CEC), ultimately increasing seed yield. Sari et al. (2019) also said the same thing. The more organic material added to the soil, the better the plant growth. Providing biochar helps retain nutrients so that they are available to plants, including phosphorus and potassium, which play an essential role in the generative process of plants.

The size of the seeds produced influences the quality of soybean seeds, so the larger the size of the seeds produced, the greater the weight of 100 seeds. This is supported by research that the P3 treatment (75% sago dregs biochar + 25% rice straw biochar) produces more weight of 100 seeds than other treatments. This is due to the higher dose of sago dregs biochar than rice straw biochar. Apart from that, the availability of P elements in the essential ingredients of biochar is also

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very influential in the pod-filling phase, thereby affecting the weight of the existing pods. The same thing was also stated by Zustika et al. (2021), who stated that adding biochar to the soil can also increase the availability of main cations and P elements, which play a role in plant growth by supplying and retaining nutrients. Biochar is a soil amendment material that can increase the elements N, P, and K in the soil. It can also meet the N needs of soybean plants through the decomposition and mineralization of organic fertilizer from the essential ingredients of biochar, sago dregs, and rice straw itself. The better the vegetative growth of soybean plants, the more the photosynthesis process will run well so that more photosynthesis is produced. Photosynthesis results from the vegetative phase to the generative phase and will be stored as food reserves in the form of carbohydrates in the form of seeds. The higher the photosynthate, the higher the seed yield (Muliarta & Purba, 2020; Zustika et al., 2021). The higher the photosynthate, the higher the results obtained. This aligns with research that P3 biochar treatment (75% sago pulp biochar + 25% rice straw biochar) increased soybean yield by 1.64 t ha^{-1}.

Table 4. The average seed weight, weight of 100 seeds, and harvest yield of soybean plants were given several biochar treatments.

Biochar Treatment	Seed Weight (g tan $^{-1}$)	Yields (t ha $^{-1}$)	Weight of 100 seeds (g)
P0	19.31 a	1.40	14.98 ab
P1	20.82 ab	1.37	14.88 a
P2	21.91 abc	1.51	14.99 ab
P3	25.05 c	1.64	17.11 b
P4	23.72 BC	1.51	15.73 ab
P5	22.51 abc	1.51	15.40 ab
BNJ (5%)	3.83	Mr	2.27
CC (%)	7.50	8.87	6.36

Note: Numbers adjacent to the same letter in the same column or the same age do not show significant differences in the 5% BNJ test; DAP: the day after planting; tn: non-significant effect; CV: coefficient of variation; P0: control (without biochar); P1: 100% rice straw biochar; P2: 100% sago dregs biochar; P3: sago dregs biochar (75%) + rice straw biochar (25%); P4: sago dregs biochar (50 %) + rice straw biochar (50%); P5: sago dregs biochar (25%) + rice straw biochar (75%).

CONCLUSION

Providing sago dregs biochar and rice straw on inceptisol land can increase the growth and yield of soybeans. The best combination is 75% sago dregs biochar + 25% rice straw biochar, where the seed weight results (g tan -1), with a seed weight range of 19.31 – 23.72 g tan -1, were not significantly different. The seed weight results, with a value of 25.05 g tan $^{-1}$, were substantially different from the other treatments.

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