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Effect of Rice Husk Bioactive Compost Charcoal Application on the Agronomic Characteristics of Peanut (*Arachis hypogaea* L.) on Alluvial Soil

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ABSTRACT

Peanut production on alluvial soil faced challenges due to low soil fertility. The application of soil amendments such as bioactive compost charcoal (BCC) was necessary to improve alluvial soil fertility. The aim of the study was to assess the effect of rice husk BCC application on the agronomic characteristics of peanut in alluvial soil. The research was conducted using a Completely Randomized Design (CRD) and analyzed using the F-test and Tukey's test at 5% significance level. The study design included 4 samples and 6 treatment levels: d_1 (20 g/polybag), d_2 (40 g/polybag), d_3 (60 g/polybag), d_4 (80 g/polybag), d_5 (100 g/polybag), and d_6 (120 g/polybag). The observation variables included plant height, number of branches, number of pods, pod wet weight per plant, and pod dry weight per plant. The data analysis results showed that the application of BCC had a significant effect on the agronomic characteristics of the peanut plants. The application of BCC at a dose of 120 g/polybag showed the best results and was recommended for use on alluvial soil with crop yield of of 31.72 g fresh pod or 24.86 g dry pod weight.

1. INTRODUCTION

Peanut (*Arachis hypogeae* L.) production in 2023 reached 350.06 thousand tons, experiencing a decrease of 29.91 thousand tons or 7.87 percent compared to peanut production in 2022, which was 379.93 thousand tons. To meet domestic peanut demand, most of the supply was still imported, making efforts to increase peanut production necessary (Direktorat Jenderal Tanaman Pangan, 2024). Suboptimal lands, such as alluvial soils, could be used to increase peanut production. The alluvial land area in West Kalimantan, approximately 1,793,771 hectares, is highly suitable as a substitute for the increasingly scarce fertile land (BPS, 2016). Alluvial soils, formed from the deposition of fine sediments along riverbanks and floodplains, presented a unique set of challenges for the cultivation of peanuts (Chen *et al*., 2018). These soils were often characterized by nutrient deficiencies, high soil acidity levels, and poor drainage, which could hinder the growth and productivity of peanut crops (Diallo *et al*., 2016).

One of the main concerns with alluvial soils was the lack of essential nutrients needed by plants. This nutrient imbalance could result in stunted growth and reduced crop yields. Additionally, the high concentrations of iron, manganese, and aluminum in these soils could be toxic to peanut plants, exacerbating the challenges faced by farmers (Singh *et al*., 2022). Another significant problem with alluvial soils was the low organic matter content, which could lead to poor soil structure and reduced water-holding capacity. This, in turn, could make the soil more susceptible to waterlogging and compaction, making it difficult for farmers to manage the soil and prepare it for planting (Kögel-Knabner & Amelung, 2021).

Bioactive compost charcoal (BCC) is a promising soil amendment for improving the fertility of alluvial soils. The biochar in BCC enhances the composting process by increasing humification, boosting microbial activity and diversity, reducing nitrogen loss and bulk density, and increasing pH, CEC, total carbon, organic matter, and nutrients (Antonangelo *et al*., 2021). BCC had been shown to increase total soil carbon, nitrogen, and phosphorus, stabilize soil aggregates, and stimulate soil microorganism activity. BCC enhances microbial activity by increasing air circulation, reducing soil density, raising compost temperature, reducing ammonia loss, increasing water-holding capacity, reducing nutrient loss through percolation, and enhancing humification (Teodoro *et al*., 2020; Asadi *et al*., 2021).

Previous research indicated that the use of BCC could improve the growth of Desho grass and the properties of acidic soils in Ethiopia (Shifa *et al*., 2023), the physical and chemical properties of metal-contaminated soils (Görl *et al*., 2023), wheat growth and biomass (Gao *et al*., 2022), agronomic characteristics in lettuce (Trupiano *et al*., 2017), rice (Ali *et al*., 2023), and maize (Nurida & Jubaedah, 2022). Research by Suyanto *et al*. (2019) demonstrated that the use of BCC from coconut shells could increase plant height, the number of tillers, and grain weight in alluvial soils. Utilizing rice husk as a material for BCC was very beneficial because most farmers just discarded and burned the husks in the fields. By doing so, farmers could reduce planting costs and air pollution caused by burning in the fields (Dhaliwal *et al*., 2022). Therefore, this research was necessary to observe the agronomic characteristics of peanut plants in response to the application of BCC from rice husks on alluvial soils. The results of this research are expected to serve as a reference for the use of environmentally friendly and sustainable BCC, as well as for improving peanut production on alluvial soil.

2. MATERIALS AND METHODS

Tools such as scales, tarps, a straw chopping machine, and a mortar and pestle were used. The materials included charcoal from husks, rice straw, duck manure, *Trichoderma* sp., bran, and clean water. The research was conducted from April to July 2022 in the Green House of the Faculty of Agriculture at Panca Bhakti University, Pontianak. A Completely Randomized Design (CRD) was used in the study, consisting 6 treatment levels of BCC doses, namely: D1 (20 g/polybag), D2 (40 g/polybag), D3 (60 g/polybag), D4 (80 g/polybag), D5 (100 g/polybag), and D6 (120 g/polybag). Gajah variety was selected for seeds used in this experiment. Each treatment was replicated 4 times.

Soil samples were collected compositely from a depth of 0-30 cm and subsequently sent to the Soil Laboratory at Tanjungpura University in Pontianak. The nutrients and analysis methods used included organic carbon (Walkley and Black method), total nitrogen (Kjeldahl method), calcium, magnesium, potassium, sodium, cation exchange capacity (CEC), and base saturation using the NH4OAC 1N extraction method, aluminium and hydrogen using the KCl 1N extraction method, pH (measured with a pH meter), along with supporting data such as soil texture (pipette method). The analysis results were compared with soil fertility standards provided by Sulaeman *et al*. (2009). The BCC samples were also sent to the Soil Laboratory at Tanjungpura University for content analysis. The research was carried out according to the following stages (Figure 1).

Figure 1. Research flowchart

1. Preparation of Planting Media

Two weeks before planting, alluvial soil was taken from a depth of approximately 20 cm and air-dried for 7 days. The soil was cleared of debris, then sieved to obtain a loose medium. After sieving, the soil was placed into polybags measuring 40 x 50 cm, with 8 kg of soil per polybag.

2. Preparation of BCC

About 5 kg of husk were burned into charcoal for 20 h, 10 kg of straw were chopped, 5 kg of duck manure were prepared, and 20 g of *Trichoderma* sp. were used at a ratio of 1 g per kg of compost, along with 1 kg of bran. These materials, including husk charcoal, rice straw, duck manure, *Trichoderma* sp., and bran, were mixed on a tarp and then moistened with water. The compost materials were wrapped with a tarp to maintain the composting temperature between 38°C - 50°C. One week after composting, the wrap was opened to mix the compost materials evenly. After 2 weeks, the compost was applied in the research.

3. Application of BCC

The application of BCC was done once, one week before planting. The BCC was weighed according to the treatment dose for each polybag, mixing it with 8 kg of soil in each polybag.

4. Planting

Planting was done one week after the treatment was applied to the planting media. During the planting process, it was important to make planting holes about 1-2 cm deep. The seeds were then carefully placed into the holes, with the recommended amount being 2 seeds per planting hole, and then slightly covered with loose soil.

5. Fertilization with NPK Mutiara

NPK Mutiara fertilization was done 2 weeks after planting with a recommended dose of 200 kg/ha. Each sample plant received a dose of 1 g/polybag.

6. Maintenance

Maintenance included watering, replanting, weed control, hilling, and pest and disease control.

7. Harvesting

Ninety days after planting, peanuts were harvested when the stems began to harden, the leaves turned yellow and began to fall off, the pods were fully filled and hardened, and turned dark brown. The research parameters observed included plant height, number of branches, number of pods, wet weight of pods per plant, and dry weight of pods per plant. Data analysis used the F test and Tukey (HSD) test at the 5% level.

3. RESULTS AND DISCUSSION

3.1. Soil Analysis

The soil analysis results are presented in Table 1. The availability of nutrients in the alluvial soil studied ranged from low to very high, as indicated by the variables total nitrogen, P_2O_5, and potassium (Table 1). The Cation Exchange Capacity (CEC) of the soil was very high, suggesting that the soil had a strong capacity to exchange base cations and that the availability of plant nutrients could change (Sharma *et al*., 2018). However, the acidic soil pH (4.79) and very low base saturation were major concerns.

The level of base saturation is directly correlated with soil acidity; if the soil acidity is high, the base saturation (BS) will be low, and conversely, if the soil acidity is low, the BS will be high. BS reflects the ratio of base cations to the total cations in the soil solution. Adequate base cations will meet the nutritional needs of plants, as indicated by a high BS level (Sharma *et al*., 2018). The electrochemical properties of soil colloids are influenced by chemical reactions, which in turn regulate the impact of soil pH on the availability of plant nutrients (Barrow & Hartemink, 2023).

Highly acidic conditions can limit the availability of certain nutrients; for example, iron phosphate does not dissolve in acidic conditions and will bind with phosphorus, significantly limiting P availability (Manurung *et al*., 2017). The organic carbon parameter showed a value of 3.67% (high). The presence of organic carbon plays a crucial role in assessing the quality of mineral soil; the higher the total organic carbon content, the higher the soil quality (Penn & Camberato, 2019). Peanut plants require sufficient macro and micronutrients during their growth (Herman & Resigia, 2018).

Table 1. Alluvial soil properties

Parameters	Unit	Value	Category
pH H_2O	--	4.79	Acid
pH KCl	--	4.05	
C-organic	%	7.01	Very high
Total Nitrogen	%	0.82	Very high
P_2O_5 (ppm)	ppm	12.01	High
Calcium	cmol(+)/kg	1.88	Very low
Magnesium	cmol(+)/kg	0.83	Low
Kalium	cmol(+)/kg	0.30	Low
Natrium	cmol(+)/kg	0.49	Adequate
CEC (cation exchange capacity)	cmol(+)/kg	30.23	High
Base Saturation	%	11.58	Very low
Aluminium	cmol(+)/kg	0.63	
Hidrogen	cmol(+)/kg	3.52	
Soil Texture			Silty clay
Sand	%	3.46	
Silt	%	43.84	
Clay	%	52.70	

3.2. Analysis of BCC

Based on Table 2, the results of the BCC analysis showed that the N, P, and K contents did not meet the standards, although the levels were quite high. The pH and organic C content also met the minimum requirements for organic fertilizer content as per the decree of Agriculture Minister (Menteri Pertanian, 2019). The high organic C content indicated the potential of BCC to increase soil organic matter, which is important for soil fertility and structure. Therefore, with these nutrient contents, bioactive compost charcoal can potentially serve as a source of organic material to improve suboptimal soil conditions such as alluvial soil.

Table 2. Results of rice husk biochar compost analysis

Parameters	Unit	Value	Quality Standards	Criteria
pH	--	7.33	4-9	Standard compliant
C-organic (%)	(%)	38.15	15	Standard compliant
N (%)	(%)	2.67	4	Standard compliant
C/N Ratio	--	14.29	15-25	Non-compliant
P (%)	(%)	1.52	4	Non-compliant
K (%)	(%)	1.08	4	Non-compliant
Ca (%)	(%)	0.16	-	
Mg (%)	(%)	0.12	-	

3.3. Growth and Yield of Peanut Plants

Tabel 3 meringkas pengaruh aplikasi perlakuan dosis BCC terhadap karakteristik dan hasil tanaman peanut. Based on the results of the 5% ANOVA test, all observation parameters showed a significant effect ($P<0.05$). The summary of the 5% ANOVA test results is presented in Table 4.

Table 3. Agronomic characteristics of peanut plants after BCC application in alluvial soil

Treatments	Plant Height (cm)	Number of branches	Number of pods	Fresh pod weight (g)	Dry pod weight (g)
D1 (20 g/polybag)	38.67^{a}	4.42^{a}	6.67^{a}	14.85^{a}	11.87^{a}
D2 (40 g/ polybag)	43.58^{ab}	4.83^{ab}	7.96^{ab}	16.83^{ab}	15.08^{ab}
D3 (60 g/ polybag)	50.67^{ab}	5.50^{ab}	12.50^{bc}	21.82^{abc}	18.09^{abc}
D4 (80 g/ polybag)	54.50^{bc}	5.50^{ab}	14.42^{c}	27.73^{bc}	21.57^{bc}
D5 (100 g/ polybag)	56.50^{bc}	5.75^{b}	16.08^{c}	29.42^{c}	23.87^{c}
D6 (120 g/ polybag)	65.00^{c}	6.08^{b}	17.42^{c}	31.72^{c}	24.86^{c}

Note: Mean values significantly differed in the Tukey's test at 5%, indicated by different letters

Table 4. Summary of F-count from ANOVA for all observation parameters

Plant height (cm)	Number of branches	Number of pods	Fresh pod weight (g)	Dry pod weight (g)	F-table 5%
9.33*	4.58*	14.74*	6.32*	7.77*	2.77

Note: * = Significant

3.3.1. Plant Height

Treatment D6 showed a significant difference compared to treatments D1, D2, and D3, but no significant difference compared to treatments D4 and D5. At the treatment level D6, the highest average peanut plant height was 65.00 cm, while the lowest was at treatment level D1 with 38.67 cm. Increasing the BCC dosage also showed an increase in plant height (Table 3).

This was due to the supply of macro nutrients N, P, K, Ca, S, and Mg, as well as micro nutrients present in the BCC, which were effectively utilized by the peanut plants, meeting their growth needs. The increase in plant height is also suspected to be due to the role of BCC rice husk in increasing soil organic matter content, which in turn can improve the physical, chemical, and biological properties of alluvial soil, thereby supporting better peanut plant growth (Li *et al*., 2023).

3.3.2. Number of Branches

Treatment D6 showed a significant difference compared to treatment d_1 but no significant difference with the other treatments. Treatment D6 showed a relatively higher number of branches compared to the other treatments (Table 3). The nutrient content that meets the needs for peanut plant growth in BCC results in a higher number of branches in treatment d6 compared to other treatments. The application of organic fertilizer with a complete nutrient content enhances plant growth and soil fertility. Peanut plants require optimal macro and micro nutrients, so treatment d6 is effective in supporting peanut plant growth. This research result is also in line with the study by Agegnehu *et al.* (2016), which showed that the application of BCC can improve peanut plant growth on Ferralsol.

3.3.3. Number of Pods

Treatment D6 showed a significant difference compared to treatment D1 and D2 but no significant difference with D3, D4 and D5. Treatment d_6 showed a relatively higher number of pods compared to the other treatments (Table 4). The nutrient content that meets the needs for peanut plant growth in BCC results in a higher number of pods per plant in treatment D6 compared to other treatments. Plant development is closely related to cells. The availability of N, P, and K in sufficient amounts affects the transportation of phosphorus and the formation of chlorophyll in the leaves, leading to optimal formation of proteins, fats, and carbohydrates in the plant (Mondal *et al*., 2020). Consequently, this results in higher plant growth and pod production. Nutrients are a key factor determining plant growth and yield. Optimal growth requires a balanced supply of nutrients in the amounts needed by the plant. Complete and balanced nutrient availability will affect overall plant growth, with phosphorus playing a crucial role in fruit formation. Phosphorus accelerates cell development and the synthesis of cell nuclei, fats, and proteins, facilitates photosynthesis, and improves the quality of flowers and fruit (Xie *et al*., 2020).

3.3.4. Fresh and Dry Pod Weight

Treatment D6 showed relatively higher results compared to the other treatments for the variables of pod wet and dry weight. Treatment D6 differed significantly from treatments D1 and D2, but did not differ significantly from treatments D3, D4, and D5 (Table 3). The macro and micro nutrients present in BCC are suspected to be effectively utilized by peanut plants and meet their growth needs. Macro nutrient fertilization can increase the base weight of peanut plants. Additionally, the fresh weight of the plant is influenced by the number of leaves and plant height; as the number of leaves and the height of peanut plants increase, their fresh weight also increases.

Treatment D6, which involved the application of bioactive composted charcoal at 120 g/polybag, exhibited the best growth and yield of peanut plants compared to other treatments (Table 3). The improved growth and yield of peanut plants are believed to be associated with the ability of bioactive composted charcoal to enhance the conditions of alluvial soil in terms of its physical, chemical, and biological properties. The application of bioactive composted charcoal significantly improved soil properties by increasing soil nutrient content, enhancing soil organic carbon, available phosphorus, exchangeable calcium, and cation exchange capacity (CEC). Organic amendment with bioactive composted charcoal can enhance soil fertility, water retention, and nutrient availability, leading to better plant growth and overall soil health (Agegnehu *et al*., 2015).

The results of this research aligns with the findings of Suyanto *et al*. (2019), demonstrating that the application of bioactive composted charcoal from coconut husks can enhance the agronomic characteristics of rice in alluvial soil. Research by Alarefee *et al*. (2021) indicates that the use of bioactive composted charcoal from rice husks can improve acidic oxisol soil conditions and enhance the growth and yield of *Zea mays*.The growth and productivity of peanut plants depend heavily on the availability of essential nutrients in the right proportions, ensuring balanced nutrient uptake by plants and optimal yields (Agegnehu *et al*., 2015). The primary source of plant nutrition depends on soil properties and fertilizer application. Kizito *et al*. (2019) demonstrated that the addition of nutrient-enriched biochar can enhance soil fertility by increasing organic matter and gradually releasing micro-nutrients compared to conventional chemical fertilizers. In this study, bioactive composted charcoal contained essential nutrients required by peanut plants, thereby enhancing agronomic characteristics.

4. CONCLUSION

The treatment of applying 120 g/polybag of BCC (d6) to peanuts on alluvial soil showed the best results, namely plant height of 65.00 cm, 6.08 branches, 17.42 pods, fresh pod weight of 31.72 g, and dry pod weight of 24.86 g, indicating that BCC rice husk had the potential to be used as an effective soil amendment to increase peanut plant productivity on alluvial soil. Future research is expected to use BCC enriched with specific micro nutrients to enhance growth and achieve more optimal yields, particularly for peanut plants in alluvial soil

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