Growth and yields of some peanut varieties with application of palm fiber biochar

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Abstract. Climate change negatively affects the growth of crops, including groundnuts. Groundnuts are susceptible to short-term weather changes, as well as climate change. Climate change can reduce groundnuts production because it affects soil fertility. Biochar is a kind of soil enhancer that can increase soil fertility. This study aims to determine the appropriate dose of palm fiber biochar for the growth and yield of various varieties of groundnuts. This research was conducted in July - December 2022 at the Experimental Field of the Faculty of Agriculture UNS Jumantono, Karanganyar. The study used a factorial Complete Randomized Block Design consisting of 2 factors, namely the type of peanut variety (Takar 2; Hypoma 1) and the dose of palm fiber biochar (0 t.ha⁻¹; 7.5 t.ha⁻¹; 15 t.ha⁻¹; 22.5 t.ha⁻¹). The variables observed were number of branches, number of flowers, number of pods, number of seeds, seed weight per plant, and harvest index. Data analysis used analysis of variance and was further tested using 5% Duncan’s Multiple Range Test. The results showed that the addition of palm fiber biochar at a dose of 7.5 t.ha⁻¹ could increase the number of peanut flowers. Treatment of the Takar 2 variety had a higher number of flowers, number of pods, number of seeds, seed weight, and yield index than Hypoma 1.

1 Introduction

Climate change has a negative impact on soil conditions and texture. Climate change will decrease land productivity due to environmental imbalance, so land degradation cannot be avoided [1]. Land degradation also affects the physical condition of the soil, which results in changes in the properties and conditions of the soil. Apart from that, climate change can also cause a decrease in the quality, fertility, and carrying capacity of land so that the productivity of agricultural products also decreases. Peanut plants are one of the food crops that are very vulnerable to the impacts of climate change, where they can experience a decrease in production due to climate change [2]. One type of soil that is often used for peanut cultivation is alfisol soil. Alfisol soil is a type of soil that has low nutrient and organic material content. Apart from that, this soil has a clay texture, which causes a lack of oxygen supply and inhibits root growth [3]. Climate change can worsen the condition of

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Biochar is a carbon-rich product defined as a solid material obtained through a pyrolysis process at temperatures ranging from 250°C to >900°C and oxygen availability below the limit [5]. Biochar has benefits as a soil amendment. Applying biochar to the soil can potentially increase soil C levels, water retention, and nutrients in the soil. Another advantage of using biochar is that the carbon in biochar is stable so that it can be stored for thousands of years in the soil [6]. Biochar plays a role in improving poor soil conditions such as leaching, acidity, and contamination. Besides that, biochar can reduce carbon emissions in the atmosphere directly and become renewable energy [7].

Biochar can be made from various agricultural waste, including palm fiber. The palm fiber used comes from palm tree trunks, which have been made into palm fibers. Palm fiber is one of the ingredients that can be used as biochar because it has a high cellulose content. The presence of cellulose in palm fiber biochar makes palm fiber absorb and store more water in the soil. In addition, the form of fibrous palm fiber biochar will increase the oxygen supply for plants.

Using palm fiber biochar as a soil conditioner for peanut cultivation can increase the growth and yield of peanuts. However, the correct dose of biochar fertilization for the growth of peanuts has yet to be found. This study aims to determine and understand the effect of administering various doses of palm fiber biochar on the growth and yield of various peanut varieties to obtain the optimal dose of biochar for peanut cultivation.

2 Materials and method

This research was conducted in July-December 2022 at the Experimental Field of the Faculty of Agriculture, Sebelas Maret University, Jumantono, Karanganyar. The method used was a factorial randomized complete block design (RCBD) consisting of 2 factors, namely the type of groundnut variety (Takar 2; Hypoma 1) and the dose of palm fiber biochar (0; 7.5; 15; 22.5 tons/ha). The experiment was repeated three times, obtained 24 units; in each unit, there were three plants, a total of 72 plants. The variables observed were the number of branches, number of flowers, number of pods, number of seeds, seed weight per plant, and harvest index. Data analysis used analysis of variance and was further tested using 5% Duncan’s Multiple Range Test.

3 Results and discussions

3.1 Number of branches

Branches is a plant organ that functions as a place for leaves to grow and an intermediary or place to channel water and nutrients from the stem to the plant leaves. Table 1 shows that the treatment of a variety of types did not significantly affect the number of branches in plants aged 12 WAP. Giving various doses of palm fiber biochar also did not significantly affect the number of branches.

The Takar 2 variety had slightly more branches, namely 56.42 branches, compared to the Hypoma 1 variety, which only had 53.06 branches (Table 1). Providing biochar at various doses did not affect the number of branches throughout the plant's life. The genetic factors of each variety influence the number of plant branches. The number of branches can lead to more intense competition for light sources between leaves, resulting in lower net photosynthetic rates, smaller leaf areas, and shorter stem lengths per branch as leaves compete for light and resources used to produce biomass. To eliminate the negative effects of such competition as much as possible, plants can grow additional leaves as well as enlarge their total leaf area to make better use of limited light sources [8].
Table 1. Effect of giving various doses of palm fiber biochar on peanut growth at 12 WAP

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of branches (branches)</th>
<th>Number of flowers (flowers)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Takar 2</td>
<td>56.42±1.19 a</td>
<td>4.14±0.70 a</td>
</tr>
<tr>
<td>Hypoma 1</td>
<td>53.06±1.19 a</td>
<td>2.83±0.23 b</td>
</tr>
<tr>
<td>Biochar (t.ha⁻¹)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>57.67±2.07 a</td>
<td>2.33±0.58 b</td>
</tr>
<tr>
<td>7.5</td>
<td>56.83±1.48 a</td>
<td>3.56±0.28 a</td>
</tr>
<tr>
<td>15.0</td>
<td>53.39±0.95 a</td>
<td>3.44±0.21 a</td>
</tr>
<tr>
<td>22.5</td>
<td>51.06±2.60 a</td>
<td>3.28±0.90 a</td>
</tr>
</tbody>
</table>

Description: Numbers followed by the same letter in each treatment show no significant difference based on DMRT at 5%.

Branches on peanut plants are one of the places where gynophores grow, where gynophores are plant organs that will develop into peanut pods. Therefore, indirectly, a high or low number of branches will affect the yield of peanuts. The number of branches will affect the yield components, namely the number of plant pods, the yield of plant pods, the yield of plant seeds, and the weight of 100 seeds [9]. The number of branches positively correlates with pods and the number of filled pods per plant. The more the number of branches, the more the number of leaves, so the process of photosynthesis increases. Increased photosynthesis will also increase photosynthate, a material for filling pod seeds [10].

3.2 Number of flowers

Flowers are one of the plant organs that play a role in the formation of peanut pods and seeds. Table 1 shows that the treatment of a variety of types and the administration of various doses of palm fiber biochar did not have a significant effect on the number of flowers in plants aged 12 WAP. The Takar 2 variety significantly affected the number of flowers at 12 WAP, with an average of 4.14 flowers (Table 2). Varietal treatment is very influential, especially in forming peanut plant flowers. Each plant variety has a different genotypic response to the environment in which the variety grows. High-quality varieties generally have advantages that can be seen in high yields, response to fertilization, and resistance to pests and plant diseases [11].

Table 2 also shows that the application of palm fiber biochar significantly affects the number of flowers at 12 WAP compared to no biochar. Palm fiber biochar with a dose of 7.5 t.ha⁻¹ produced the highest number of flowers, with an average of 3.56. Providing the correct dose of biochar has been proven to increase the number of flowers in peanuts. Biochar has excellent potential to increase the efficiency of using plant fertilizers by expanding the availability of nutrients in the soil [12]. Providing biochar into the soil can directly retain plant macronutrients such as N, P, K, and Ca [7]. Flower formation is influenced by the element phosphorus, where the element phosphorus can stimulate flowering. The presence of the element P can accelerate the flowering and ripening of cultivated plants’ seeds and increase yield production [13]. Biochar is a stable carbon material that can last a long time in the soil. The use of biochar is good as a soil amendment for managing soil. In the long term, biochar can maintain the stability of soil organic C [14]. At 12 WAP, applying biochar can increase the number of flowers but cannot increase the number of branches because peanuts will shed some leaves and branches when they enter the harvest period [15]. Peanuts focus more on the growth of generative organs such as flowers and pods.
3.3 Number of pods

Peanut pods are one of the yield parameters to determine the generative growth process of plants and the production results from peanut cultivation. Table 2 shows that the treatment of varieties had a significant effect on the number of pods per plant. Giving palm fiber biochar had no significant effect on the number of pods.

Table 2. Effect of giving various doses of palm fiber biochar on peanut yield at 12 WAP

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of pods (pods)</th>
<th>Number of seeds (seeds)</th>
<th>Fresh weight of seeds (g)</th>
<th>Harvest index (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variety</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Takar 2</td>
<td>24.08±2.02 a</td>
<td>43.00±3.49 a</td>
<td>27.25±1.33 a</td>
<td>0.88±0.12 a</td>
</tr>
<tr>
<td>Hypoma 1</td>
<td>18.36±2.02 b</td>
<td>33.14±3.49 b</td>
<td>23.48±1.33 b</td>
<td>0.54±0.12 b</td>
</tr>
<tr>
<td>Biochar (t.ha⁻¹)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>18.89±1.65 a</td>
<td>34.39±2.60 a</td>
<td>22.95±1.71 a</td>
<td>0.71±0.00 a</td>
</tr>
<tr>
<td>7.5</td>
<td>22.61±0.98 a</td>
<td>40.83±1.95 a</td>
<td>26.38±0.72 a</td>
<td>0.73±0.01 a</td>
</tr>
<tr>
<td>15.0</td>
<td>22.61±0.98 a</td>
<td>40.33±1.60 a</td>
<td>27.39±1.43 a</td>
<td>0.73±0.01 a</td>
</tr>
<tr>
<td>22.5</td>
<td>20.78±0.31 a</td>
<td>36.72±0.95 a</td>
<td>24.73±0.45 a</td>
<td>0.67±0.03 a</td>
</tr>
</tbody>
</table>

Description: Numbers followed by the same letter in each treatment show no significant difference based on DMRT at 5%.

The Takar 2 variety treatment significantly affected the number of pods per plant, namely 24.08. The Takar 2 variety is one of the superior varieties with the advantage of being resistant to various diseases and having high productivity. The Takar 2 variety has the most number of branches but is low in plant height parameters, where the number of branches is also a factor affecting the number of peanut pods [16]. The dose of palm fiber biochar did not significantly affect the number of pods per peanut plant. One of the factors that significantly influence the formation of peanut pods is the availability of nutrients in the soil. Peanut plants are different from other legume plants in that peanuts produce flowers in the air and pods in the ground. The pods in the soil will absorb nutrients directly from the soil for their growth and development [17].

3.4 Number of seeds

Peanut seeds are the main production product in peanut cultivation and can be called peanuts. After fertilization, a gynophore will be formed, which acts as an organ that carries the peanut seeds into the soil. Table 2 shows that the variety type treatment had a significant effect on the number of seeds per plant. Giving palm fiber biochar had no significant effect on the number of seeds.

Based on Table 2, the treatment of the Takar 2 variety significantly affected the number of seeds per plant, namely 43 seeds. In comparison, biochar application did not significantly affect the number of seeds per plant. One factor that influences yield productivity, especially the number of peanut seeds, is the genotype of the cultivated variety. Using superior peanut varieties can increase the productivity of peanuts [18]. As its name implies, the Takar 2 variety has the advantage of being resistant to leaf rust disease and has high yield potential. Several factors affect the formation of peanut seeds, including the number of flowers and gynophores that are formed, environmental conditions, and what is quite important is the process of photosynthesis, which provides food and energy for the development of peanut seeds.
3.5 Fresh weight of seeds

The weight of peanut seeds can indicate the oil and protein content and various nutrients that are beneficial to health, especially the fatty acid composition. Table 2 shows that the treatment of varieties had a significant effect on the fresh weight of the seeds. Giving palm fiber biochar had no significant effect on fresh weight of seeds.

Based on Table 2, variety treatment significantly affected the fresh weight of peanut seeds, whereas the Takar 2 variety had a higher fresh seed weight, namely 27.25 g (Table 2). Varieties play an important role in determining yield components because achieving high productivity is largely determined by the yield potential of the superior varieties planted [19]. One of the superior varieties of peanuts is the Takar 2 variety. The superiority of the Takar 2 variety is that it is resistant to leaf rust and wilt disease and has good pod quality. Treatment of palm fiber biochar doses did not significantly affect the fresh weight of peanut seeds. However, the treatment of palm fiber biochar with an amount of 15 t.ha\(^{-1}\) had the highest average seed fresh weight of 27.39 g. The application of biochar will improve soil's physical and chemical properties, which include soil friability, soil water binding capacity, increased cation exchange capacity, increased soil organic matter content, and the ability to retain nutrients against leaching so they can be available for plants [20].

3.6 Harvest index

The harvest index is one of the observation variables that can show the productivity of peanut plants. The harvest index value indicates the level of efficiency of the plant in using the results of photosynthesis. Table 2 shows that the treatment of varieties had a significant impact on the harvest index, but not by administering various doses of palm fiber biochar.

Based on Table 2, the Takar 2 variety treatment significantly affected the harvest index, namely 0.88 g. The application of palm fiber biochar did not significantly affect the harvest index. These data show that the Takar 2 variety is more efficient in utilizing photosynthesis results, as seen from the high harvest index. The harvest index value indicates the level of efficiency of the plant in using the results of photosynthesis. The higher the harvest index value, the higher the seed yield produced. The differences in different harvest indices are caused by differences in varieties and the ability of each variety to adapt to the environment [21]. The genetic superiority of each variety is different, so each variety has a different level of productivity, depending on the nature of the plant variety itself [14]. The genetic factors of each variety greatly influence the results. Differences in genetic structure cause variations in the growth and yield of each variety studied [22].

4 Conclusion

Climate change has a negative effect on soil conditions and texture, which causes land degradation and affects crop productivity. The provision of palm fiber biochar acts as a soil enhancer that can improve soil problems. The use of superior varieties is also a method used to increase productivity. Based on the research results, providing 7.5 t.ha\(^{-1}\) palm fiber biochar can increase the number of peanut flowers. The Takar 2 variety treatment has a higher number of flowers, number of pods, number of seeds, seed weight and peanut harvest index than Hypoma 1.

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