Soybean growth and yield on corn cob compost application

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Abstract. The continuous use of chemical fertilizers contributes to gas emissions that cause global warming, climate change and low nutrient use efficiency. Compost is an effort to increase nutrient supply to improve soil quality and nutrient efficiency in food crops. The aim of the study was to examine the role of corn cob compost on soybean growth and yield. The study used a complete randomized block design with one factor, namely the dose of corn cob compost with six levels, namely chemical fertilizer 0.225 ton/ha, corn cob compost dose 2; 3; 4; 5; 6 tonnes/ha. The dose of compost affects the root biomass. Corn cob compost 5 tons/ha was able to increase soybean yields by 2.28 tons and was not significantly different from chemical fertilizers. Corn cob compost 5 tons/ha produced the highest weight of 100 seeds, namely 41.33 g. Soybean yields were positively correlated with root biomass, number of leaves and crown biomass. Compost from corn cobs is an organic nutrient that can promote soybean growth and yield.

1 Introduction

Climate change has become an urgent global issue and affects various sectors of life, including the agricultural industry, which has a vital role in meeting world food needs [1]. Unstable weather patterns, rising global average temperatures, changes in rain patterns, and natural disasters are increasingly occurring due to climate change. Climate change has caused significant disruption to agricultural productivity worldwide [2,3]. Population growth and changes in consumption patterns cause demand for agricultural production to increase, which will create a gap between production and consumption. One of the dominant approaches used to meet this demand is the use of inorganic fertilizer because it can provide high results instantly [4,5]. The use of inorganic fertilizers can increase plant growth and yield significantly, but the use of these fertilizers also causes several environmental problems. The
use of inorganic fertilizers tends to cause a decrease in soil quality in the long term [6,7]. This fertilizer tends to disrupt the balance of microorganisms in the soil, damage the soil structure, and reduce the availability of micronutrients [8]. In addition, using inorganic fertilizers also contributes to releasing greenhouse gasses such as nitrogen oxide (N2O), which accelerates global climate change [9].

Meeting food needs can be done in two ways, namely agricultural intensification and extensification. Agricultural extensification has obstacles, namely the availability of land, which is decreasing due to urbanization, changes in land use, and other environmental factors [10]. Reducing optimal land conditions encourages increased productivity and quality of existing land to meet food needs. One solution that can be taken to overcome this problem is through agricultural intensification, which focuses on improving soil quality [11]. Organic fertilizer can be an alternative because it can increase nutrients and water-holding capacity, improve soil structure, and support soil microbial activity [12,13]. Organic fertilizer includes various types: compost, animal manure, and green fertilizer. This fertilizer is obtained from natural materials such as plant residues, organic waste, and animal materials that are decomposed naturally [14].

The utilization of agricultural waste as raw material for organic fertilizer has not been widely used. One of the agricultural wastes that can be utilized is corn cobs[15]. Corn cobs are not widely used, so they have the potential to be used as organic fertilizer because they are quite abundant. Corn cobs also contain essential nutrients such as nitrogen, phosphorus, and potassium, as well as organic materials that can help increase plant growth and yield [16]. It has been proven from previous research that corn cobs processed into organic fertilizer can support the growth and yield of corn plants [17]. Corn cob fertilizer can also be applied to soybeans. Soybean is a legume plant that has the potential to interact with microbes in the soil. Legume plants are generally able to form a symbiotic relationship with Rhizobium and mycorrhiza bacteria [18,19]. Rhizobium bacteria help in nitrogen fixation, while mycorrhizae help in nutrient absorption and improve overall soil quality. This interaction forms a mutualistic symbiosis, which can increase the availability of nutrients in the soil, thereby supporting plant growth and yield [20].

The use of organic fertilizer has been proven to increase the productivity of several types of plants, such as soybeans, corn, and rice. Previous research states that the application of organic fertilizer can significantly increase soybean yields [21]. Similar analysis was also carried out on corn and rice plants, which provided significant increases in yield [22,23]. The combination of applying organic fertilizers and planting soybeans has been shown to improve soil nutrition and health in the long term [24]. Soil that has high fertility can support plant growth so that it can provide maximum results. High plant productivity is expected to be able to meet increasing global food needs. The novelty of this research is using organic fertilizer from corn cobs to support the growth and yield of soybeans. This research aims to examine the use of organic corn cob fertilizer on soybean growth and yield.

2 Materials and methods

This research was carried out in Bakaran Hamlet, Sukosari Village, Jumantono District, Karanganyar Regency, Central Java, with analysis coordinates LS (07°38'07.04" E (110°57'00.7"), altitude 181 meters above sea level. The materials used in this research were Dena 1 soybean seeds, corn cob compost, cow dung fertilizer, and inorganic fertilizer with Urea, SP36, and KCl. The study used a complete randomized block design with one factor: corn compost dose. Corn compost dosage with six levels, namely inorganic fertilizer 0.225 tons/ha (Urea: 50 kg/ha, SP36: 75 kg/ha, KCl: 100 kg/ha), corn compost dosage 2;3;4;5 and 6 tons/ Ha. Each experimental unit was repeated three times so that there were 18 experimental units. Soybeans are planted at a distance of 20 x 30 cm. The variables observed were plant height, number of leaves, root weight, crown weight, number of pods, fresh weight.
of pods, one hundred seeds, and soybean yield per hectare. These variables were observed in soybean plants ten days after planting. The data obtained were analyzed using analysis of variance (ANOVA) at a level of 5%. If it had a significant effect, it was continued with the Duncan Multiple Range Test (DMRT) at a level of 5%.

3 Results and discussion

3.1 Soybean growth

The results showed that fertilizer treatment did not affect the height, number of leaves, and crown weight of soybeans (Table 1). Treatment with increasing doses of corn cob compost increased the height of soybean plants. A dose of 2 tons/ha of corn cob compost could not increase plant height compared to inorganic fertilizer treatment. However, with a dose of 5 tons/ha, it showed higher plant height compared to the inorganic fertilizer treatment. Apart from that, the 4-ton/ha treatment also showed many leaves. These results indicate that a 4 tons/ha dose has supported soybean growth. Corn compost can support soybean growth because it contains available nitrogen, potassium, and phosphate elements, which meet the standards as organic fertilizer according to No.70/Permentan/SR.140/10/2011. Corn compost contains 1.44% total nitrogen, 1.43% phosphate, and 2.17% potassium [17]. These nutrients are essential nutrients that play a role in the growth and quality of crop yields because they affect plant physiological processes [25]. A 3 tons/ha dose of corn cob compost has encouraged soybean canopy growth. Shoot biomass at a dose of 3 tonnes/ha was higher than the inorganic fertilizer treatment and increased by 6.5%. The increase in canopy biomass was higher with higher treatment doses. Corn cob compost contains high organic matter that supports the growth of soil microorganisms [26]. The activity of soil microorganisms helps provide good nutrition for plant growth [27,28]. Based on Table 3, plant height and number of leaves are positively correlated with the canopy biomass of soybean plants. The higher and more leaf growth shows higher canopy biomass. The higher growth of the leaves will increase plants' photosynthetic capacity so that biomass production is high [29]. However, nitrogen absorption is supported in photosynthesis because nitrogen is an essential component of chlorophyll and a component of the enzymes involved in photosynthesis [30]. Plant height positively correlates with fresh pod weight, number of pods, and crown weight (Table 3). Plants that grow taller mean they get more nutrients to support crown growth and pod formation [31]. Taller soybeans usually have more nodes from which to flower and produce pods.

Corn compost treatment affects root biomass (Table 1). Corn compost at a dose of 4 tons/ha has shown higher root biomass than inorganic fertilizers. However, the two and 3-ton/ha corn compost treatments showed the lowest root biomass. These results indicate that a dose of 4 tons/ha has encouraged the growth of soybean plant roots. Soybean root growth is supported by the high availability of organic matter in corn compost. Compost can promote the growth of beneficial soil microorganisms in helping to break down organic matter and increasing the availability of nutrients for plant roots [32,33]. Corn cobs compost contains 85.71% organic matter and 62.21% high organic carbon [17]. Organic matter plays a role in improving soil structure and increasing the activity of soil microorganisms [29]. Organic matter can increase soil porosity and water-holding capacity so that roots can easily penetrate the soil, thereby increasing the roots' absorption of water and nutrients [34]. Absorption of root nutrients is correlated with root biomass and density [35]. Higher root biomass can transport nutrients in more significant quantities, thereby supporting the nutritional needs of plants—higher root biomass results in higher root density and greater surface area available for nutrient uptake.
of several different doses of fertilizer gives the same results on the weight of one hundred seeds and increased the weight by 44.16% compared to the application of inorganic fertilizer. Organic fertilizers contain high levels of phosphate and potassium to support seed formation [41]. In addition, organic fertilizers also have a neutral pH so that they can improve soil conditions. The availability of phosphate and potassium at a neutral pH is higher to meet the photosynthesis process to be more optimal so that it can produce more photosynthesis.

Corn cob compost did not affect soybean yield (Table 2). The number of pods and the yield of soybeans per hectare were high in the treatment of inorganic fertilizers. Corn compost at a dose of 2 to 4 tons/ha has yet to be able to increase the number of pods, fresh weight of pods, weight of one hundred seeds, and soybean yield per hectare. This is due to the slow-release nature of organic fertilizers [36]. However, corn compost treatment at a dose of 5 tons/ha produced a higher number of pods, fresh pod weight, one hundred seeds, and soybean yield per hectare compared to the inorganic fertilizer treatment. Doses of 5 tons/ha have increased by 7% of pods compared to inorganic fertilizer treatment. This pod increase was supported by the high content of phosphor and potassium in corn cob compost [17]. Phosphorus is a component of adenosine triphosphate used in nutrient absorption, cell division, and the synthesis of organic compounds. A high phosphate content will support efficient energy transfer, plant metabolic activity, and plant growth and yield [37]. Plants with intensive development and short cycles, such as soybeans, require higher amounts of phosphate in solution and adding P, which is adsorbed more quickly than annual plants [38].

Based on Table 3, the number of pods positively correlates with root biomass. Roots have an essential role in absorbing nutrients from the soil. Soybeans with more and more roots have a wider absorption field. This causes soybeans to get more water and nutrients for growth and yield [39]. These results are supported by high organic matter and organic carbon in corn compost. Organic matter and organic carbon can improve soil physics, chemistry, and biology. Organic matter can improve soil structure to increase the activity of microorganisms and the availability of nutrients for plants [40].

The weight of one hundred seeds reflects the quality of the soybean seeds. The application of several different doses of fertilizer gives the same results on the weight of one hundred seeds. Application of 2 tons/ha of corn cob fertilizer produced the highest weight of one hundred seeds and increased the weight by 44.16% compared to the application of inorganic fertilizer. Organic fertilizers contain high levels of phosphate and potassium to support seed formation [41]. In addition, organic fertilizers also have a neutral pH so that they can improve soil conditions. The availability of phosphate and potassium at a neutral pH is higher to meet soybeans' needs [42,43]. One hundred seed weight positively correlates with the number of leaves and shoot weight (Table 3). This is because the increasing number of leaves causes the photosynthesis process to be more optimal so that it can produce more photosynthesis.

### Table 1. Soybean growth.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Crown Weight</th>
<th>Number of Leaves</th>
<th>Plant Height</th>
<th>Root Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic fertilizer 0.225 tons/ha</td>
<td>58.22</td>
<td>28.67</td>
<td>28.83</td>
<td>0.72 b</td>
</tr>
<tr>
<td>Corn compost dosage 2 tons/ Ha</td>
<td>43.31</td>
<td>22.17</td>
<td>20.50</td>
<td>0.40 a</td>
</tr>
<tr>
<td>Corn compost dosage 3 tons/ Ha</td>
<td>62.30</td>
<td>34.67</td>
<td>26.87</td>
<td>0.65 a</td>
</tr>
<tr>
<td>Corn compost dosage 4 tons/ Ha</td>
<td>64.80</td>
<td>40.33</td>
<td>34.07</td>
<td>0.75 ab</td>
</tr>
<tr>
<td>Corn compost dosage 5 tons/ Ha</td>
<td>80.87</td>
<td>41.33</td>
<td>38.83</td>
<td>0.85 b</td>
</tr>
<tr>
<td>Corn compost dosage 6 tons/ Ha</td>
<td>68.04</td>
<td>33.17</td>
<td>33.90</td>
<td>0.98 b</td>
</tr>
</tbody>
</table>

Note: numbers followed by different letters in one column, indicate a significant difference in DMRT (α = 0.05).

### 3.2 Soybean yield

Corn cob compost did not affect soybean yield (Table 2). The number of pods and the yield of soybeans per hectare were high in the treatment of inorganic fertilizers. Corn compost at a dose of 2 to 4 tons/ha has yet to be able to increase the number of pods, fresh weight of pods, weight of one hundred seeds, and soybean yield per hectare. This is due to the slow-release nature of organic fertilizers [36]. However, corn compost treatment at a dose of 5 tons/ha produced a higher number of pods, fresh pod weight, one hundred seeds, and soybean yield per hectare compared to the inorganic fertilizer treatment. Doses of 5 tons/ha have increased by 7% of pods compared to inorganic fertilizer treatment. This pod increase was supported by the high content of phosphor and potassium in corn cob compost [17]. Phosphorus is a component of adenosine triphosphate used in nutrient absorption, cell division, and the synthesis of organic compounds. A high phosphate content will support efficient energy transfer, plant metabolic activity, and plant growth and yield [37]. Plants with intensive development and short cycles, such as soybeans, require higher amounts of phosphate in solution and adding P, which is adsorbed more quickly than annual plants [38]. Based on Table 3, the number of pods positively correlates with root biomass. Roots have an essential role in absorbing nutrients from the soil. Soybeans with more and more roots have a wider absorption field. This causes soybeans to get more water and nutrients for growth and yield [39]. These results are supported by high organic matter and organic carbon in corn compost. Organic matter and organic carbon can improve soil physics, chemistry, and biology. Organic matter can improve soil structure to increase the activity of microorganisms and the availability of nutrients for plants [40].
Many leaves can provide good photosynthetic quality so that they can be used to produce quality seeds. The yield of soybeans per hectare in treating 5 tons/ha of corn cob compost was 2.28 tons/ha. This yield is low compared to the potential yield of the Dena 1 variety, which is 2.9 tons/ha. However, 5 tons/ha of corn cob compost gave the highest soybean yield and increased by 10.14% compared to inorganic fertilizers. These results indicate that corn compost and inorganic fertilizers can increase soybean yields. Corn cob compost has a high nitrogen, phosphate, and potassium content, so it can support the process of forming soybean pods [44]. Organic fertilizers that are slow-releasing guarantee the availability of nutrients until harvest because they are not easily washed away by water [36]. In addition, compost can improve soil quality, add nutrients to the soil, increase the activity of microorganisms, and increase its water-holding capacity [12,13]. This can support soybean growth so that soybeans can grow optimally and provide the best results.

**Table 2. Soybean yield.**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Fresh Weight of Pods</th>
<th>Number of Pods</th>
<th>Soybean Yield per Hectare</th>
<th>Weight of One Hundred Seeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inorganic fertilizer</td>
<td></td>
<td></td>
<td>2.28</td>
<td>28.67</td>
</tr>
<tr>
<td>0.225 tons/ha</td>
<td>12.73</td>
<td>23.67</td>
<td>2.07</td>
<td>28.67</td>
</tr>
<tr>
<td>Corn compost dosage 2 tons/ Ha</td>
<td>9.93</td>
<td>15.67</td>
<td>1.22</td>
<td>22.17</td>
</tr>
<tr>
<td>Corn compost dosage 3 tons/ Ha</td>
<td>11.96</td>
<td>16.67</td>
<td>1.51</td>
<td>34.67</td>
</tr>
<tr>
<td>Corn compost dosage 4 tons/ Ha</td>
<td>11.38</td>
<td>18.33</td>
<td>1.81</td>
<td>40.33</td>
</tr>
<tr>
<td>Corn compost dosage 5 tons/ Ha</td>
<td>16.39</td>
<td>25.33</td>
<td>2.28</td>
<td>41.33</td>
</tr>
<tr>
<td>Corn compost dosage 6 tons/ Ha</td>
<td>15.91</td>
<td>21.67</td>
<td>2.00</td>
<td>33.17</td>
</tr>
</tbody>
</table>

**Table 3. Correlation of soybean growth and yield.**

<table>
<thead>
<tr>
<th></th>
<th>Soybean yield per hectare</th>
<th>Weight of 100 seeds</th>
<th>Fresh weight of pods</th>
<th>Number of pods</th>
<th>Root weight</th>
<th>Header weight</th>
<th>Number of leaves</th>
<th>Plant height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant height</td>
<td>-0.105</td>
<td>0.259</td>
<td>0.529*</td>
<td>0.518*</td>
<td>0.406</td>
<td>0.759**</td>
<td>0.259</td>
<td>1</td>
</tr>
<tr>
<td>Number of leaves</td>
<td>-0.303</td>
<td>1.000**</td>
<td>0.156</td>
<td>0.104</td>
<td>-0.061</td>
<td>0.826**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Header weight</td>
<td>-0.261</td>
<td>0.826**</td>
<td>0.421</td>
<td>0.378</td>
<td>0.210</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Root weight</td>
<td>0.262</td>
<td>-0.061</td>
<td>0.576*</td>
<td>0.494*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of pods</td>
<td>0.420</td>
<td>0.104</td>
<td>0.847**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fresh weight of pods</td>
<td>0.366</td>
<td>0.0156</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight of one hundred seeds</td>
<td>-0.303</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean yield per hectare</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: ** = significantly very different  
* = significantly different
4 Conclusion

The dose of compost affects the root biomass. Corn compost at a dose of 4 tons/ha has shown higher root biomass than inorganic fertilizers. The dose of corn compost did not affect soybean yield. Corn cob compost 5 tons/ha was able to increase soybean yields by 2.28 tons and was not significantly different from chemical fertilizers. Corn cob compost 5 tons/ha produced the highest weight of 100 seeds, namely 41.33 g. Soybean yields were positively correlated with root biomass, number of leaves and crown biomass. Compost from corn cobs as an organic nutrient that can promote soybean growth and yield.

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The dose of compost affects the root biomass. Corn compost at a dose of 4 tons/ha has shown as an organic nutrient that can promote soybean growth and yield. Corn cob compost 5 tons/ha was able to increase soybean yields by 2.28 tons

Conclusions

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