Effect of bokashi fertilizer on growth and yield of local maize from muna island under net house treatment in west muna southeast sulawesi, indonesia

Resman¹, Muhammad Tufaila¹ Azhar Ansi², Halim², Makmur Jaya Arma² and Wa Ode Harlis³

¹Department of Soil Science, Faculty of Agriculture, Halu Oleo University, Southeast Sulawesi, Indonesia
²Department of Agrotechnology, Faculty of Agriculture, Halu Oleo University, Southeast Sulawesi, Indonesia
³Department of Biology, Faculty of Mathematics and Natural Sciences, Halu Oleo University, Southeast Sulawesi, Indonesia

*Correspondence: halim_haliwu_lim73@yahoo.co.id  Accepted: 5June 2018 Published online: 31 July 2018

This study conducted in Kusambi Village, West Muna and Laboratory of Analytical Chemistry, Faculty of Mathematics and Natural Sciences, Halu Oleo University, Southeast Sulawesi, Indonesia. The aimed of this research was to know the effect of bokashi fertilizer on growth and yield of local maize from Muna Island under net house treatment using Ultisol. The experimental design used in this study was Randomized Block Design (RBD). The treatments were: without bokashi fertilizer (P0), bokashi fertilizer as 100 g per polybag (P1), bokashi fertilizer as 200 g per polybag (P2), bokashi fertilizer as 300 g per polybag (P3) with four replications for each treatment. The research variables observed included: plant height, stem diameter, leaf number, leaf area, cob diameter, cob length without husk, weight of cob without husk and with husk. The results showed that bokashi fertilizer application as 300 g per polybag (P3) gave the best result to growth and yield component of local maize from Muna Island.

Keywords: bokashi fertilizer, local maize, organic matter, Ultisol

INTRODUCTION

In Indonesia maize is a carbohydrate-producing cereal crop which is the second staple food after rice. In addition, corn can also be used as industrial raw materials such as paint, beverages, oil, paper and animal feed ingredients. According Nugroho (2009), the maize chemical composition consisting of 61% carbohydrate, 13.5% water, 10% protein, 4% fat, 1.4% sugar, 6% pentosan, 2.3% crude fiber, 1.4% ash and 0.4% other substances. The growth of Indonesia's population from year to year increased, causing the need for land for agriculture and settlement increased. To support the government's efforts in meeting these needs, it is necessary to develop the marginal lands spread throughout in Indonesia (Hasanuddin, 2003). The soil properties in each region have different physical characteristics and chemical properties depending on the parent material. According to Prasetyo and SuriadiKarta (2006), Ultisol can develop from a variety of parent materials, from acid to alkaline. But most of Ultisol ground material is sour sedimentary rock. The constraint from the soil physical aspects of stability and low water holding and slows permeability.

The stability of low soil aggregates in turn causes the soil to break easily when hit by rain
water grains. The crushed particles will cause Ultisol soil to become solid. The solid soil has a low porosity so that infiltration and percolation are low, resulting in increased surface flow and easy erosion. While the constraints of the soil chemical aspect are very low aeration of soil, react sour, lack of available elements of phosphorus (P), calcium (Ca), magnesium (Mg) and molybdenum (Mo), also has high Aluminum (Al), Iron and Manganese (Mn) active high, if the elements are numerous in the soil will cause poisoning in plants. One of the efforts to control soil density on Ultisol soils is by the giving of the organic matter. The organic matter not only increases the nutrients and microorganism activity in the soil but also plays an important role in improving soil physical and chemical properties (Sudirja, 2007). According Murbandono (2007) the provision of organic materials such as bokashi fertilizer will be able to stimulate granulation, improve soil aeration, improve the ability to hold water and improve soil structure so that the soil becomes loose.

The bokashi fertilizer is an organic fertilizer that process decomposition rate and its mineralization runs very fast after immersed into the soil, so it can release nutrients quickly, both in quantity and time availability. According Simatupang (1990), the timing of the provision of organic materials will determine the decomposition of organic materials that will produce nutrients. Decomposition of organic materials should be immediately given to the plant at the right time so that the nutrients they contain can be effectively utilized and avoid loss due to rain washing, spray water or competition with weeds. The use of bokashi as a fertilizer is very good because it can provide several benefits that's to provide micro nutrients for the plants, soil erosion, improve soil structure, increase porosity, aeration and composition of soil microorganisms, increase the binding of soil to water and facilitate the growth of plant roots. Result of research Halim et al., (2016) application bokashi fertilizer independently significant effect on the shoot root ratio.

MATERIALS AND METHODS

Survey of Research Location and Soil Sampling

This study conducted in Kusambi Village, West Muna and Laboratory of Analytical Chemistry, Faculty of Mathematics and Natural Sciences, Halu Oleo University, Southeast Sulawesi, Indonesia. This research activity begins by conducting survey on the location to be used as research location by using Rapid Rural Appraisal (RRA) method. This activity aims to determine the condition of the location of research land and farmer's activities. At the times of conducting the survey at the same time with soil sampling. Soil samples were taken using a soil drill at 0-30 cm in depth with 10 points of soil sampling. The sample of soil that has been taken is composite, then taken to the laboratory for physical and ground chemistry analysis.

Experimental Set Up

The soil used as a planting medium is Ultisol soil taken composite from the top layer with a depth of 0-30 cm, dried for 2-4 days, mashed, sterilized using a furnace oven. Furthers weighed as much as 10 kg per polybag for research needs. The experimental design used in this study was Randomized Block Design (RBD). The treatments were: without bokashi fertilizer (P0), bokashi fertilizer as 100 g per polybag (P1), bokashi fertilizer as 200 g per polybag (P2), bokashi fertilizer as 300 g per polybag (P3) with four replications for each treatment.

Observation Variable

The research variables observed included: (1) vegetative component (plant height, stem diameter, leaf number, leaf area) at the 14, 28 and 42 day after planting (DAP), (2) generative component (cobs diameter, cob length without husk, weight of cob without husk and weight of cob with husk) after harvest. Supporting data were analyzed for physical and ground chemistry of soil sample from research location and bokashi fertilizer.

Data Analysis

The data of plant growth and yield observation was analyzed using the variety of variance according to the design used. If the variance shows the real effect will be continued with Least Significant Difference (LSD) at 0.05% confidence level.

RESULTS AND DISCUSSION

Soil Condition of Research Location

Table 1, showed that the physical and ground chemistry of soil samples from research location belong to low criteria.
Table 1. Result of the physical and ground chemistry of soil samples from location of research

<table>
<thead>
<tr>
<th>No</th>
<th>Parameters</th>
<th>Unit of measure</th>
<th>Value*</th>
<th>Criteria**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>pH</td>
<td>-</td>
<td>4.50</td>
<td>Sour</td>
</tr>
<tr>
<td>2</td>
<td>C-organic</td>
<td>%</td>
<td>4.80</td>
<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>Nitrogen</td>
<td>%</td>
<td>0.15</td>
<td>Low</td>
</tr>
<tr>
<td>4</td>
<td>Phosphor</td>
<td>ppm</td>
<td>17.88</td>
<td>Low</td>
</tr>
<tr>
<td>5</td>
<td>Potassium</td>
<td>me/100 g</td>
<td>0.29</td>
<td>Low</td>
</tr>
</tbody>
</table>

Notes: * = Result of analysis Laboratory of Analytical Chemistry, Faculty of Mathematics and Natural Sciences, Halu Oleo University, ** = Result of assessment of soil chemical properties of PPT Bogor (1983) in Hardjowigeno (2003).

This is due to intensive nutrient washing, binding of bases by elements of Al, Fe and Mn (Judge, 2009). According to Prasetyo and Suradi (2006), Ultisol soils can develop from a variety of parent materials, from acid to alkaline. But most of the parent material is sour sedimentary rocks. Soil pH reactions, the availability of nutrients and organic matter are some of the soil chemical properties that determine plant growth and development.

Ground Chemistry of Bokashi Fertilizer

The nitrogen content in bokashi fertilizer (Table 2) is above the critical value, easy to mineralizing and easy to release the compounds they contain so as to improve the quality of Ultisol. Stevenson (1982), states that to soon be mineralized, the nitrogen content in organic matter must be higher than its critical value of 1.5% - 2.5%. Janzen and Kucey (1988) suggested that the critical value of nitrogen content is about 1.1% - 1.9%, when nitrogen levels fall below that critical value, then immobilization will occur.

Table 2. Result of the ground chemistry of bokashi fertilizer

<table>
<thead>
<tr>
<th>No</th>
<th>Parameters</th>
<th>Value (%)</th>
<th>Criteria**</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nitrogen</td>
<td>2.31</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>Phosphor</td>
<td>0.28</td>
<td>Low</td>
</tr>
<tr>
<td>3</td>
<td>Potassium</td>
<td>1.30</td>
<td>Low</td>
</tr>
<tr>
<td>4</td>
<td>C-organic</td>
<td>33.21</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>C and N ratio</td>
<td>14.38</td>
<td>High</td>
</tr>
</tbody>
</table>

Notes: * = Result of analysis Laboratory of Analytical Chemistry, Faculty of Mathematics and Natural Sciences, Halu Oleo University, ** = Result of assessment of soil chemical properties of PPT Bogor (1983) in Hardjowigeno (2003).

In order for nitrogen mineralization to occur soon, the required minimum nitrogen content must be higher than 1.73% and the C and N ratio must be lower than 2.5% (Wahyudi, 2009).

Plant Height

The result of variance analysis showed that the application of bokashi fertilizer had very significant effect on plant height at 14, 28 and 42 DAP. Table 3, shows that the highest of maize at 14 DAP obtained at treatment of P3 which significantly different from with other treatments. The highest plant at the 28 DAP was obtained at the treatment of P3 which was significantly different from with other treatments. The results of this study indicate that the higher concentration of bokashi fertilizer application, the more the content of nutrient. The nutrient element plays an important role in cell division that has a direct impact on plant height increase. The same with the opinion Nasruddin (2010), that the available nutrients in the soil can accelerate the vegetative growth of plants.

Stem Diameter

The result of variance analysis showed that the application of bokashi fertilizer had a very significant effect on plant diameter at 14, 28 and 42 DAP. Table 4 shows that the greatest average of stems diameter at 14 DAP was obtained at treatment of P3, which was not significantly different from with treatment of P2 but significantly different from with other treatments. The greatest average of stem diameter at 28 DAP was obtained at treatment of P3 and significantly different from with other treatments. The diameter of the stems affect the establishment of the plant so as not to easily collapse when the higher the plant.
Table 3. The average of plant height at 14, 28 and 42 DAP

<table>
<thead>
<tr>
<th>Treatments</th>
<th>14 DAP</th>
<th>28 DAP</th>
<th>42 DAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>without bokashi fertilizer (P0)</td>
<td>33.58d</td>
<td>65.51d</td>
<td>192.64d</td>
</tr>
<tr>
<td>bokashi fertilizer as 100 g per polybag (P1)</td>
<td>45.52c</td>
<td>83.32c</td>
<td>144.53c</td>
</tr>
<tr>
<td>bokashi fertilizer as 200 g per polybag (P2)</td>
<td>55.91b</td>
<td>106.38b</td>
<td>165.21b</td>
</tr>
<tr>
<td>bokashi fertilizer as 300 g per polybag (P3)</td>
<td>64.76a</td>
<td>126.95a</td>
<td>188.84a</td>
</tr>
<tr>
<td>LSD 0.05%</td>
<td>1.64</td>
<td>3.44</td>
<td>6.70</td>
</tr>
</tbody>
</table>

Notes: The numbers followed by a letter that is not the same in the same column significantly different at LSD 0.05% confidence level.

Table 4. The average of stem diameter at 14, 28 and 42 DAP

<table>
<thead>
<tr>
<th>Treatment</th>
<th>14 DAP</th>
<th>28 DAP</th>
<th>42 DAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>without bokashi fertilizer (P0)</td>
<td>0.14c</td>
<td>0.58c</td>
<td>1.28d</td>
</tr>
<tr>
<td>bokashi fertilizer as 100 g per polybag (P1)</td>
<td>0.22b</td>
<td>0.95b</td>
<td>1.38c</td>
</tr>
<tr>
<td>bokashi fertilizer as 200 g per polybag (P2)</td>
<td>0.30a</td>
<td>1.10b</td>
<td>1.55b</td>
</tr>
<tr>
<td>bokashi fertilizer as 300 g per polybag (P3)</td>
<td>0.34a</td>
<td>1.31a</td>
<td>1.69a</td>
</tr>
<tr>
<td>LSD 0.05%</td>
<td>0.008</td>
<td>0.034</td>
<td>0.019</td>
</tr>
</tbody>
</table>

Notes: The numbers followed by a letter that is not the same in the same column significantly different at LSD 0.05% confidence level.

The availability of nutrients present in the fertilizer is easily absorbed by the plant is one of the factors that affect the growth of plants, thus increasing the enlargement of cells that affect the growth of plant stem diameter. The more nutrient that can be absorbed by the plant will result in a larger diameter in which the stem is the accumulated area of younger plant growth so that with the provision of nutrients can encourage vegetative growth of plants. According Mugianto (2007) the advantages of organic fertilizer is able to overcome nutrient deficiency and able to provide nutrients quickly, not damage the soil and plants, although used as often as possible. In addition, organic fertilizer given to the soil surface can be directly used by plants for growth.

Leaf Number

The result of variance analysis showed that the application of bokashi fertilizer had a very significant effect on leaf number at 14, 28 and 42 DAP.

Table 5 shows that the highest average of leaf number at 14 DAP was obtained in treatment of P3, which was not significant with treatment of P2, but significantly different from with other treatments. The results showed that the number of leaves increased in line with the increased dose of bokashi fertilizer. Fageria and Baligar (2005), that the application of fertilizer with sufficient nitrogen content can accelerate the growth and development of plant organs so that more quickly experience the increase in the number of leaves and the size of plant leaf area.

The availability of sufficient nitrogen for plants can stimulate the growth of plant height. The element of nitrogen is one of the most important macro elements for plants. According Lakitan (2002) nitrogen element is one of the elements forming chlorophyll used as absorbent sunlight in the process of photosynthesis. The nitrogen elements can accelerate overall plant growth especially stems and leaves. The availability of nitrogen and other components in the process of photosynthesis will lead to an increase in the rate of photosynthesis. The resulting of the photosynthesis will be transited to the plant growth organ such as stems so as to spur the growth of plant height. According to Hakim (2009) plant height is a measure that is often observed, both as an indicator of growth and as a parameter used measures the influence of the environment or the treatment applied.
Table 5. The average of leaf number at 14, 28 and 42 DAP

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average of leaf number (sheet)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14 DAP</td>
</tr>
<tr>
<td>without bokashi fertilizer (P0)</td>
<td>3.00b</td>
</tr>
<tr>
<td>bokashi fertilizer as 100 g per polybag (P1)</td>
<td>3.50b</td>
</tr>
<tr>
<td>bokashi fertilizer as 200 g per polybag (P2)</td>
<td>5.00a</td>
</tr>
<tr>
<td>bokashi fertilizer as 300 g per polybag (P3)</td>
<td>5.75a</td>
</tr>
<tr>
<td>LSD 0.05%</td>
<td>0.39</td>
</tr>
</tbody>
</table>

Notes: The numbers followed by a letter that is not the same in the same column significantly different at LSD 0.05% confidence level.

Table 6. The average of leaf area at 14, 28 and 42 DAP

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Average of leaf area (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>14 DAP</td>
</tr>
<tr>
<td>without bokashi fertilizer (P0)</td>
<td>107.02d</td>
</tr>
<tr>
<td>bokashi fertilizer as 100 g per polybag (P1)</td>
<td>152.61c</td>
</tr>
<tr>
<td>bokashi fertilizer as 200 g per polybag (P2)</td>
<td>167.26b</td>
</tr>
<tr>
<td>bokashi fertilizer as 300 g per polybag (P3)</td>
<td>181.37a</td>
</tr>
<tr>
<td>LSD 0.05%</td>
<td>13.308</td>
</tr>
</tbody>
</table>

Notes: The numbers followed by a letter that is not the same in the same column significantly different at LSD 0.05% confidence level.

Leaf Area

The result of variance analysis showed that the application of bokashi fertilizer had a very significant effect on leaf area at 14, 28 and 42 DAP. Table 6 shows that the leaf area of the plant at the age of 14 DAP was obtained in the treatment of P3 which significantly different from with all other treatments. At the 28 DAP the largest leaf area was obtained at treatment of P3 and significantly different from with all other treatments.

The results showed that an increase in the number of doses of bokashi fertilizer given to plants could increase the area of plant leaves. The leaf are of development depends on the availability of nutrients present in the soil, which can stimulate the growth and yield of the plant. Baligar et al., (2001), high value of nutrient use efficiency can eliminated potential nutrient loss and increase yield of the plants.

The availability of nutrients present in complete organic fertilizer causes the plant to grow rapidly so that the amount of leaf area of the plant increases. It is evident from the results of this study that the application of bokashi fertilizer with a higher dose able to produce more leaf number and large leaf area larger than the control. According to Latarang and Syakur (2006) that’s the formation of the number of leaves was determined by the number and size of cells, also influenced by the nutrients absorbed by the roots to serve as food. The presence of a nitrogen element that serves as a constituent of chlorophyll enzymes and molecules serves as activators of various protein synthesis enzymes as well as carbohydrate of metabolism, the phosphorus plays an active role in transferring energy in plant cells and magnesium as chlorophyll constituents and helps the translocation of phosphorus in plants. Subhan et al., (2008) suggests that the addition of nitrogen can decrease the C and N ratio of organic matter, thus rapidly decaying or decomposing. The sooner the organic material decays, the faster the essential nutrients will be available to the plant.

Yield of Maize

The result of variance analysis showed that the application of bokashi fertilizer had a very significant effect on cob diameter without husk, cob length without husk, weight of cob with husk and weight of cob with husk.

The application of various levels doses of bokashi fertilizer very positive effect on the growth and production of maize. According to Usman (2010), the availability of sufficient nitrogen leads to a balance of ratios between leaves and roots, so that vegetative growth is normal and complete. Sirajuddin and Lasmini (2010) stated that the provision of nitrogen fertilizer in corn plants has a real effect on the growth of plants that can stimulate the growth of roots, stems, leaves and plant height.
Table 7. The average of yield component after harvest

<table>
<thead>
<tr>
<th>Observation Variable</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cob diameter (cm)</td>
<td>PQ P1 P2 P3</td>
</tr>
<tr>
<td>Cob length with husk (cm)</td>
<td>9.10d 10.23c 11.19b 12.99a</td>
</tr>
<tr>
<td>Cob length without husk (cm)</td>
<td>7.40c 7.95c 8.78b 10.88a</td>
</tr>
<tr>
<td>Cob weight with husk (g)</td>
<td>65.83c 76.08c 95.45b 120.60a</td>
</tr>
<tr>
<td>Cob weight without husk (g)</td>
<td>53.75c 62.03c 78.90b 95.75a</td>
</tr>
<tr>
<td>Number of seed line</td>
<td>8.5d 10.75c 12.50b 14.50a</td>
</tr>
</tbody>
</table>

Notes: The numbers followed by a letter that is not the same in the same column significantly different at LSD 0.05% confidence level.

Sholeh et al., (1997), the addition of organic matter into the soil can increase the content of organic matter and soil nutrients. This is because more and more doses of organic fertilizer are given, so the nitrogen contained in bokashi fertilizer is also getting more and more accepted by the soil. Nitrogen element is a very important nutrient because it is the most needed element for plant growth. Nitrogen acts as a constituent of amino acids, proteins, and chlorophyll pigment components that are important in the process of photosynthesis. Conversely, if nitrogen deficiency causes the growth and development of disturbed plants and declining results caused by disturbance formation of chlorophyll is very important for the process of photosynthesis.

The addition of organic materials such as bokashi fertilizer into the soil can increase the content of organic matter and soil nutrients. This is due to the more doses of bokashi fertilizer given then the nitrogen contained in the bokashi fertilizer is also increasingly being accepted by the soil. Usman (2010) stated that the appearance of plants is influenced by genetic and environmental factors. Environmental factors can be through the provision of nitrogen in the soil, because plants that lack nitrogen will affect the content of chlorophyll in the leaves thus affecting the rate of photosynthesis. According to Isrun (2010), the yield of maize is also influenced by P-available in the soil, i.e. 85% of the maize cob's weight is determined by the above variables and the rest is determined by other factors. This is similar with the results of research Ayunda's (2014) phosphorus can enlarge the formation of fruit, in addition the availability of phosphorus as an ATP builder will ensure the availability of energy for growth so that the formation of assimilate and transport to storage place can run well. This causes the resulting cob in large diameter.

The phosphorus element works on the completion of the ear, as well as the element of potassium is also important for filling the cob is to make a cob full of seeds. According to result of research Isrun (2006) the role of phosphorus among others for the filling of seeds or tubers and increase the growth and yield of plants. Improvement of soil chemical properties due to organic matter helps plant roots penetrate deeper soil more capable of absorbing nutrients and water in large quantities, improving the rhizosphere that can maintain nutrient cycles, improving exudation by plant roots that can increase the degradation of soil organic matter and nitrogen mineralization (Morgan et al., 2005). The availability of phosphorus in plant tissues is moderate to high. This proves that the growth of crops grows better when with the provision of organic materials. The phosphorus is one of the essential macro nutrients for plant growth. Although plants require less phosphorus than nitrogen, but phosphorus is needed to produce energy and speed of plant growth, fruit formation (Nuryani et al., 2010).

CONCLUSION
The best treatment in this research is bokashi fertilizer with dose 300 g per polibag (P3). The application of bokashi fertilizer has a very significant effect on plant height, stem diameter, leaf number, leaf area, cobs diameter, cob length without husk, length of cobs with husk, weight of cob with husk, weights of cobs without husk, the number of rows of maize and weight of 100 seeds.

CONFLICT OF INTEREST
The authors declared that present study was performed in absence of any conflict of...
Effect of bokashi fertilizer on growth and yield of maize


ACKNOWLEDGEMENT
The author would like to thank to the Ministry of Research, Technology and Higher Education of the Republic of Indonesia for the financial assistance through the scheme of Applied Product Grants in 2017 with contract number 65/UN29.20/PPM/2017. The authors also thank to the Rector of Halu Oleo University, Dean of Agriculture Faculty and the Chairman of the Research Institute of Halu Oleo University for serviced an administrative.

AUTHOR CONTRIBUTIONS
Resman, Muhammad Tufaila and Azhar Ansi were designed and performed the experiments and also wrote the manuscript. Halim was reviewed the manuscript. Makmur Jaya Arma analyzed and interpreted the data. Wa Ode Harlis was collected the data. All authors read and approved the final version.

REFERENCES


interest.

Copyrights: © 2017 @ author(s).
This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author(s) and source are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.