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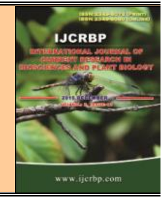

Original Research Article

The Effectiveness of Liquid Cow Bokashi to Create Root Optimum Environmental Conditions on Maize Growth

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Abstract

Environmental root growth conditions could be primer determinants to increase the maximum potential plant production. The objective of this research is to evaluate improving of environmental plant growth especially on soil physical properties as the effect of liquid cow bokashi application. Soil bulk density, porosity, penetration resistance, plant height, and root volume involving four levels, i.e., 0, 5, 10 and 15 $t.ha^{-1}$ of liquid cow bokashi addition were investigated. Randomized block experimental design arrangement and Duncan multiple range test with three replications was used to analysis the effect of treatment on all parameters evaluated. Significant effect and linier correlation was shown in all parameters with 15 $t\ ha^{-1}$ of liquid cow bokashi addition. Improvement of soil physical properties is clear performance in this treatment. From the results it could be concluded that addition of liquid cow bokashi is effective and useful in creating environmental conditions to support optimum maize growth.

Keywords

Liquid cow bokashi

Plant growth

Root optimum conditions

Introduction

Optimizing of plant production is determined on various factors which are rising from plant varieties and environmental conditions to support plant growth. Genetic factor in plant was bring maximum production potential and it could be realized when cultivation environment in the best conditions. Plant roots are important plant component to provide of plant growth and production. Their function, their ability to grow under a range of soil-climatic conditions, and the extent of soil contact will significantly affect the growth and development of the whole plant (Carson, 1993 *in* Jones 2012).

The developments of root and root systems of plant will be growing well, if the root environmental condition is optimum. Particularly in terms of the physical properties of soil, the dominant factor of limitations root development is soil mechanical resistance.

Islami and Utomo (1995) explained that soil structure and texture were the main physical properties directly affected by mechanical resistance process. It process was related to soil compaction and soil strength which could be determined growth and development of roots. Hazelton and Murphy (2007) was indicated that root growth is largely restricted to existing pores, planes of weakness or cracks between soil structural units or peds Improving soil physical properties to support plant growth environment using organic matter has been suggested as affect root growth (Canellas et. al., 2002, Giorgi et. al. 2008, Baldi and Toselli, 2013), change in physico-chemical and biological (Bouajila, and Sanaa**,** 2011), soil conditions and plant growth (Passioura, 2002). The application of OM to the soil may by increasing inorganic ions and humic substances that induce a proliferation of lateral roots and root hairs and cause a higher differentiation rate of root cells (Concheri et al. 1996). Organic matter could be contributes directly as a binder and indirectly affect the porosity and water content. Interactions between soil strength, bulk density, and water content as well as its relationship with mechanical resistance of roots (Hamblin, 1985). Furthermore as described by Rosmarkam and Yowono (2002) that application of organic matter will assisting of soil tillage, especially in soils with heavy clay texture and soil will be easily penetrated by plant roots.

Plant root support development and its relation to rhizosphere environment management would be the key in successful plant production. Therefore, improvement of environmental conditions to serve optimum rooting growth was become challenging study. Application of organic matter in bulky form as compost, crop residue, various manure sources have been many used in agriculture field for various objectives. Recently, liquid bokashi from animal husbandry by-product was interesting organic matter resource to be applied for improvement of plant growth environment. In that relation, this study have objective to evaluate the effectiveness of liquid cow bokashi to create optimum root environmental conditions, especially in relation to physical, mechanical of root resistance, and plant growth.

Materials and methods

Field experiment was conducted in Inceptisols soil type (Soil Taxonomy, NRCS-USDA, 2003) at experimental farm of Gowa Agricultural Extension College, South Sulawesi, Indonesia. Plot experiments were arranged in 2 m x 2 m, and it was plough twice before planting. In the last plough liquid cow bokashi was sprinkled in each plot experiment as the level of each treatment. Liquid cow bokashi was incubated in the field for two weeks, after incubation maize was planting with planting space 75 cm x 25 cm.

Randomized block design arrangement with three replications was applied in this experiment. The treatments were designated in 4 (four) concentrations: 0 $t.ha^{-1}$ (without liquid cow bokashi), 5 $t.ha^{-1}$ liquid cow bokashi, 10 $t.ha^{-1}$ liquid cow bokashi, and 15 $t.ha^{-1}$ liquid cow bokashi, respectively. Each plot received a basal fertilizer of 300 kg. ha^{-1} Urea (applied in 3 splits), 150 kg ha^{-1} SP-36 and 100 kg ha^{-1} KCl. Soil sample analysis was done at Biotechnolgy Laboratory, Gowa Agricultural Extension College.

In this study, some parameters related to soil fertility were considered, i.e. soil physical properties measured, soil porosity, bulk density was determined by the core method and penetration resistance was measured with a cone-penetrometer (Yamanaka method). Measurements of plant height and root volume were also done to evaluate the treatments effect on plant performance.

For all data collected, the differences between means were evaluated by analysis of variance (ANOVA) and standard error test by Kerlinger, (1990) was used. Duncan's multiple range test was applied to test the significantly differences between treatments. Statistical analyses were carried out using SPSS statistical program.

Results and discussion

Bulk density

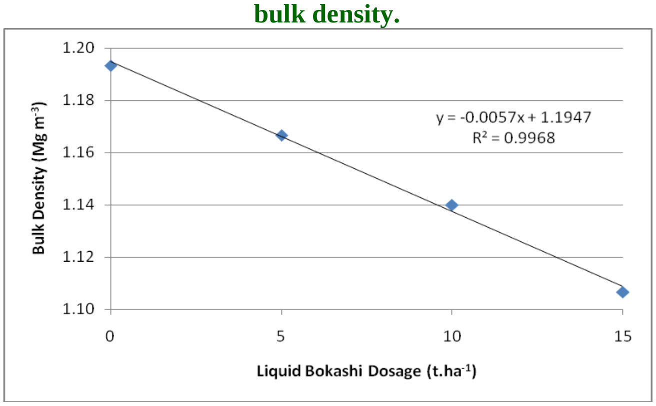
Bulk density is a dynamic soil property, altered by cultivation, compression by animals or machinery, weather, and loss of organic matter. The difference of bulk density as the effect of introducing liquid cow bokashi was shown in Table 1. Effect of each treatment analysis using Duncan multiple range test was found that application of liquid cow bokashi resulted in significant effect on bulk density with 15 $t.ha^{-1}$ treatment being the best result. Result also shown that application of 15 $t.ha^{-1}$ improved soil bulk density to 1.1067 Mg m^{-3} compared with control (1.1933 Mg m^{-3}). Application liquid cow bokashi of 5 $t.ha^{-1}$ and 10 $t.ha^{-1}$ were not significant effect but it still difference when compared with control.

Table 1. Average of soil bulk density value at various of liquid bokashi dosage.

Treatment	Soil bulk density (Mg m^{-3})*
0 $t.ha^{-1}$	1.1933^a
5 $t.ha^{-1}$	1.1667^b
10 $t.ha^{-1}$	1.1400^c
15 $t.ha^{-1}$	1.1067^d
*The value with same letter is not significant different at Duncan multiple range test α 0.05.	

These data also showed a negative linear relationship between increasing of liquid cow bokashi followed with decreasing of soil bulk density (Fig. 1). The relation of the treatments and bulk density was shown by the equation of y = -0.0057 x + 1.1947 and the coefficient of determination 0.9968. The equation means that the 99.68% of decreasing in soil BD was affected by the addition of liquid cow bokashi.

Fig. 1: Relationship between liquid cow bokashi with soil bulk density.



Reducing of soil bulk density as a result of liquid cow bokashi application might be expected due to interactions of various processed between soil, organic matter, and living microorganism. As mentioned by Dexter (1988) that soil microbiological activity would be improved soil physical properties, especially in improving soil pores and it made effect to decreasing soil bulk density. The other process related to decreasing of bulk density could be drive of dilution effect resulting from the mixing of organic matter addition (OM) with the denser mineral fraction of the soil as explained by Powers et al., (1975). This process could be associated to variable containing of lignin and polyphenols, which influence decomposition and mineralization rates (Vanlauwe et al., 1997) and its build an improvement and stable instantaneous effect on aggregation Debosz et al. (2001). The result was shown clear effect of liquid cow bokashi in improving environmental plant growth through decreasing soil bulk density.

Soil porosity

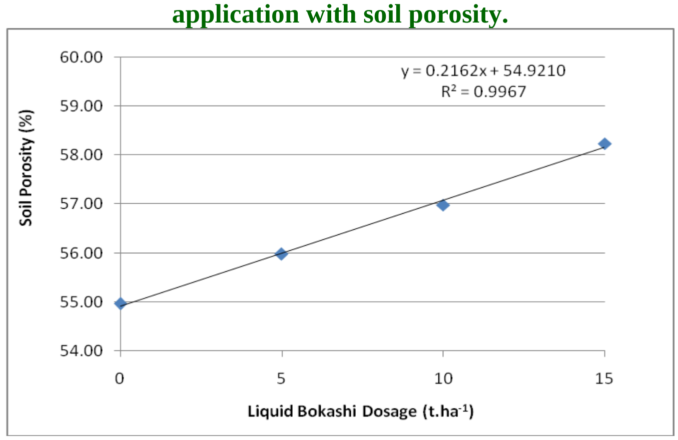
Addition of liquid cow bokashi and soil porosity was significantly interacted as shown in Table 2. Soil porosity was reached to 58.24% on 15 $t.ha^{-1}$ of liquid cow bokashi treatment. Between treatment of 5 $t.ha^{-1}$ and 20 $t.ha^{-1}$ was not significant effect to soil porosity (55.98% and 56.98%, respectively). At the whole result application of liquid cow bokashi could be improved soil porosity better than without this treatment (control).

Table 2. Average of soil porosity at various of liquid cow bokashi treatments.

Treatment	Soil Porosity (%)*
0 $t.ha^{-1}$	54.97^a
5 $t.ha^{-1}$	55.98^b
10 $t.ha^{-1}$	56.98^c
15 $t.ha^{-1}$	58.24^d
*The value with same letter is meaning not significant different at Duncan multiple range test α 0.05	

Interaction analysis between liquid cow bokashi and soil porosity was found a positive linear relationship (Figure 2). The regression equation was y = 0.2162 x + 54.9210 and the coefficient of determination was 0.9967. Using this interaction, it could be concluded that 99.68% of soil porosity differences depend to application of liquid cow bokashi.

Fig. 2: Relationship between liquid cow bokhasi application with soil porosity.



Soil porosity was significant change with addition liquid cow bokashi. It was demonstrated that liquid cow bokashi have a positive effect on soil physical properties by increasing soil porosity that was favourable to root growth. Studies on soil porosity was shown increasing of the number of total transmission pores when organic matter applied (Passioura, 2002; Vignozzi et al., 2005). In generally, increasing of total soil pore was indicating the soil revealed a better structural stability when applying liquid cow bokashi and finally it was served better root extension.

Soil penetration resistance

Significant effect analysis using Duncan multiple range test on liquid cow bokashi treatment to soil penetration resistance was found that application of 15 $t.ha^{-1}$ decreased to70.58 kPa and significantly different with other treatment (Table 3). Between treatment of 5 $t.ha^{-1}$ and 10 $t.ha^{-1}$ was not significant effect to soil penetration resistance but it difference when compared to control. In general, application of liquid cow bokashi allowed better soil penetration resistance. The results showed that the application liquid cow bokashi improved soil penetration resistance (94.50, 85.17 and 70.58 kPa, respectively) when compared with control (114.33 kPa).

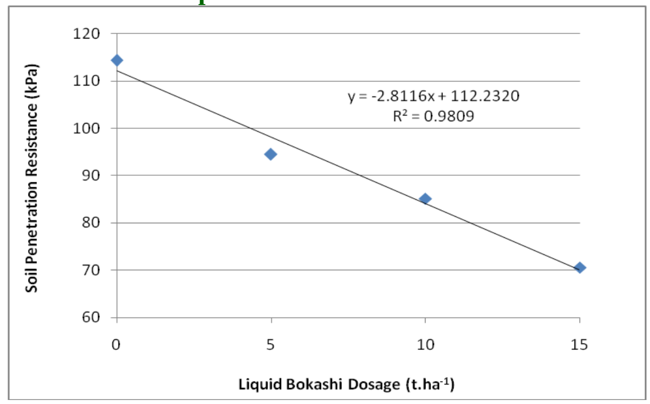
Table 3. Average of soil penetration resistance at various of liquid cow bokashi application.

Treatment	Soil Penetration Resistance (kPa)*
0 $t.ha^{-1}$	114.33^a
5 $t.ha^{-1}$	94.50^b
10 $t.ha^{-1}$	85.17^c
15 $t.ha^{-1}$	70.58^d
* The value with same letter is meaning not significant different at Duncan multiple range test α 0.05	

These data also showed a negative linear relationship between the increasing of liquid cow bokashi with decreasing soil penetration resistance (Figure 3). The regression equation was y = -2.8116 x + 112.2320 and the coefficient of determination 0.9809. It means that 98.09% decreasing of soil penetration resistance was determined by the addition of liquid cow bokashi.

Soil penetration resistance is a representing of soil hardness or soil strength which was characterized by the presence of soil compaction or decrease of macropores (Gusli, 1998). Maintaining the aggregate structure is important for plant productivity as the aggregate structure can influence soil strength and mechanical resistance to emergence and root growth. Letey (1985) explained that normal plant growth needed low soil strength or low soil bulk density, which can be penetrated by plant roots. Utomo et al. (1991) was obtained a relationship between soil penetration index with decreasing soybean production.

Fig. 3: Relationship between liquid cow bokhasi with soil penetration resistance.



Taylor et al. (1972) have found that growth of plants roots faster at low mechanical resistance. The study result could be suggesting that liquid cow bokashi application would be improved soil penetration resistance and it effective to support root growth environment.

Plant height

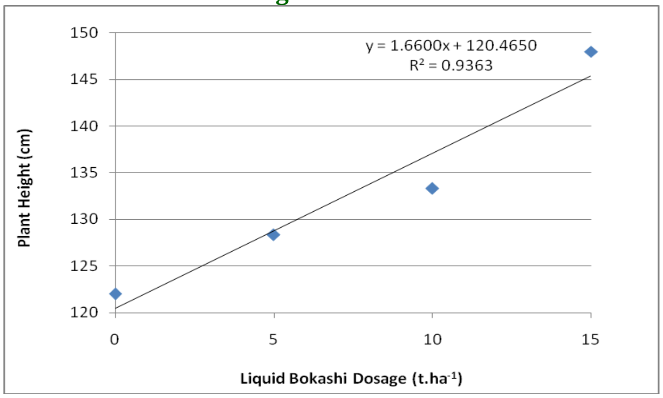
Plant height could be indicating their performance to the effect of liquid cow bokashi application. As can be seen in Table 4, application liquid cow bokashi resulted in significant increase plant height, with the treatment 15 $t.ha^{-1}$ being the highest result (148.00 cm). In the treatments of 5 $t.ha^{-1}$ and 10 $t.ha^{-1}$ were not significantly different to plant height, but it difference compared to control.

Table 4. Average of plant height at various liquid cow bokashi treatments.

Treatment	Plant Height (cm)*
0 $t.ha^{-1}$	122.00^a
5 $t.ha^{-1}$	128.33^b
10 $t.ha^{-1}$	133.33^b
15 $t.ha^{-1}$	148.00^c
*The value with same letter is meaning not significant different at Duncan multiple range test α 0.05.	

A positive linear relationship between treatments of liquid cow bokashi dosage with plant height (Fig. 4). The relationship equation was y = 1.6600 x + 120.4650 and the coefficient of determination value is 0.9363. The equation means that 93.3% of the increasing of plant height was determined by increasing of liquid cow bokashi application. The environmental growth conditions in upper part and below soil surface might be observed on plant height.

Fig. 4: Relationship between liquid cow bokhasi with plant height of maize.



Nutrient availability in the soil and the ability of plant to uptake that nutrient were the cycling of soil-plant nutrients which was the beneficial of organic matter could be supply chemical and nutritional plant growth demand (Bot and Benites, 2005). This experiment result was shown at least 20% increasing of plant height by application of 15 $t.ha^{-1}$ liquid cow bokashi. The result also shown the influence of liquid cow bokashi to support plant roots in absorb and uptake available nutrient around the rhizosphere. The addition of organic matter into soil would be improved soil properties and directly affect root development and the ability of roots to absorb water and nutrients.

Root volume

The total number of plant roots could be used as indicator of growth development and plant response to the rhizosphere environment. Significant differences analysis of the each treatment using Duncan multiple range test was shown that application of liquid cow bokashi significantly difference compared to control (Table 5). Application of 15 $t.ha^{-1}$ was the highest roots volume (370.00 cc), and it was significantly different to other treatment. There was not significantly different in total roots volume between addition of 5 $t.ha^{-1}$ (338.33 cc) and 10 $t.ha^{-1}$ (351.67 cc) liquid cow bokashi but it still higher compare to control (316.67 cc).

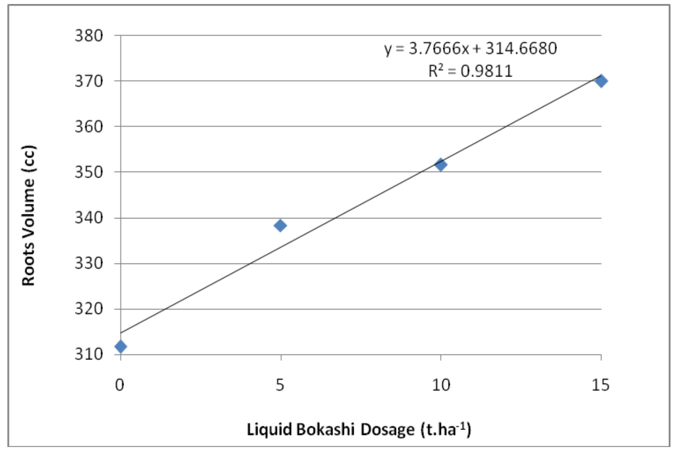
Table 5. Average of plant roots volume at various liquid cow bokashi treatments.

Treatment	Roots Volume (cc)*
0 $t.ha^{-1}$	311.67[a]
5 $t.ha^{-1}$	338.33[b]
10 $t.ha^{-1}$	351.67[b]
15 $t.ha^{-1}$	370.00[c]

*The value with same letter is meaning not significant different at Duncan multiple range test α 0.05.

These data also showed a positive linear relationship between increasing of liquid cow bokashi treatment with increasing of roots volume (Fig. 5) with the equation of y = 3.7666 x + 314.6680, and the coefficient of determination 0.9811. The equation made clear effect of this treatment that 98.11% of root development was determined by application liquid cow bokashi.

Fig. 5: Relationship between liquid cow bokhasi with roots volume of maize.



Root development was dynamic process as the plant response to changes rhizosphere environment. Introducing liquid cow bokashi into soil had effect to soil and plant root interaction. This experiment was shown significantly increasing of roots volume with increasing liquid cow bokashi application. Young and Crawford (2004) explained that the release of organic compounds provided a substrate for microbes that promote aggregation of particles and with all of their effects on soil structure. This process then influenced to plant roots development. Improving root environmental conditions could be done by application organic matter, especially using liquid cow bokashi.

Conclusion

Plant roots environmental conditions would be influence plant performance. Concerning the improvement of root environmental conditions, liquid cow bokashi additions could be used as material in improvement soil physical properties related. Moreover, application of 15 $t.ha^{-1}$ liquid cow bokashi was significantly improved the properties of the soil, i.e: decreased soil bulk density, increased soil porosity, and decreased soil penetration resistance which contributes to better plant performance in plant height and roots volume.

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