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HYDRODYNAMIC ANALYSIS OF COMPOST SOIL MIXTURE AND ITS IMPLICATION ON GROWTH AND POTASSIUM UPTAKE IN CORNS (Zea Mays L)

Abisatya Pambayun W S
Department of Bioengineering, School of Science and Technology, Bandung Institute of Technology, Bandung, Indonesia
abisatya.pambayun@gmail.com

Mubiar Purwasasmita
Faculty of Industrial Technology, Bandung Institute of Technology, Bandung, Indonesia
mubiar@che.itb.ac.id

Taufik Urahman
School of Science and Technology, Bandung Institute of Technology, Bandung, Indonesia
taufik@sith.itb.ac.id

Abstract

The research has been conducted on the hydrodynamics analysis of compost soil mixture and its implications for growth and potassium uptake in corns. The study design arranged in a completely randomized method with six repetitions for soil treatment (T_0), a mixture of soil:compost 3:1 (T_1), and a mixture of soil:compost 1:1 (T_2) also treatment without nutrients (N_0), NPK with 200 kg/ha concentration (N_1), and NPK with 400 kg/ha concentration. (N_2). The research method was conducted on the porosity, capillarity and water holding test. The results showed soil:compost mix of 1:1 has a porosity value of 0.66±0.01 (11% greater than the porosity of the soil) and water holding value of 64.79±1.99 (18% greater than water holding of the soil). Corn plants grown in *soil:compost mix of 1:1 has grown 35% higher than the planting of corn in soil and biomass gain of 125%. Potassium uptake in corn plants grown in compost soil mix 1:1 are 5% higher than the potassium uptake of corn plants grown in soil. This can be concluded that giving compost to the soil can improve the structure of soil and the flow of water from the soil to the plant as well as the implications for the growth and potassium uptake in plants.*

Keywords
Hydrodynamics, Soil, Compost, Corn, Growth, Uptake of Potassium

1. Introduction

The hydrodynamic of the media refers to the flow characteristic of the media, especially the flow of water. Hydrodynamic characteristics can be explained as capilarity, permeability, and the ratio of water retained in the media (water holding capacity of the media). The size and shape of particles in a medium affects the flow characteristics. An example of the type of media is compost. Clumps of compost looks like soil actually has a lot of space which is shaped like capillary tubes. These capillary tubes have various size and shape that depend on the constituent materials. It will change its form from time to time continuously to form a cycle of space. It will form a system with grain of soils. Then, it will interact well with the plant root system. The pipe shape from the capillary will accommodate physical processes, chemical reactions, and biochemical processes required in physiological processes that occur in plants. . In addition to facilitate the process of physical and chemical reactions, these capillary pipes also support the survival of soil microorganisms which are useful for plants. It will accommodate the processes to be more effective and selective. This is because the space where the chemical process happens is reduced. So, the mass-energy transfer and the reaction rate will be greater. (Purwasasmita & Sutaryat, 2011).

This study aims to determine the hydrodynamic characteristics which include porosity, capillary action and the ratio of water suspended in the mixture of soil and compost media. Also to determine its implications for growth and potassium uptake in corns.

Nowadays trends in health food needs of consumers are increasing. Conduction of life has change in the rush of time and a lot more interesting image. As a result, some consumer groups, especially the health conscious consumer to get the nutrients while consumers around the world give priority to health.

2. Materials and Methods

Porosity Test

Porosity test is performed using a 500 ml measuring cup filled with 135 mL of media. Then the measuring cup is filled with 200 mL of water and wait until the water certainly enter all the pores of the test medium (column) for 12 hours. Porosity of the media can be measured by the formula of porosity in the following equation.

$$\varepsilon = \frac{(V_{media}+V_{water})-V_{bulk}}{(V_{media})} \tag{1}$$

With ε is the porosity, V_{media} is the media volume on the measuring cup and V_{water} is the volume of water that is poured into a measuring cup. V_{bulk} is total volume of water and mediaon measuring cup after settling for 12 hours.

Capillarity Test

Lu & Likos (2004) in their research states that the ratio of capillarity on media is made by looking at the high profile of water level rise over the time. Capillarity test is done using a column with a diameter of 6 cm and a height of 12 cm. The partition is given in the downside of the column to ensure the media in the column did not fall during the capillarity test. The media is poured into the column until reaching the height of 12 cm. Then, the column which contains the media is placed in a container of water. The water must be contacted with the bottom of the media (column). Finally, the graph can be made by judging the rising water in the column every 5 minutes and observing the water level in column over the time.

Water Holding Capacity Test

Water holding capacity test is done to look at the media's ability to store water which is represented as a percent of the volume of water contained in the media to the total volume of the media. Tuller and Or (2004) states that the value of retained water ratio represented as the volume of water contained in the medium divided by the volume of media used. Before the test, the weight of the media and the columns that will be used during the test are measured first. Water resistance test is begun by inserting the media into a 135 mL column with a diameter of 6 cm and a height of 12 cm. Furthermore, the column which contains the media is soaked in water for ± 3 hours to ensure the mediain the column already saturated with the water. After that, the column is transferred into another container at room temperature and waited for ± 12 hours until no more water dripping through the bottom of the column. Water loss due to evapotranspiration is assumed very small so that the amount can be ignored. In the final stage, the column is measured the weight of water contained in the media using the data which is measured before the addition of water.

Corn Plant Growth Test

Corn seeds were obtained from Balitbang Research Institution in South Sulawesi, Indonesia. The corn is a hybrid variant of Sukmaraga. Plants were grown in a green house. The medium used at the stage of sowing is soil with the mesh of 5 (pass the filter particles of porous 4 mm) which is included in the classification of the soil silty clay containing silt at 50%, clay by 40%, and sand by 10% in the case of seeds or tray. At this stage of growth, growing medium used was a mixture of soil mesh 5: compost mesh 5 (1:1) (v: v), mixture of soil mesh 5: compost mesh 5 (3:1) (v:v), and soil mesh 5. The growing medium is placed in a polybag with the size of 20 x 12 cm (height x diameter). Each polybags filled with medium as high as 12 cm.

The green house dimension is 1,5x1x1 m. Each of the green house can accommodate 54 pieces of polybag which consists of 18 pieces of polybag filled with soil: compost (1:1) (v: v), 18 pieces of polybag filled with soil: compost (3:1) (v: v), and 18 pieces of polybag filled with soil. The first stage is the sowing stage. At this stage, 98 corn seeds are sown in seed box or tray with the capacity of 98 seeds filled with soil. After 5 days, the germinated seeds are carried out to the transplanting stage. Germinated seeds are placed in polybag with the diameter of 12 cm and height of 12 cm. Each polybag is planted with onegerminated seed with the height of 5-6 cm. The third stage is the growth stage of the corn plant for 42 days.

The treatment consists of three variations of media and three variations of nutrient. Variations of media consist of a mixture of soil mesh 5: compost mesh 5 (1:1) (v: v), mixture of soil mesh 5: compost mesh 5 (3:1) (v: v), and soil mesh 5. Variations of nutrient consist of variation without the addition of NPK, the addition of NPK at a concentration of 200 kg/ha, and the addition of NPK at a concentration of 400 kg/ha. So that when combined, it will create 9 varieties of plant. Each of the variation has six repetitions.

The concentration of NPK fertilizer 400 kg/ha and 200 kg/ha is the number of the required area of 1 ha with a soil depth of 20 cm (Ismail, 1985). The polybags with the diameter of 12 cm and the height of 12 cm are used in this research. So, the total requirement for NPK are 0.27 gram/polybag forthe variation of 400 kg/ha (N_2) and 0.135 gram/polybag forthe variation of 200 kg/ha (N_1). Each week, the plant height is measured from the ground to the tip of the highest leaf stretched vertically. The matrix treatment of corn cultivation can be seen in Table 1.

Table 1: *Matrix Treatment of Cultivation*

	Without additional nutrition (N_0)	NPK 200 kg/ha (N_1)	NPK 400 kg/ha (N_2)
Soil (T0)	T_0N_0	T_0N_1	T_0N_2
(S:C) 3:1 (T1)	T_1N_0	T_1N_1	T_1N_2
(S:C) 1:1 (T2)	T_2N_0	T_2N_1	T_2N_2

42-day-old plants are taken for the determination of dry weight of the plant. Plant samples are dried in an oven with a temperature of 80°C for 7 days. Furthermore the samples are measured to obtain the dry weight of the plant.

3. Results and Analysis

Porosity Test

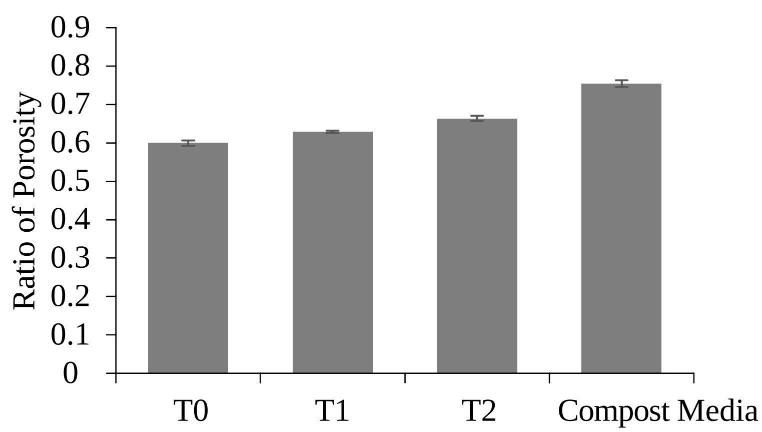

Figure 1: *Porosity test on the media*

Based on Figure 1, can be seen that the standard deviation soil porosity measurements (T_0) is the smallest compared to other media, this is because the shape of the soil particles that can be likened to a ball with a relatively uniform in size. Any errors in other media containing compost are due to the difficulty of ensuring the size and shape of each particle in the compost spreading evenly on one type of media, the distribution particle of compost is affecting directly to the measurement of the porosity. This result also proves that the variation of size and shape of the particles on a media will affect the amount of space contained in the media.

The results of the porosity testare soil (T_0) 0.60 ± 0.01, compost soil mixture with a volume ratio of 3:1 (T_1) 0.63 ± 0.001, compost soil mixture with a volume ratio of 1:1 (T_2) 0.66 ± 0.01 and 0.75 ± 0.01 for the pure compost (compost) proved that compost relatively has a larger free space than the soil. Based on this result, the addition of compost can increase the space in a media with increasing levels of compost in the soil. Increasing the space on the media will have an impact on the process of respiration that occurs in a media that can facilitate the exchange of CO_2 resulted from activity at the root respiration and degradation of organic matter from the soil to the atmosphere (Yu, 2015).

The pure compost has the highest value of porosity, but in its application in the field, the use of compost in full as a planting medium is less possible. Because of the other factor such as economical factor to use pure compost for the media is too costly. Therefore, based on this study, the best composition of soil and compost in terms of the porosity for growing media for the plant is a media type of soil and compost with volume ratio of 1:1 (T_2).

3.2 Capillarity Test

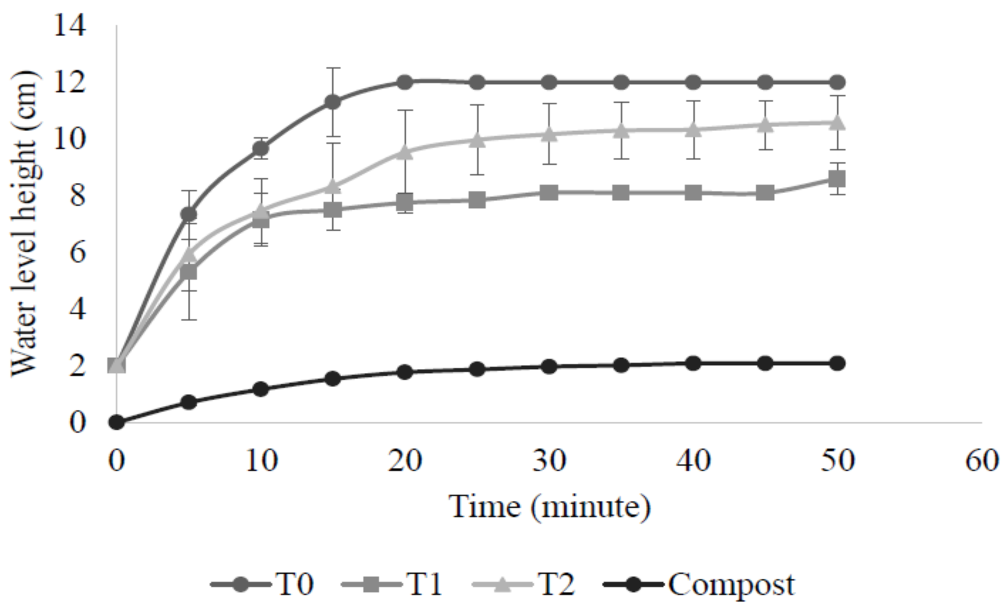

Figure 2: *Capillarity test on the media*

Based on Figure 2, it can be seen that the soil without any mixture of compost (T_0) has the highest water rise and the fastest compared to the other three types of media, this is because the size of the soil particles are relatively smaller and more uniform than particles of compost. The physical properties of the soil are easily to bind with water than the compost, also increasing the ability of the water to rise pass through the pores between soil particles are much larger within a shorter time.

The media with a mixture of soil and compost (T1 and T2) had a high increase in the water level far enough compared with the pure compost media. It is proved that the soil particles have a significant impact in improving the increase of water level by filling the space between particles of compost. The error is large enough in the media mix of soil and compost because of the difficulty of reading the water level which indicates the distribution of the particle size of the compost is not homogeneous at any point. It reinforces the conclusion that the events capillarity occurs with rising water in the capillary tube of soil and compost is largely determined by the size of the as well as the particle size distribution in the planting medium. Therefore, based on the results of this study showed that the ability of a capillary tube at compost media to lift water from the bottom is very low, so the presence of a mixture of soil and compost is a solution that is right for growing media in order to maximize utilization of existing water underground to rise to the surface by utilizing capillarity events.

Water Holding Capacity Test

The amount of water retained or water holding capacity as measured in this study is expressed in terms of percent (%), this figure shows the percentage of the volume of water retained in the bed of the total volume of the growing media. The amount of total water volume that can be stored in the medium is important to give the availability of water in the soil to be one of the main factors that affect plant growth. Based on research conducted by Gupta (2015), the greater the amount of water that can be retained in a planting medium will increase root length, height, number of branches, number of leaves and dry weight of a plant. Highly enough water holding capacity in medium can also minimize water consumption of crops especially grown in indoors or greenhouse, it would be very useful to improve the efficiency of water use in maintaining plant growth. Figure 3 shows the water resistance values for each type of growing media used in this study.

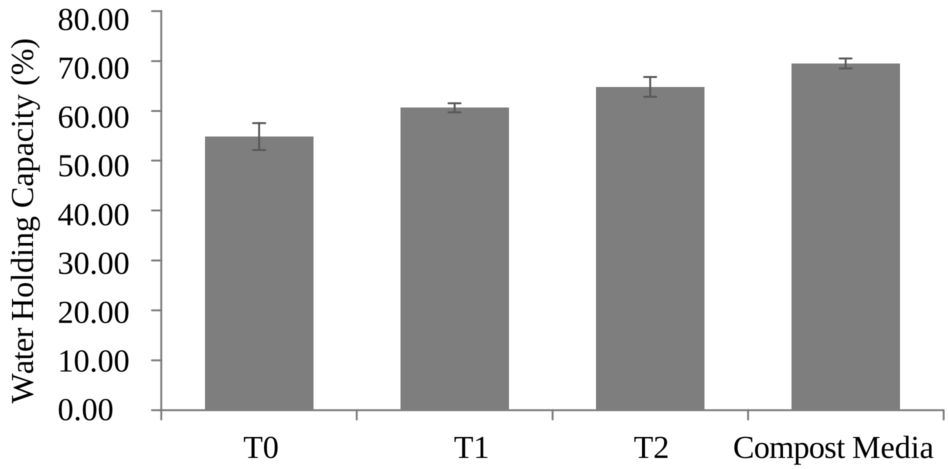

Figure 3: *Water holding capacity test on media*

Based on Figure 3 can be seen that the largest water holding capacity in media is owned by compost. This is in accordance with the test results in which the porosity of the compost has the most free space than the other medium. The test results also explain that the water suspended in compost media is not only found in the empty space between particles, but also because of the shape and size of the particles of compost that resembles the capillary pipes of the vascular tissue in plants so compost can store water in a relatively more longer than soil particles. It can be concluded that the compost has an important role to increase the water content in a planting medium.

The importance of the influence of compost from the above results show the evidence that the soil is not enough to be a media for cultivation. Not only it has low water holding capacity, but alsothe transpiration occurs on the surface of the soil is considered quite large based on research conducted by Gupta (2015). This causes the water stored in the ground will continue to decrease over time faster than the reduction of water at the compost. Results of this study also prove that the addition of compost can increase the water holding capacity in the media. It also can retain moisture for a longer period of time. The media with ratio of soil and compost 1:1 has the best ability to holdup the water when compared to other soil mixture that is equal to 68.19 ± 1.99%. These results indicate that this type of growing media has the potential to be applied to plants that require high water content and can be applied in areas with low rainfall.

3.4 Plant Height Test

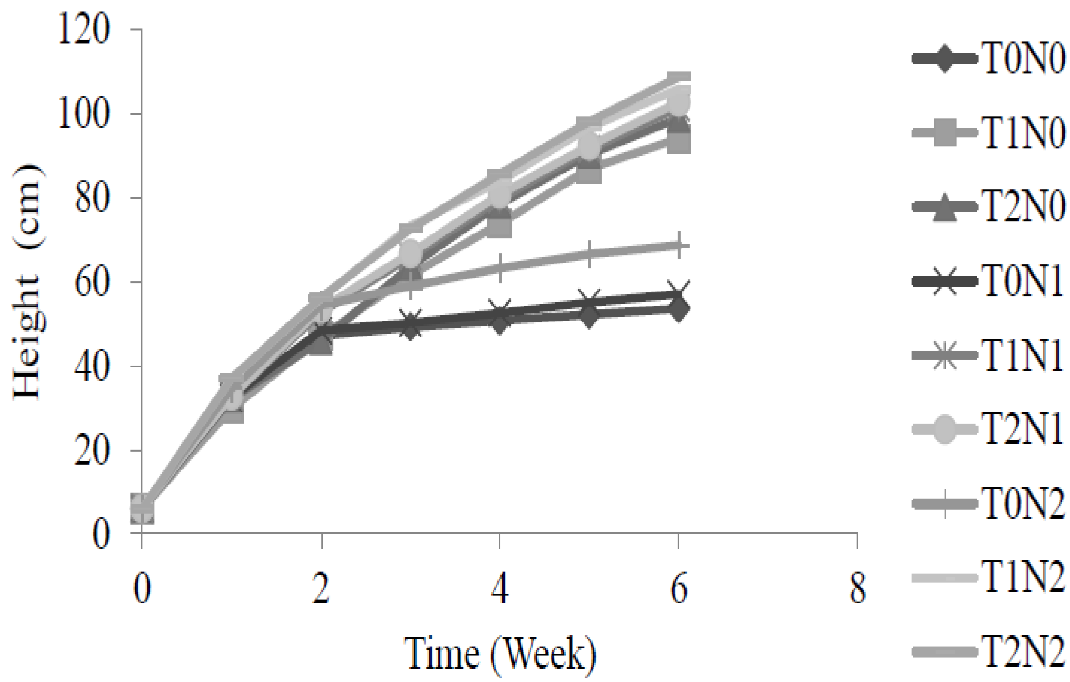

Figure 4: *Plant Cultivation Test*

Figure 4 shows the highest growth of corn plants for each treatment and nutrition media is corn plants with media soil: compost 1:1 (T_2) and the addition of 400 kg NPK/ha (N_2). It has an average height of 108 cm at week 6. It is known that all types of plants are in need for nutrients, both macro nutrients and micro nutrients. In the combination of compost and NPK fertilizers are eight nutrients (macro and micro) required for plant growth. Tuherkih and Sipatuhar (2008) states that if one nutrient is not available, it can lead to plant growth and development and hampered productivity.

The additions of compost on media provide additional nutrients for corn plant. Because there are available nutrients in a certain amount in compost (Salundik & Simamora, 2006). The addition of compost in the media also increases the capacity of water being stored on the media so that the crop water needs can be met.

Plant Dry Biomass

Dry biomass corn crop in each treatment and nutrient media can be seen in figure 4.12 corn plant samples were dried in an oven at a temperature of 80 ° C until dry. Corn plant dry biomass data presented in units of grams.

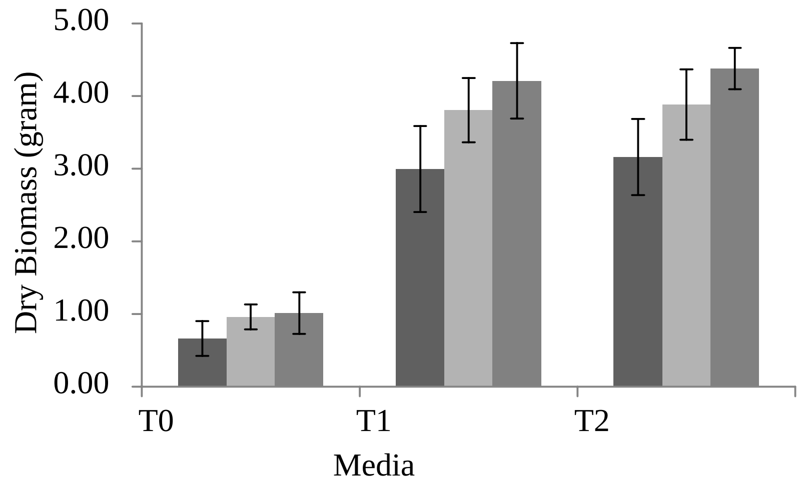

Figure 5: *Dry biomass on different cultivation media*

Figure 5 shows the highest dry biomass of corn plants contained on the media soil: compost 1:1 and nutrition NPK 400 kg / ha (T_2N_2). The dry biomass is 4.38 ± 0.28 gram. The addition of compost in the planting medium affects the plant growth and dry biomass of the plant. The addition of compost to improve the soil structure of the chamber so that the flow of water on the soil compostmixture media is better than the flow of water on the soil media. Additionally, Tuherkih and Sipatuhar (2008) states that the addition of nutrients N, P, and K affect plant growth.

Implication of Hydrodynamic Flow on Growth and Potassium Absorption

The dry biomass of corn plant is tested using AAS (Atomic Absorption Spectrophotometry) to calculate the potassium uptake. Potassium uptake in maize plants can be seen in Figure 4.13. Potassium uptake data presented in ppm (parts per million).

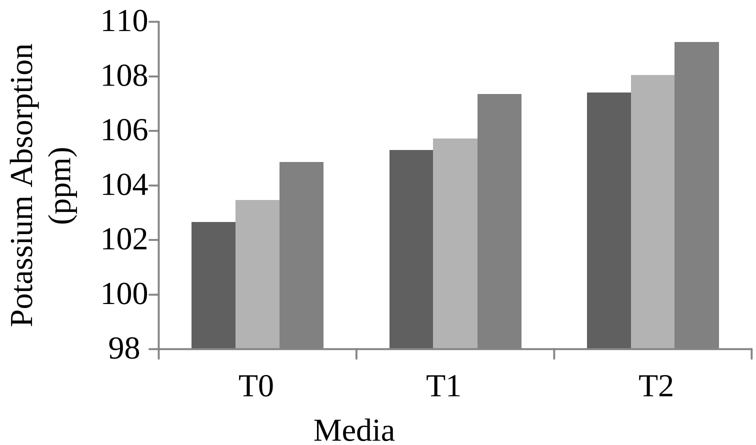

Figure 6: *Potassium absorption on plant*

Figure 6 shows, the mixture of compost soil (T_1 and T_2) has a value higher potassium uptake than the soil (T_0). In addition, increased levels of compost on the soil mix of compost also improves the uptake of potassium. This can be explained because the flow of water in the soil compost mixture to the plant is better than the flow of water in the soil to the plant. The water flow was carrying potassium which is absorbed by the plant. The structure of space in a mixture of compost and soil is facilitating water absorption to the plant. The structure of space on compost soil mixture forma branched capillary arrangement that can facilitate the flow of water to the plant. Capillary tube structure also allows the stored air to increase the surface tension of water present in the mixture of compost soil. It implicates the flow of water to the plant from the media.

4. Conclusion

From the observation, it can be concluded that giving compost to the soil can improve the structure of soil and the flow of water from the soil to the plant as well as the implications for the growth and potassium uptake in plants.

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