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Research Article

Biohole Effectiveness Analysis Through the Distribution Pattern of Microbes in Real Time for Agricultural Activities once Conservation on Grumosol Soil

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ABSTRACT

This research was conducted on grumosol soils, especially for plantations, with the aim of not only restoring the health and fertility of the soil due to the use of chemical fertilizers and pesticides as well as seeing the pattern of EC distribution at each depth from the center of the biohole based on the time of observation. Through controlled microbial activity, its spread through two types of biohole, namely horizontal and vertical biohole. This research observes in real time through soil parameter sensors connected to the micro controller to changes in soil acidity, infiltration rate, conductivity electrolyte level and porosity level through soil infiltration rate.

Through simulations with 2 types of biohole, it can be seen the increase in EC in each depth to the time of observation in real time. From the observations of graphs and EC standards, it can be seen that the ability of the soil to provide nutrients in the root growth zone to support the schedule and distribution patterns of planting both during vegetative growth and generative growth periods. So that we will know the proper biohole distance and spacing in order to be able to provide vegetative and generative mass nutrition based on nutrient values monitored through sensors that change the analog parameters in the micro posesor into digital information transmitted by Wi-Fi in real time.

Grumosol soil fertility simulation based on the number of microbial populations=10^8/cfu with **Variable 1:** The effective depth for providing root nutrition is up to a depth of 30 cm with a soil fertility value or Electrolyte Conductivity/EC 1000 uS/cm to 1500 uS/cm achieved on the 20th to day 60th day.

Varibale 2: The effective depth for providing root nutrition is up to a depth of 24 cm with a soil fertility value or Electrolyte Conductivity/EC 1000 uS/cm to 1500 uS/cm achieved on the 50th to day 60th day.

Keywords: Biohole, Microbial, Alluvial, Micro Controller, Horizontal Biohole, Vertical Biohole, Soil acidity, ***Infiltration***, Electrolyte conductivity, Biosoildam

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INTRODUCTION

The potential of grumosol land is very large for agricultural business, but the structure of this soil layer is also easily damaged if managed incorrectly. The ability of farmers also needs to be improved, especially in understanding the characteristics of this soil. So that with Biosoildam technology it will save fertilizer use and increase crop production while preserving natural resources through soil and water conservation.

The current decline in carrying land capacity continues to expand (*environement degradation*). One of the main contributing factors is the decrease in the soil fertility, health and absorption (*infiltration* rate), triggered by excessive use of inorganic fertilizers (pesticides) (Nugroho Widiasmadi, 2019). To restore the land's capacity quickly and measurably and to restore soil productivity as well, *infiltration* is not enough. Biological agents (biofertilizer) are needed to support soil and water conservation. However, so far, there has not been any periodical and continuous/real-time measurement of the monitoring and assessment system of agricultural cultivation. Thus, accurate information on a soil parameter in achieving a harvest target is needed.

Infiltration is the process of water flowing into the soil which generally comes from rainfall, while the *infiltration* rate is the amount of water that enters the soil per unit time. This process is a very important part of the hydrological cycle which can affect the amount of water that is on the surface of the soil. Water on the surface soil will enter the soil and then flow into the river (Sunjoto S, 2011). Not all surface water flows into the soil, but some portion of the water remains in topsoil to be further evaporated back into the atmosphere through the soil surface or soil evaporation (Suripin, 2013).

Infiltration capacity is the ability of the soil to absorb large amounts of water into the ground and influenced by the microorganism activities in the soil (Nugroho Widiasmadi, 2020). The large *infiltration* capacity can reduce surface runoff. The reduced soil pores, generally caused by soil compacting, can cause a decreased *infiltration*. This condition is also affected by the soil contamination (Nugroho Widiasmadi, 2020) due to excessive use of chemical fertilizers and pesticides which hardens the soil as well.

Smart-Biosoildam is a Biodam technology development that involves microbial activity in increasing the measured and controlled inflation rate. Biological activities through the role of microbes as agents of biomass decomposition and soil conservation become important information for soil conservation efforts in supporting healthy food security (Nugroho Widiasmadi, 2020). Such development has used a microcontroller to effectively monitor the activities of the said agents through the electrolyte conductivity parameter as an analogue input of EC sensors embedded in the soil and further converted to digital information by the microcontroller (Nugroho Widiasmadi, 2020).

To control the activities of biological agents, other variables are needed, such as information on pH, Humidity (M) and Soil temperature (T) obtained from pH sensors, T sensors, M sensors. These sensors are connected to a microcontroller which can be accessed through a pin that functions as a GPIO (General Port Input Output) in the ESP8266 Module so as to provide the additional capability of a WIFI-enabled microcontroller to send all analogue responses to digital in real-time, every second, minute, hour, day and monthly. Furthermore, we can display this data in infographics and numeric tables to be stored and processed in the WEB (Sigit Wasisto, 2018)

METHODOLOGY

To maximize yields, optimal soil nutrient content is required ranging from vegetative growth to generative growth so as to save the use of organic fertilizers and other nutrients. This research is to observe the number of microbes that spread radially through the horizontal and vertical biohole as the center of microbial distribution which is observed in real time using soil parameter sensors. This research will show soil characteristics in its ability to increase natural fertility and the ability to nourish the soil from toxins that come from water and air pollution.

The study was conducted on alluvial land which for decades has been the source of livelihood for the community of Purworejo Village Blora District Blora District. Land management lacks soil and water conservation. People use chemical fertilizers and pesticides excessively which harden the soil texture, acidify the soil and decrease the yields. Hardened agricultural land also triggers floods, since the soil's ability to absorb decreases. This research that took place from June-August 2020, intends to restore the carrying capacity of the land.

Tools and materials used in research are: Mikrokontroler Arduino UNO, Wi-Fi ESP8266, Soil parameter sensor: Temperature (T) DS18B20, humidity (M) V1.2, Electrolit Conductivity (EC) G14 PE, Acidity pH) Tipe SEN0161-V2 , LCD module HD44780 controller, Biohole as *Injector for Biosoildam, Biofertilizer* Mikrobia Alfafaa MA-11, red union straw as microbia nest , Abney level, , Double *Ring Infiltrometer*, Erlemeyer, ruler, Stop watch , plastic bucket , tally sheet, measuremet glass, micro scale , hydrometer dan water (Douglas MG, 2018) (Figures 1-4).

Determining plot and sensor points

To determine plots and sensors, this study uses purposive sampling at distances 3 metre from the center of Biohole with a diameter of 0,25 and 0,3 meter as the central radial distribution of the biological agent Microbe Alfaafa MA-11 through the water injection process. *Infiltration* rate and radial biological agent distribution can be controlled in real-time through measurement sensors with parameters: EC/salt ion (macronutrients), pH, humidity and soil temperature. And as a periodical control, the *infiltration* rates with a Double *Ring Infiltrometer* on the variable distance from the centre of the Biohole are manually measured. Next, soil samples are also taken to analyse their characteristics, such as soil texture, organic material content and bulk density (Douglas MG, 2018).

Data processing

Catalysis discharge: Smartbiosoildam innovation uses runoff discharge as a media for biological agent's distribution through the inlet/inflow (Biohole) as a center for the microbial population's distribution with water. The runoff discharge calculation as a basis for the Inflow Biosoildam formula requires the following stages:

1. conducting a rainfall analysis,
2. calculating the catchment area, and
3. analyzing the soil/rock layers.

Biosoildam structure can be made with holes in the soil layer without or using water pipes/reinforced concrete pipes (RCP) with perforated layer that will let microbes to spread radially. We can calculate the discharge entering Biohole as a function of the catchment characteristic with a rational formula:

$$Q=0{,}278\ CIA \quad (1)$$

Where C is the runoff coefficient value, I is the precipitation and A is the area (Sunjoto S, 2018). Based on this formula, the Table presents the

Figure 1: Double *ring infiltrometer* and sensors

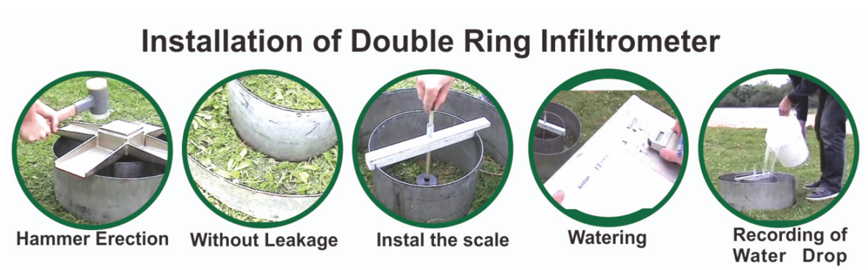

Figure 2: Instalation of double ring infiltrpmeter

Figure 3: Grumosol soil layers

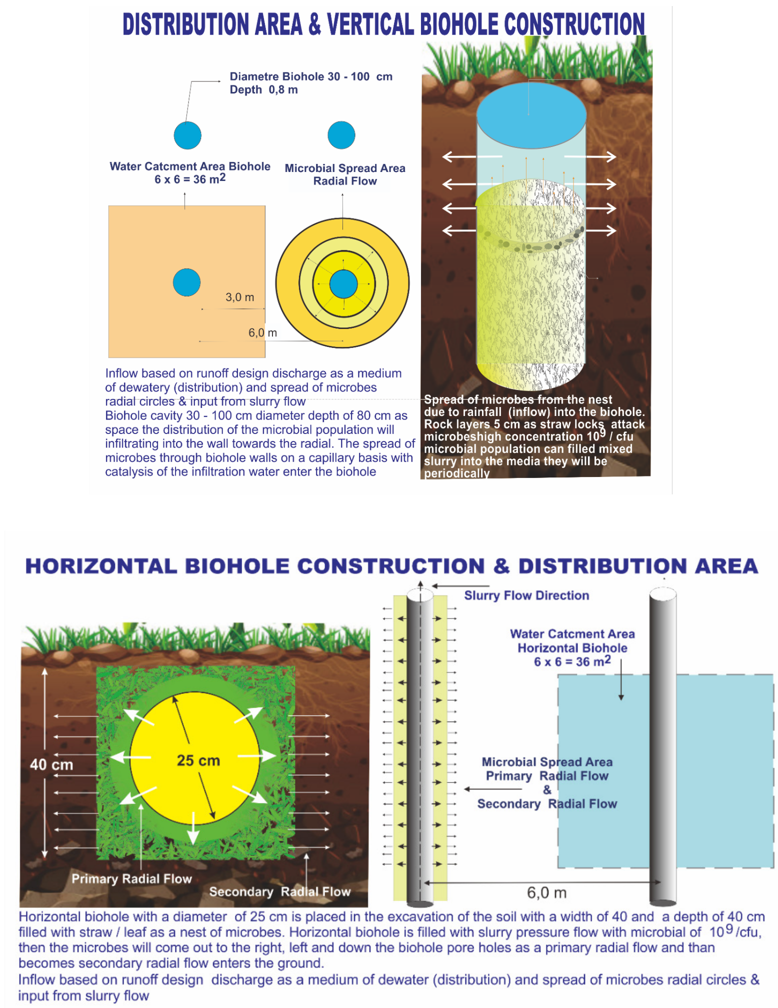

Figure 4: Distributiom and biohole structure

results of runoff discharge.

Infiltration

Infiltration is the process by which water on the ground surface enters the soil. It is commonly used in both hydrology and soil sciences. The *infiltration* capacity is defined as the maximum rate of *infiltration*. It is most often measured in meters per day but can also be measured in other units of distance over time if necessary. The *infiltration* capacity decreases as the soil moisture content of soils surface layers increases. If the precipitation rate exceeds the *infiltration* rate, runoff will usually occur unless there is some physical barrier. Infiltrometers, permeameters and rainfall simulators are all devices that can be used to measure *infiltration* rates. *Infiltration* is caused by multiple factors including; gravity, capillary forces, adsorption and osmosis. Many soil characteristics can also play a role in determining the rate at which *infiltration* occurs.

The spread of microbes as a biomass decomposting agent can be controlled through the calculation of the *infiltration* rate at point radius from Biohole as the centre of the spread of microbes by using the Horton method. Horton observed that *infiltration* starts from a standard value fo and exponentially decreases to a constant condition f_c. One of the earliest *infiltration* equations developed by Horton is:

$$f(t)=f_c + (f_o - f_c)e\text{-}kt \quad (2)$$

where :

k is a constant reduction to the dimension [T-1] or a constant decreasing *infiltration* rate.

f_o is an *infiltration* rate capacity at the beginning of the measurement.

f_c is a constant *infiltration* capacity that depends on the soil type.

The f_o and f_c parameters are obtained from the field measurement using a double-*ring infiltrometer*. The f_o and f_c parameters are the functions of soil type and cover. Sandy or gravel soils have high values, while bare clay soils have little value, and for grassy land surfaces, the value increases (Nugroho Widiasmadi, 2019).

The *infiltration* calculation data from the measurement results in the first 15 minutes, the second 15 minutes, the third 15 minutes and the fourth 15 minutes at distance from the centre of Biohole are converted in units of cm/hour with the following formula:

$$\textit{Infiltration}\ \text{rate}=(\Delta H/t \times 60) \quad (3)$$

Where ΔH=height decrease (cm) within a certain time interval, T=the time interval required by water in ΔH to enter the ground (minutes) (Huang Z *et al.*, 2011). This observation takes place every 3 days for one month.

Soil characteristics: The porosity of soils is critical in determine the *infiltration* capacity. Soils that have smaller pore sizes, such as clay, have lower *infiltration* capacity and slower *infiltration* rates than soils that have large pore size, such as sands. One exception to this rule is when clay is present in dry conditions. In this case, the soil can develop large cracks which leads to higher *infiltration* capacity.

Soil compaction is also impacts *infiltration* capacity. Compaction of soils results in decreased porosity within the soils, which decreases *infiltration* capacity. Hydrophobic soils can develop after wildfires have happened, which can greatly diminish or completely prevent *infiltration* from occurring.

Soil moisture content: Soil that is already saturated has no more capacity to hold more water, therefore *infiltration* capacity has been reached and the rate cannot increase past this point. This leads to much more surface runoff. When soil is partially saturated then *infiltration* can occur at a moderate rate and fully unsaturated soils have the highest *infiltration* capacity.

Organic materials in soils: Organic materials in the soil (including plants and animals) all increase the *infiltration* capacity. Vegetation contains roots that extent into the soil which create cracks and fissures in the soil, allowing for more rapid *infiltration* and increased capacity. Vegetation can also reduce surface compaction of the soil which again allows for increased *infiltration*. When no vegetation is present *infiltration* rates can be very low, which can lead to excessive runoff and increased erosion levels. Similarly to vegetation, animals that burrow in the soil also create cracks in the soil structure.

Microbial population

This analysis uses MA-11 biological agents that have been tested by the Microbiology Laboratorium of Gadjah Mada University based on Ministerial Regulation standards: No 70/Permentan/SR.140/10 2011, includes (Table 1). Its application in Biosoildam is concentrating the microbes into "population media", as a source of soil conditioner for increasing *infiltration* rates and restoring natural fertility.

Table 1: Microbes analysis

No	Population analysis	Result	No	Population analysis	Result
1	Total of Micobes	$18{,}48 \times 10^8$cfu	8	Ure-Amonium-Nitrat Decomposer	Positive
2	Selulotik Micobes	$1{,}39 \times 10^8$cfu	9	Patogenity for plsants	Negative
3	Proteolitik Micobes	$1{,}32 \times 10^8$cfu	10	Contaminant E-Coli and Salmonella	Negative
4	Amilolitik Micobes	$7{,}72 \times 10^8$cfu	11	Hg	2,71 ppb
5	N Fixtation Micobes	$2{,}2 \times 10^8$cfu	12	Cd	<0,01 mg/l
6	Phosfat Micobes	$1{,}44 \times 10^8$cfu	13	Pb	<0,01 mg/l
7	Acidity	3,89	14	As	<0,01 ppm

Microcontroller against nutrient content, acidity, temperature and soil moisture: Indications of microbial activity on fertility can be controlled through acidity. The number of nutrients contained in the soil is an indicator of the level of soil fertility due to the activity of biological agents in decomposing biomass. Important factors that influence the absorption of nutrients (EC) by plant roots are the degrees of soil acidity (soil pH), temperature (T) and humidity (M). Soil Acidity level (pH) greatly influences the plant's growth rate and development (Boardman CR *et al.*, 2016).

Microbial activity as a contributor to soil nutrition from the biomass decomposition results can be controlled through the salinity level of the nutrient solution expressed through conductivity as well as other parameters as analogue inputs. Conductivity can be measured using EC, Electroconductivity or Electrical (or Electro) Conductivity (EC) is the nutrients density in solution. The more concentrated the solution is, the greater the delivery of electric current from the Cation (+) and Anion (-) to the anode and cathode of the EC meter. Thus, it results in the higher EC. The measurement unit of EC is mS/cm (millisiemens) (John M Lafle *et al.*, 2011).

This study uses an Arduino Uno microcontroller which has 14 digital pins, of which there are 6 pins used as Pulse Width Modulation or PWM outputs, namely the pins D.3, D.5, D.6, D.9, D.10, D.11, and 6 analogue input pins for these soil parameter elements, namely EC, T, pH, M. Analog input on Arduino Uno uses C language and for programming uses a compatible software for all types of Arduino

(Samuel Greengard, 2017). Arduino Uno microcontroller can facilitate communication between Arduino Uno with computers including smartphones. This microcontroller provides USART (Universal Synchronous and Asynchronous Serial Receiver and Transmitter) facilities located at the D.0 (Rx) pin and the D.1 (Tx) pin.

This research uses the ESP8266 data transmission system with the firmware and the AT Command set that can be programmed with Arduino. The ESP8266 module is an on-chip system that can be connected to a WIFI network. Besides, several pins function as GPIO (General Port Input Output) to access these ground parameter sensors that are connected to Arduino, so that the system can connect to Wi-Fi (Klaus Schwab, 2018). Thus, we can process analogue inputs of various soil parameters into digital information and process them via the web.

RESULTS AND DISCUSSION

Rainfall design and Frequency Duration Intensity (FDI)

The rainfall design intensity was determined using rainfall data from Blora Station in 2013-2017 Statistical analysis was performed to determine the distribution type used, which in this study was the Log Person III's. Distribution checking on whether rain opportunities can be accepted or not is calculated using the Chi Square test and the Kolmogorov Smirnov test. Next, the design rainfall intensity is calculated using the mononobe formula.

Discharge plan

The discharge plan as a MA-11 microbial catalyst uses the rainfall intensity for 1 hour since it is estimated that the most predominant rainfall duration in the area studied is 1 hour. The runoff coefficient for various surface flow coefficients is 0.70-0.95 (Suripin, 2013), while in this study we use the smallest flow coefficient value, which is 0.70.

The discharge plan has various catchment areas, between 9 m^2 to 110 m^2 with a proportional relationship. The larger the plot, the greater the plan discharge generated as a biohole inflow.

The depth of Biohole in the study area in the 25-year return period ranges from 0.80 m to 1.50 m.

The absorption volume will determine the maximum capacity of water contained in Biohole. The greater the volume of Biohole is, the greater the water container.

Biohole design

Vertical Biohole walls use natural walls with a 0.3 m diameter and a 0.8 m depth or the storage area of 36 m^2. Organic material (slurry combined with solid pressed red onion straw waste) is used as a place for microbial populations/microbial sources. The top is installed pipe from ground tank to slurry flow from digester. Thus, when filled with organic material water, it remains stable to maintain the radial spread of microbes. The Biohole volume capacity for that dimension is 0.157 m^3, with a catchment of 36 m^2 and the 25 year-discharge=0.0000841 m^3/sec and will be fully filled in about 15 to 20 minutes. This figure considers natural resources in the form of rainfall intensity of the study area which adjusted to the spread of microbes. Therefore, the water-emptying phase and the microbial population formulation phase can take place optimally.

Horizontal Biohole walls use natural walls with a 0,25 m diameter and a 0.4 m depth or the storage area of 36 m^2. Organic material (solid pressed padi straw waste) is used as a place for microbial populations/microbial sources. The top is coated with a 5 cm thick rock which acts as an energy-breaking medium. Thus, when filled with organic material water, it remains stable to maintain the radial spread of microbes (Nugroho Widiasmadi, 2019). The Biohole volume capacity for that dimension is 0.125 m^3, with a catchment of 36 m^2 and the 25 year-discharge=0.0000841 m^3/sec and will be fully filled in about 15 to 20 minutes. This figure considers natural resources in the form of rainfall intensity of the study area which adjusted to the spread of microbes. Therefore, the water-emptying phase and the microbial population formulation phase can take place optimally.

Soil coating effect on biohole

If land is covered by impermeable surfaces, such as pavement, *infiltration* cannot occur as the water cannot infiltrate through an impermeable surface This relationship also leads to increased runoff. Areas that are impermeable often have storm drains which drain directly into water bodies, which means no *infiltration* occurs.

Vegetative cover of the land also impacts the *infiltration* capacity. Vegetative cover can lead to more interception of precipitation, which can decrease intensity leading to less runoff, and more interception. Increased abundance of vegetation also leads to higher levels of evapotranspiration which can decrease the amount of *infiltration* rate. Debris from vegetation such as leaf cover can also increase *infiltration* rate by protecting the soils from intense precipitation events.

Geomorphology of agricultural land and its surroundings is in the form of grumosol lands. Grumusol soil is soil formed from source rock of limestone and volcanic tuff which is generally alkaline so that there is no organic activity in it. This is what makes this soil very poor in nutrients and other organic elements. The nature of lime itself is that it can absorb all the nutrients in the soil so that high lime levels can be toxic to plants. Grumusol soil still carries the same characteristics and characteristics as its parent rock. Weathering that occurs only changes the physical and textures of elements such as Ca and Mg, which were previously tightly bound to the host rock to become looser which is influenced by external factors such as weather, climate, water and others. Sometimes grumusol soil has lime concretions with soft lime elements and continues to develop into a thick and hard layer.

Grumusol soil characteristics

Just like other types of soil, grumusol soil has very distinctive properties and characteristics and is easy to recognize and distinguish, such as hard and clayey, so farmers often use special tools to turn this type of soil. That is a small part of the grumusol soil properties and the following characteristics and their complete explanation.

1) Textured Clay, Grumusol soil has clay properties, namely a little hard, easily formed and easily broken or crushed. Actually it consists of various types of clays and sizes ranging from clayey clay with characteristics of a bit coarse, easy to shape, especially when dry, can be slightly rolled when pressed, but the rolls are easily crushed and the level of attachment is medium. Clay clay is often found in the deep grumusol layer or is on the horizon A to B, while on the surface it generally has a sandy clay texture which is almost the same as visible clay, only has a larger grain texture, which is above 50 microns while the clay type is clayey with a texture. less than 2 microns. This different soil texture makes it have a high enough ability to hold water.

2) The structure of the upper and lower layers is very different. Generally, the grumusol soil profile has several layers from top to bottom. For the top layer that is shaped like a granular with a size slightly larger than sand, the granular shape is often seen in the form of a cauli flower structure, while the inner layer is lumpy or can be said to be solid, this layer is what often makes processors feel difficult. and had to use some sort of crowbar to soften it.

3) Does not have an Eluviation and Iluviation Horizon. Because it has clay properties, grumusol soil does not have a layer that is useful for washing soil elements, this is because the binding power of Ca and Mg and other elements in this type of soil is so strong that when water enters it is not easy for water to dissolving and washing away these various elements. Unlike other soils such as Inceptisols or andosols, which have layers or horizons of A3 and B in each vertical section of the soil.

4) High Expansion Coefficient. This can happen especially if the water content in the grumusol soil is changed or in other words when it is dry, it is very easy to expand if all the water in it is removed. That is why the volume of grumusol soil will be greater during the distribution of the dry season and will return to normal during the rainy season. In areas where there is grumusol soil, it can be seen with the condition of the soil that expands and breaks when there is a hot or dry season.

5) Has Gray To Black Color. Grumusol soil has a color similar to sediment soil such as alluvial soil and entisol soil, which distinguishes it from the texture of the soil if you pay close attention to it, it will obviously be different, especially on the surface of the soil, grumusol is more clayey and a little rough while sediment soil is softer and smoother. The content of the elements in grumusol soil also determines the appearance of its color.

6) Low Organic Content. Grumusol soils generally have organic matter content ranging from 0.06 percent to 4.5 percent, very little when compared to other soil types such as andosol soils. The organic content will decrease in the inner layer, this is due to the higher lime content because the deep soil layer is closer to the source rock. In addition, the organic content also depends on the type of land cover vegetation, for example, rice field grumusol will be different from grumusol which is overgrown with grass.

7) Have a neutral to alkaline PH. As previously explained, the main constituent of the source rock from grumusol soil is lime so that it has an alkaline PH, but in some conditions, especially if it is mixed with slightly acidic volcanic ash, the PH can be in a neutral area. So the factors that determine the level of acidity are inherited characteristics and causes that come from outside such as the volcanic ash.

8) The Cation Exchange Capacity Is High. Grumusol soil has a high to very high CEC value of 36.13 to 77.38 cmol (+) kg-1, while for grumusol with a clay texture it has a value of 52 to 176.48 cmol (+) kg-1. The reason why CEC in this soil type is so high is due to the very dominant smectite element.

This soil type is widely distributed in the Blora plains area.

Grumosol soil fertility simulation based on biohole type with

▪ Varibale 1 using vertical type Biohole diameter 30 cm depth 80 cm with microbial population 10^8/cfu, recording soil parameters is done every 5 days for 60 days at every 10 cm depth.

▪ Varibale 2 using horizontal type Biohole diameter 25 cm depth 40 cm with Microbial Population 10^8/cfu, recording soil parameters is done every 5 days for 60 days at every 10 cm depth.

The initial nutrient condition before simulating the soil fertility value with the Electrolyte Conductivity (EC) parameter is 669 uS/cm, a distance of 3 meters from the center of the Biohole. From one point for every 10 cm depth, the EC value was measured to a depth of 90 cm, which was observed in real time every 5 days (Figure 5).

A. The results of observations and recording on the Vertical Biohole variable are:

1. The value of soil fertility or electrolyte conductivity/EC 600 uS/cm to 1000 uS/cm is achieved at:

a) 12 cm depth on the 60^{th} day

b) 30 cm depth on the 20^{th} day

c) 54 cm depth on the 35^{th} day

d) depth of 65 cm on the 60^{th} day

2. Soil fertility or Electrolyte Conductivity/EC 1000 uS/cm to 1400 uS/cm is achieved at:

a) 22 cm depth on the 60^{th} day

b) 30 cm depth on the 55^{th} day

c) depth of 48 cm on the 60^{th} day

3. The effective depth for providing root nutrition is up to a depth of 30 cm with a soil fertility value or Electrolyte Conductivity/EC 1000 uS/cm to 1500 uS/cm achieved on the 20^{th} to day 60^{th} day

B. The results of observation and recording on the Horizontal Biohole variable are:

1. The value of soil fertility or electrolyte conductivity/EC 600 uS/cm to 1000 uS/cm is achieved at:

a) 8 cm depth on the 60^{th} day

b) 24 cm depth on the 30^{th} day

c) 30 cm depth on the 40^{th} day

d) depth of 35 cm on the 60^{th} day

2. Soil fertility or Electrolyte Conductivity/EC 1000 uS/cm to 1400 uS/cm is achieved at:

a) 18 cm depth on the 60^{th} day

b) 22 cm depth on the 50^{th} day

c) a depth of 28 cm on the 60^{th} day

3. The effective depth for providing root nutrition is up to a depth of 24 cm with a soil fertility value or Electrolyte Conductivity/EC 1000 uS/cm to 1500 uS/cm achieved on the 50^{th} to day 60^{th} day

The soil parameters mentioned above can be controlled against the level of the *infiltration* rate, where the *infiltration* rate graph shows a constant value at a level of 40 to 90 cm/hour which is reached after the 30^{th} day. While the EC value in stable conditions is reached on day 35 with a value between 650-700 uS/cm. So that the activity of biological agents on gromosol soils with an optimal *infiltration* rate on the 33rd day (Figure 6).

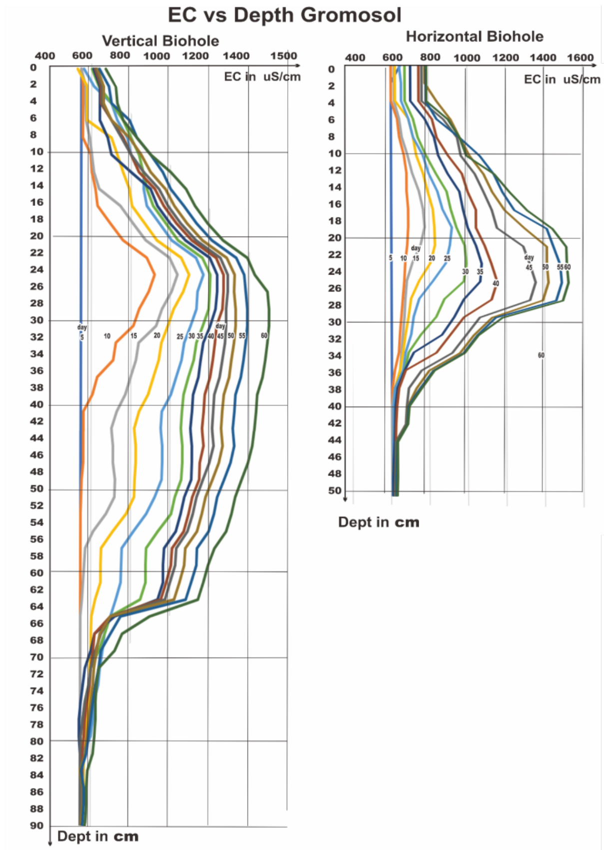

Figure 5: Graph of EC vs depth

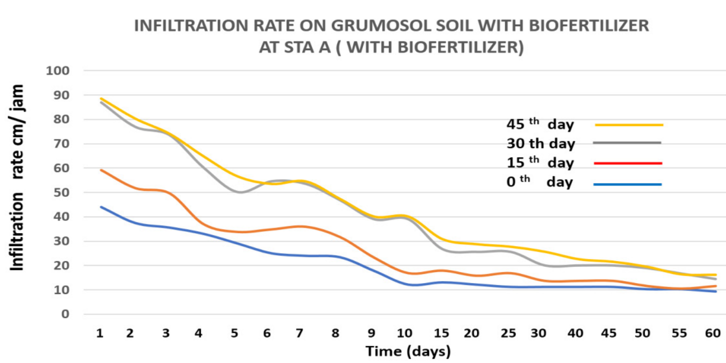

Figure 6: Graph of infilration rate

CONCLUSION

1 Vertical use of Biohole on gromosol soils is effective in plants with root depths of up to 30 cm, but it still takes more than 60th days for soil nutrient enhancement to reach above 2000 uS/cm.

2 Use of Horizontal Biohole is effective in plants with a root depth of up to 24 cm, but it also takes more than 60th days for soil nutrient enhancement to reach above 2000 uS/cm.

3 Soil surface gromosol is not effective in storing soil nutrients, but it is still quite effective for long-term plants with medium and deep rooted plants, the increase in soil nutrient value can be controlled through the depth and diameter of the biohole.

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