THE EFFECT OF AGRICULTURAL WASTE COMPOST ON THE POPULATION OF AZOTOBACTER, AZOSPIRILLUM, AND PHOSPHATE SOLUBILIZING BACTERIA IN CORN PLANT MEDIA ON INCEPTISOLS JATINANGOR

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ABSTRACT

Plants require nutrients in order to grow. One method is to provide organic fertilizer in the form of compost. rice straw, Oil Palm Empty Fruit Bunch (OPEFB), and sugarcane bagasse can all be used as compost material. The purpose of this study is to see how different types of agricultural waste compost affect the population of beneficial bacteria such as *Azotobacter* sp., *Azospirillum* sp., and Phosphate Solubilizing Bacteria (PSB) on maize planting media in Jatinangor. The study was carried out at the screen house of Ciparanje Experimental Garden in Jatinangor District, utilizing a Randomized Block Design with 9 treatments and three replications. The treatments included a control (no treatment) and three dose levels (5 tons.ha^{-1}, 10 tons.ha^{-1}, and 15 tons.ha^{-1}) of each type of compost (oil palm empty fruit bunch, sugarcane bagasse, and rice straw). The findings revealed that the use of various types of agricultural waste compost influenced the population of *Azotobacter* sp., *Azospirillum* sp., and PSB. When compared to the compost treatment of rice straw and bagasse, the application of OPEFB compost at a dose of 15 tons.ha^{-1} produced a greater population of *Azotobacter* sp. 106.43 x 10^{7} cfu.g^{-1}. While the population of *Azospirillum* sp. increased by 2.20 x 10^{7} cfu.g^{-1} as a result of the 15 tons.ha^{-1} compost of OPEFB, the effect was similar to that of rice straw and bagasse compost. PSB population increased at 15 tons.ha^{-1} of rice straw compost to 3.73 x 10^{4} cfu.g^{-1} but not different from 15 tons.ha^{-1} of OPEFB compost. Compost can be used as an environmentally friendly fertilizing alternative to enhance the population of beneficial bacteria in corn growth media and increasing nutrient availability for plants.

Keywords: Beneficial Microbes, Bacterial Population, Soil Microbes.

1. INTRODUCTION

The use of fertilizers for plants to produce optimal productivity is needed (Kasno, 2009) stated that plants cultivated today generally require nutrients in relatively large quantities. The continuous use of inorganic fertilizers can have a negative impact on the physical, chemical, and biological conditions of the soil. The use of organic fertilizers can streamline the use of inorganic fertilizers by 50%, it depends on the mineralization of organic fertilizers. (Siwanto et al., 2015).

One of the efforts to increase productivity and fertilizer efficiency is by applying organic waste compost. Rice straw compost has the potential to help increase the productivity of food crops. The nutrient content of straw compost has a composition, including: 35.11% C-organic, 1.86% nitrogen, 0.21% P_2O_5, 5.35% K_2O (Murnita et al., 2019). The recommended dose of rice

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straw compost use in corn plants is around 5-20 tons ha^{-1} (Samosir et al., 2014). Based on research results (Rhofita, 2015) application of 10 tons ha^{-1} of rice straw compost there is an increase in yield of 95% which is 6.20 tons.

Bagasse has fiber content, which can increase soil organic matter. Bagasse can help increase plant productivity by being decomposed first. Bagasse compost with the composition of bagasse, bran, cow dung, and decomposer contain a C/N ratio of 15.65%, C-organic 28.64%, N-total 1.83% and cellulose 34.37% (Setiawati et al., 2019).

Agricultural waste is generated in high quantities in the palm oil industry such as palm empty fruit bunches. Based on the analysis results (Buana et al., 2003) the nutrient content of OPEFB compost contains organic carbon 24.8%, nitrogen 0.80% and phosphorus in the form of P_2O5 0.22%, and potassium in the form of K2O 2.90%. According to Darnoko and Sembiring (2005) composted organic fertilizer of OPEFB can provide nutrients for plants with the mechanism of keeping nutrients in the soil not easily washed away by water.

The application of compost into the soil can be utilized to supply plant nutrient needs and also as a provider of energy sources for soil microbial activity (Wawan, 2017). Adequate availability of P nutrients is very important to support the growth and development of vegetative and reproductive plants, improve the quality of yield and plant resistance to disease (Nursyamsi & Setyorini, 2009). According to Widawati (2016), the availability of N nutrients for plants is due to the fixation of N_2 from the air by nitrogen fixing bacteria that can tether N_2, facilitate the N element for plants, and can produce growth hormones such as indole acetic acid (IAA) which has the use as a spur plant growth and development. The purpose of this research is to improve soil fertility in corn crops by utilizing compost from various agricultural wastes as raw materials for compost through increasing the population of microbes that are beneficial to plants, namely the population of *Azotobacter* sp., *Azospirillum* sp. and Phosphate Solubilizing Bacteria.

2. MATERIALS AND METHODS

This experiment was conducted in a plastic house located in the Experimental Garden of the Faculty of Agriculture Universitas Padjadjaran located in Cileles, Jatinangor, Sumedang Regency, West Java with an altitude of ± 745 m above sea level. This research took place from August to September 2021. The material used in this research is Inceptisols Jatinangor soil. The chemical properties of Inceptisols Jatinangor soil have a pH of 6.67 (neutral), containing C-organic 1.06% (low), N-total 0.1% (very low), total P 45.15 mg/100g (high), available P 6.89 (low) and total K 5.22 mg/100g (very low), CEC 33.73 cmol/kg (high), base saturation 25.92 (low), with clay texture. Maize seeds used were BISI-2 variety. Sugarcane bagasse compost, straw compost, and oil palm empty fruit bunch compost were used as types of raw materials from compost made from agricultural waste in Table 1.

Table 1. C-organic, C/N, and N-Total Content of Compost Made from Agricultural Waste

Compost Type	C-Organic (%)	C/N	N-Total (%)
Sugarcane Bagasse Compost	24.56	38.22	0.64
Straw Compost	20.54	25.67	0.80
Oil Palm Empty Bunch Compost	20.54	28.85	1.06

According to the treatment based on the weight of soil in the polybag used. Two weeks before planting, compost was mixed into the soil while maintaining soil moisture by watering into the planting medium according to field capacity. Planting was done after the planting media had been incubated for 2 weeks. Maize planting was done by making a planting hole in the centre of the polybag and inserting 2 maize plant seeds. In addition, inorganic fertilizer was added as a base fertilizer.

Inorganic fertilizers used were Urea, SP-36, and KCL as base fertilizers. Urea fertilization was divided into two times, the first at 1 week after planting (MST) as much as ½ dose, and the second at 3 MST as much as ½ dose. This was done because this N fertilizer has hygroscopic properties and is easily *leached*, while SP-36, KCl were applied once at planting time. Fertilizer doses were given in accordance with the literature of Purnama et al. (2018), namely Urea 300 kg/ha, SP-36 150 kg/ha, and KCl 150 kg/ha, respectively. KCl and SP-36 were applied by mixing in one hole on the other side while Urea fertilizer was applied by digging on the side of the plant with a depth of 3 cm.

Calculating the population of *Azotobacter* sp., *Azospirillum* sp., and Phosphate Solubilizing Bacteria using Ashby, Okon, and Pikovskaya media respectively. The initial soil biological properties showed that the N-fixing bacteria, *Azotobacter* sp. in this soil was 51 x 10^7 cfu.g^{-1} and *Azospirillum* sp. was 0.12 x 10^6 cfu.g^{-1} and phosphate solubilizing bacteria was 2.69 x 10^4 cfu.g^{-1}

The experimental design used in this experiment was a Randomized Group Design consisting of 9 treatments. Polybags contained 5 kg of air-dried soil. The treatments were no compost and three types of compost (bagasse, straw, and oil palm empty fruit bunch) with each dose of 5 tons.ha^{-1} (equivalent to 25 grams/polybag), 10 tons.ha^{-1} (equivalent to 50 grams/polybag), 15 tons.ha^{-1} (equivalent to 75 grams/polybag). Each treatment was repeated three times, resulting in 30 polybags.

Observation of microbial populations was carried out when the plants were 27 days after planting (DAP), the parameters observed were the total population of *Azotobacter* sp., *Azospirillum* sp., and Phosphate Solubilizing Bacteria using the total agar plate count method.

Preparation of Maize Seeds and Planting Media

The planting media used in this experiment were soil from Ciparanje Experimental Garden, Universitas Padjadjaran, Jatinangor and composted rice straw, sugarcane bagasse and

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emptypalm bunches that had been analyzed in the laboratory. Soil was taken compositely from a depth of 0-20 cm from the soil surface. The type of compost and its dosage were given according to the treatment based on the weight of soil in the polybag used. Two weeks before planting, compost was mixed into the soil while maintaining soil moisture by watering water into the planting medium according to field capacity. Planting was done after the planting media had been incubated for 2 weeks. Maize planting was done by making a planting hole in the center of the polybag and inserting 2 maize plant seeds. In addition, inorganic fertilizer was added as a base fertilizer.

Inorganic fertilizers used are urea, SP-36, and KCl. Urea fertilization was divided into two times, the first at 1 week after planting (WAP) as much as ½ dose, and the second at 3 WAP as much as ½ dose. This was done because this N fertilizer has hygroscopic properties and is easily *leached*, while SP-36, KCl were applied once at planting time. Fertilizer doses were given in accordance with the literature of Purnama et al. (2018), namely Urea 300 kg/ha, SP-36 150 kg/ha, and KCl 150 kg/ha, respectively. KCl and SP-36 were applied by mixing in one hole on the other side while Urea fertilizer was applied by digging on the side of the plant with a depth of 3 cm.

Maintenance and Observation

Maintenance includes watering, replanting, thinning, weeding, and pest control. Watering is done every day in the morning or evening according to the field capacity. Plants that died after transplanting were replanted. Weed growth is overcome by weeding so that weeds do not interfere with plant growth. Pest and disease control is done manually and chemically. Manually done by taking the pests directly, while chemically done by using pesticides adjusted to the intensity of the attack and the type of Plant Disturbing Organisms that disturb the plants if needed. Pesticide application time is done in the afternoon.

Soil Sampling

Soil biology sampling was conducted when the corn plants were harvested. Soil sampling for soil biology, soil is taken in the area around the roots of corn. Mixing the soil evenly in each separate polybag / according to the treatment is done so that the soil is homogeneous. Soil was taken as needed for analysis and put into plastic bags that had been labelled according to the treatment. All soil samples obtained from the field were analysed in the laboratory.

Data Analysis

Observation data were analysed by analysis of variance (ANOVA) using SPSS version 25.0. Duncan's Multiple Range Test at the 5% real level was conducted to determine differences among treatment means.

3. RESULTS AND DISCUSSION

Population of *Azotobacter* sp. Bacteria

The application of compost made from agricultural waste has an influence on the total population of *Azotobacter* sp and *Azospirillum* sp. compared to without the application of agricultural waste compost in several treatments and in the soil before the experiment. The population of *Azotobacter* sp. in the initial soil (before treatment) was known to be 51 x 10^7 cfu.g^{-1}. Abiotic factors affect microbial activities and populations, including: availability of nutrients in the soil, moisture, temperature and soil acidity (Simanungkalit, 2006).

Table 2. *Azotobacter* sp. population after compost application

Sample	Description	*Azotobacter* sp. ($\times 10^7$ cfu.g^{-1})
P0	No compost application	54.03 a
P1	Straw compost 5 tons.ha^{-1}	84.13 b
P2	Straw compost 10 tons.ha^{-1}	84.90 b
P3	Straw compost 15 tons.ha^{-1}	92.97 cd
P4	Sugarcane Bagasse Compost 5 tons.ha^{-1}	85.50 bc
P5	Sugarcane Bagasse Compost 10 tons.ha^{-1}	88.27 bcd
P6	Sugarcane Bagasse Compost 15 tons.ha^{-1}	94.97 d
P7	OPEFB compost 5 tons.ha^{-1}	81.90 b
P8	OPEFB compost 10 tons.ha^{-1}	85.47 bc
P9	OPEFB compost 15 tons.ha^{-1}	**106.43 e**

Note: Numbers followed by the same letter are not significantly different at the 5% Duncan test level.

Agricultural waste compost given with several treatments (Table 2) can support the growth of *Azotobacter* sp. better than the control treatment. The treatment of agricultural waste compost with the highest dose (15 tons.ha^{-1}) of each type of compost can give significantly different results compared to the control treatment. In the research data, increasing the dose of compost given tends to increase the population of *Azotobacter* sp.

The higher total population of *Azotobacter* sp. was obtained from the treatment of compost with the highest dose (15 tons.ha^{-1}). The compost treatment of 15 tons.ha^{-1} tended to produce a high total population of *Azotobacter* sp. of 106.43 x 10^7 cfu.g^{-1} compared to the bagasse compost and rice straw compost treatments. Giving rice straw compost and giving bagasse compost at 15 tons.ha^{-1} did not differ much, namely 92.97 x 10^7 cfu.g^{-1} and 94.97 x 10^7 cfu.g^{-1} respectively.

Azotobacter sp. is one species of rhizobacteria that has been recognized as a biological agent of dinitrogen fixation, a diazotroph that converts dinitrogen into ammonium through electron reduction and protonation of dinitrogen gas (Hindersah and Simarmata, 2004). The total N content of the OPEFB compost is 1.06%. The value of total N content in the OPEFB compost has a higher value than the N content of bagasse and straw. According to Treseder (2008) the availability of nitrogen (N) greatly affects the growth and abundance of organisms. Microbial activity requires an energy source, the energy source is obtained from organic matter

(Hardjowigeno, 2010), which is carbon used by microbes as an energy source so that the C-organic content in the soil will trigger microbial activities resulting in an increase in soil decomposition processes and an increase in the process of N fixation and P dissolution (Afandi et al., 2015). The C-organic content of soil in the initial analysis of compost has a higher value than that of bagasse compost and rice straw, namely 30.58%, 24.26% and 20.54%, respectively. The higher N-Total and C-organic values of the OPEFB compost compared to the rice straw and bagasse compost provided the highest total population of *Azotobacter* sp.

Population of *Azospirilum* sp. Bacteria

The population of *Azospirillum* sp. in the initial soil analysis (before compost treatment) was 0.12 x 10^6 cfu.g^{-1}. The population of *Azospirillum* sp. after being given treatments showed an increase in number compared to the population of *Azospirillum* sp. in the initial soil analysis (Table 3). The treatment of organic fertilizer with a dose of 15 tons.ha^{-1} on all types of agricultural waste has a population of *Azospirillum* sp. tends to be higher than the application of compost doses of 5 tons.ha^{-1} and 10 tons.ha^{-1}.

The treatment of all types of compost at a dose of 15 tons.ha^{-1} showed different values compared to the doseof 5 tons.ha^{-1}. The treatment of OPEFB compost showed atotal population of *Azospirillum* sp of 2.20 x 10^6 cfu.g^{-1}. The provision of OPEFB compost at a dose of 15 tons.ha^{-1} the effect is not different from the provision of composted straw or bagasse on the population of *Azospirillum* sp. Nitrogen is an element that affects the metabolism of microorganisms, especially the process of cell division, in this study it is known that the increase in nitrogen content is directly proportional to the microbial population.

Table 3. *Azospirillum* sp. population after compost application

Sample	Description	*Azospirillum* sp (x 10^6 cfu g)$^{-1}$
P0	No compost application	1.80 abc
P1	Straw compost 5 tons.ha^{-1}	1.46 ab
P2	Straw compost 10 tons.ha^{-1}	1.67 abc
P3	Straw compost 15 tons.ha^{-1}	1.91 bc
P4	Sugarcane Bagasse Compost 5 tons.ha^{-1}	1.29 a
P5	Sugarcane Bagasse Compost 10 tons.ha^{-1}	1.53 ab
P6	Sugarcane Bagasse Compost 15 tons.ha^{-1}	1.80 abc
P7	OPEFB compost 5 tons.ha^{-1}	1.53 ab
P8	OPEFB compost 10 tons.ha^{-1}	1.76 abc

P9	OPEFB compost 15 tons.ha^{-1}	2.20 c

Note: Numbers followed by the same letter are not significantly different at the 5% Duncan test level.

In the initial analysis data, the total N content in the OPEFB compost is 1.06%. The value of total N content in OPEFB compost is known to have a higher value compared to the N content of bagasse and straw. The C-organic content of soil in the initial analysis of compost has a higher value than that of bagasse compost and rice straw, namely30.58%, 24.26% and 20.54%, respectively. The higher N-Total and C-organic values of OPEFB compost compared to rice straw and sugarcane bagasse compost affect the total population of *Azospirillum* sp. which causes the highest population of *Azospirillum* sp.

Population of Phosphate-Solubilizing Bacteria (PSB)

The results of data analysis showed a significant effect of the treatment on the total population of soil PSB (Table 4). The provision of several treatments has a higher value than without the provision of compost. This proves that the PSB population in the soil can be increased by applying agricultural waste compost.

Table 4. Result of Phosphate Solubilizing Bacteria (PSB) Population Analysis After Compost Application.

Sample	Description	PSB (x 10^4 cfu.g^{-1})
P0	No compost application	2.63 a
P1	Straw compost 5 tons.ha^{-1}	2.66 a
P2	Straw compost 10 tons.ha^{-1}	2.77 ab
P3	Straw compost 15 tons.ha^{-1}	**3.73 d**
P4	Sugarcane Bagasse Compost 5 tons.ha^{-1}	2.86 ab
P5	Sugarcane Bagasse Compost 10 tons.ha^{-1}	3.59 cd
P6	Sugarcane Bagasse Compost 15 tons.ha^{-1}	3.01 abc
P7	OPEFB compost 5 tons.ha^{-1}	2.80 ab
P8	OPEFB compost 10 tons.ha^{-1}	3.33 bcd
P9	OPEFB compost 15 tons.ha^{-1}	3.53 cd

Note: Numbers followed by the same letter are not significantly different at the 5% Duncan test level.

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PSB population in the soil can be increased by applying agricultural waste compost. The dose of 15 tons.ha^{-1} of rice straw compost and 10 and 15 tons.ha^{-1} of OPEFB compost and 10 tons.ha^{-1}of bagasse compost gave higher values than 15 tons.ha^{-1} of bagasse compost. This indicates that Jatinangor Inceptisol soil requires a high dose of compost (10-15 tons.ha^{-1}) and differs depending on the type of agricultural waste compost. Penelitian ini sejalan dengan pernyataan yang dilakukan (Noviani dkk., 2018) where straw-biochar compost and NPK fertilizer have an effect on increasing the PSB population in plants. The lowest PSB population was found in the control (without treatment) with a value of 2.62 x 10^{4} cfu.g^{-1} but not different from the provision of compost with a low dose of 5 tons.ha^{-1}.

The population of phosphate solubilizing bacteria increased as the dose of compost given increased. C-organic in the soil and soil pH play an important role in influencing soil microbes. Bacteria reproduce well at pH 5.5-7.5 (Purwanto et al., 2022). From the results of the initial soil analysis, it has a neutral pH of 6.67, making it optimal for microbial development in the rhizosphere of corn plants. The PSB population in the straw compost 15 tons.ha^{-1} was 3.73 x 10^{4} cfu.g^{-1} which was higher than the control. However, the treatment of 15 tons.ha^{-1} of straw compost was not different from the 15 tons.ha^{-1} of OPEFB compost. This is related to the C/N of straw and OPEFB compost material which is lower than the C/N of bagasse. The lower C/N indicates that the organic material has been mineralized so that the nutrients are more available to microbes than the high C/N.

4. CONCLUSIONS

Based on the results of research on the application of various types and doses of agricultural waste as compost on corn plants, it can be concluded that the provision of various types of agricultural waste compost has an effect on increasing the population of *Azotobacter* sp., *Azospirillum* sp., and PSB. The application of OPEFB compost at a dose of 15 tons.ha^{-1} produced a population of *Azotobacter* sp. 106.43 x 10^{7} cfu.g^{-1} which was higher than the compost treatment of rice straw and bagasse. While the population of *Azospirillum* sp. was 2.20 x 10^{7} cfu.g^{-1} due to the application of composted OPEFB with a dose of 15 tons.ha^{-1} the effect was not different from the application of composted rice straw and bagasse. PSB population increased at 15 tons.ha^{-1} of rice straw compost to 3.73 x 10^{4} cfu.g^{-1} but not different from 15 tons.ha^{-1} of OPEFB compost.

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