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Effect of Cyanobacteria-Enriched Compost on Maize (*Zea mays*. L) Growth and Yield and Nutrient Uptake in Inceptisols

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ABSTRACT

Increased production of food crops has various obstacles, including soil fertility, which is also caused by the price of inorganic fertilizers, which is burdensome for farmers. Organic and biofertilizers can reduce the use of inorganic fertilizers and the level of degradation of soil fertility. The research was conducted in the greenhouse of Indonesia Soil Research Institute in Bogor from October 2021 to March 2022. The treatments were laid out in a randomized block design consisting of 12 treatments with three replications, consisting of level doses of NPK combined with compost, cyanobacteria, and (Cyanobacteria-enriched compost). (NPK75%+compost) treatment gave the highest corn cobs and grain yield by 209.86 g plant^{-1} (8.55%) and 163.49 g plant^{-1} (6.42%), respectively compared to NPK100%. The treatment of (NPK75%+compost) gave a similar grain yield with 100% NPK and can scale down NPK used by 25%. (NPK50%+cyanobacteria-enriched compost) treatment increased N uptake by 48.81% compared to NPK100%. The treatment of (NPK50%+cyanobacteria-enriched compost) increased P uptake by 0.8 mg plant^{-1} or 17.0% compared to NPK50%+compost. At NPK50%+cyanobacteria, K uptake increased by about 31.46% compared to NPK50%.

Keywords: Compost, cyanobacteria-enriched compost, growth and yield of maize, Inceptisol, NPK fertilizer

INTRODUCTION

Maize is a food plant with many benefits for human and animal life. Increased productivity of maize has various obstacles, i.e., soil fertility, and the price of inorganic fertilizers is also high, which burdens farmers because their purchasing power for fertilizers is low. This condition causes a decrease in maize productivity due to the reduced use of inorganic fertilizers in maize plants. Improving soil fertility through physical, chemical, and biological properties will support plant growth, yield, and quality (Hughes, 2005). Fertilizer needs in the short term are fertilizers that are quickly available to plants so that the available nutrients are required by plants (Ahmad, 2014).

The use of organic fertilizers is one effort that can increase crop yields (Silalahi et al., 2020). Yovita (2012) reported that the growth and harvest of sweet corn plants fed by compost are better than without compost. Organic compost and biological fertilizers can provide nutrients to minimize the use of inorganic fertilizers (Dhanushkodi and Subrahmaniyan, 2012; Septian et al., 2015). Compost can increase soil fertility by repairing physical damage caused by the excessive consumption of inorganic fertilizers (Aslihah et al., 2020).

In addition to organic fertilizers, biological fertilizers also have the potential to be used to increase soil and plant productivity. Biofertilizer is a collective name for all functional groups of soil microbes that can provide nutrients in the soil to make them available to plants (Ningsih et al., 2015). Several bacteria are used as bio fertilizers and have been used in various plants to increase their production. Some bacteria that have the potential as bio fertilizers but are not widely used are cyanobacteria. Cyanobacteria produce various compounds such as amino acids, auxin, gibberellin, and cytokine (Harmoko, 2019).

Joseph et al. (2019) found that applied humic acid enriched with cyanobacteria has significantly increased the yield components of barley and fava bean (*Vicia faba*) under salt stress conditions. Paudel et al. (2012) found that blue-green algae (cyanobacteria) inoculums applied with low doses of NPK can increase all rice yield parameters over the control treatment. Cyanobacteria enhance upland rice and improve the soil's physical and chemical properties, nutrient content, and pH (Eginarta et al., 2021). Other crops, like vegetables, wheat, sorghum, corn, cotton, and sugarcane, respond to cyanobacteria biofertilizers (Tyagi and Bhardawaj, 2013). Apart from increasing plant growth and production, cyanobacteria play a role in the conservation of soil fertility (Song et al., 2005).

This study aimed to determine various levels of NPK fertilizer doses (Urea, SP36, and KCl) combined with compost, cyanobacteria, and cyanobacteria-enriched compost to increase the productivity of maize and nutrient uptake in Inceptisols

MATERIALS AND METHODS

Research site

The research was conducted at the Greenhouse Installation of the Indonesia Soil Research Institute, West Java, from October 2021 to March 2022. The type of soil used in this study was Inceptisol soil from Cibungbulang Bogor. Soil characteristics include clay texture, acid pH (5.5), and Ca and Mg contents of 8.57 $Cmol_c\ kg^{-1}$ and 1.71 $Cmol_c\ kg^{-1}$, classified as medium. The content of C (1.76%) and N (0.5%) was low, the available P_2O_5 and K_2O content was very high and moderate, and the base saturation of 71% was high (Table 1).

Research material

The research materials used in this study were the Pertiwi hybrid variety of maize seeds as an indicator plant, inorganic fertilizers (Urea, SP36, and KCl), cow manure compost, and cyanobacteria. Cyanobacteria *Pseudanabaena* sp. was obtained from the collection of the Indonesia Soil Research Institute. The tools used included pots, label paper, plastic, stationery, scale, filter, ruler, and sample envelopes.

Experimental design

The research consisted of 12 treatments arranged of a randomized block design with three replications. The treatment consisted of NPK100% (T1), NPK100%+compost (T2), NPK100%+

Table 1. The soil characteristics of Inceptisol West Java.

Soil characteristics	Method	Unit	Value	Information
Tekstur :				
a. Sand	pipet	%	17	Clay
b. Silt	pipet	%	32	
c. Clay	pipet	%	52	
pH				
a. H_2O	pH meter	-	5.5	Acid
b. KCl			4.7	
Organic matter				
a. C	Walkley & Black	(%)	1.76	Low
b. N	Kjeldahl	(%)	0.15	Low
c. C/N	-	-	12	Moderate
a. P_2O_5	HCl25%	mg 100 g^{-1}	174	Very high
b. K_2O	HCl 25%	mg 100 g^{-1}	27	Moderate
c. P_2O_5	Olsen	mg kg^{-1}	104	Moderate
d. K_2O	Morgan	mg kg^{-1}	25	Moderate
Cations				
a. Ca	N NH_4OA_C PH 7	$Cmol_c\ kg^{-1}$	8.57	Moderate
b. Mg	N NH_4OA_C PH 7	$Cmol_c\ kg^{-1}$	1.71	Moderate
c. K	N NH_4OA_C PH 7	$Cmol_c\ kg^{-1}$	0.49	Moderate
d. Na	N NH_4OA_C PH 7	$Cmol_c\ kg^{-1}$	0.76	Moderate
Total			11.53	Low
e. CEC	N NH_4OA_C PH 7-	$Cmol_c\ kg^{-1}$	16.13	Low
a. Al		$Cmol_c\ kg^{-1}$	0.00	Very low

cyanobacteria (T3), NPK100%+cyanobacteria-enriched compost (T4), NPK75% (T5), NPK75% +compost (T6), NPK75%+cyanobacteria (T7), NPK75%+cyanobacteria-enriched compost (T8), NPK50% (T9), NPK50%+compost (T10), NPK50%+cyanobacteria (T11), NPK50%+ cyanobacteria-enriched compost (T12). The dosage of dolomite, compost, and fertilizer per pot is given out in Table 2.

Table 2. Doses of Urea (N), SP36 (P), KCl (K), dolomite, compost, and cyanobacteria per pot

Treatments	Dolomite	Compost	Urea	SP36	KCl	Cyanobacteria
	..g pot^{-1}..	..g pot^{-1}..	............g pot^{-1}...........			.....g pot^{-1}....
NPK100% (T1)	7.5	-	5.250	2.625	0.75	-
NPK100%+compost (T2)	7.5	30	5.250	2.625	0.75	-
NPK100%+cyanobacteria (T3)	7.5	-	5.250	2.625	0.75	0.5
NPK100%+cyanobacteria-enriched compost (T4)	7.5	30	5.250	2.625	0.75	0.5
NPK75% (T5)	7.5	-	3.937	1.969	0.563	-
NPK75%+compost (T6)	7.5	30	3.937	1.969	0.563	-
NPK75%+cyanobacteria (T7)	7.5	-	3.937	1.969	0.563	0.5
NPK75%+cyanobacteria-enriched compost (T8)	7.5	30	3.937	1.969	0.563	0.5
NPK50% (T9)	7.5	-	2.625	1.312	0.375	-
NPK50%+compost (T10)	7.5	30	2.625	1.312	0.375	-
NPK50%+cyanobacteria (T11)	7.5	-	2.625	1.312	0.375	0.5
NPK50%+cyanobacteria-enriched compost (T12)	7.5	30	2.625	1.312	0.375	0.5

Treatments T4, T8, and T12 were cyanobacteria-enriched compost, so cyanobacteria were inoculated in the compost and incubated one week before planting.

Soil preparation

The soil samples were taken at 0-20 cm depth, then air-dried and cleaned of roots and other materials mixed in the soil, and sieved through a 2 mm diameter screen. Soil that had been finely put into the pot as much as 15 kg per pot

Application of the treatment

The soil in each pot was commixed thoroughly with dolomite, compost, cyanobacteria, and cyanobateria_enriched compost according to treatment and incubated for one week. The recommended levels of fertilizer measured by the tool "Upland Soil Test Kit" from ISRI (Indonesian Soil Research Institute) were dolomite (500 kg ha^{-1}), compost (2 Mg ha^{-1}), Urea (350 kg ha^{-1}), SP-36 (175 kg ha^{-1}), and KCl (50 kg ha^{-1}).

Urea and KCl were given twice, one week after planting (WAP) and 5 WAP. Biofertilizer (cyanobacteria) 0.5 g per pot treatment was applied into the compost, homogenized before being incorporated into the soil in the pot treatment, and then incubated for one week to give the cyanobacteria a chance to develop first. Five seeds were planted in each pot, and on the 5th day, the plant thinned out, leaving only two plants per pot.

Observation variable

Plant height and number of leaves were observed every two weeks and ended after the plants flowered (8 weeks). N, P, and K nutrient uptake of maize at 8 weeks, while the biomass and maize yield was at harvest. The parameters observed at harvest were plant height, fresh and dry weight of plants and roots, cob weight, husk weight, seed weight, and 100 seed weight.

Data analysis

Data analysis used analysis of variance (ANOVA), followed by Duncan's Multiple Range Test (DMRT) at a 5% significance level.

RESULTS AND DISCUSSION

Plant height

The effect of various levels of fertilization combined with compost or cyanobacteria on the plant height of maize is presented in Figure 1. The highest plant height of maize plants (54.67 cm) at two weeks after planting (WAP) was achieved by the NPK75%+cyanobacteria (54.67 cm), followed by other treatments but showed no significant difference with the NPK75% treatment+compost

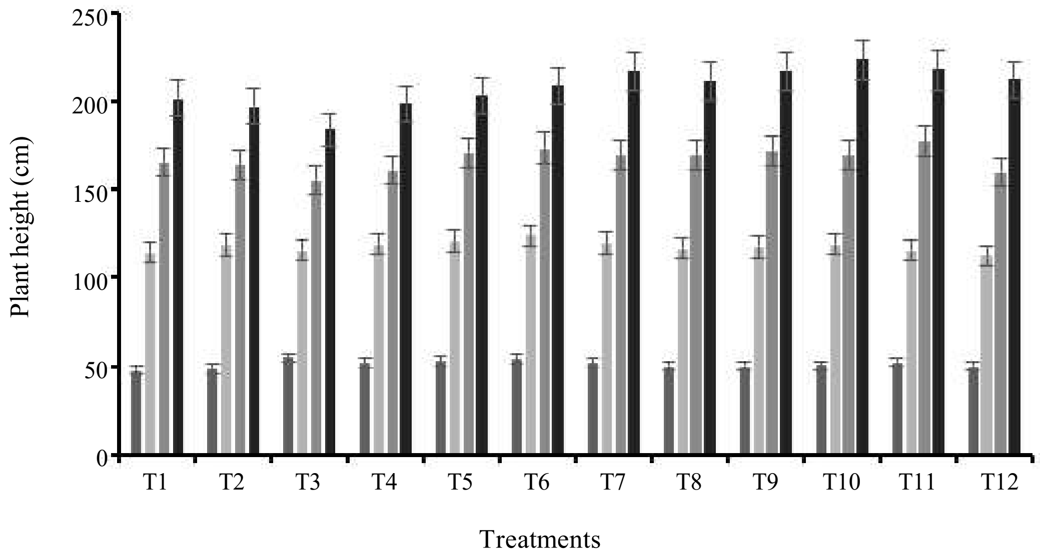

Figure 1. Effect of level dose of NPK fertilizer combined with compost and cyanobacteria on plant height at 2, 4, 6, and 8 weeks after planting (WAP). NPK100% (T1), NPK100%+compost (T2), NPK100%+cyanobacteria (T3), NPK100%+cyanobacteria-enriched compost (T4), NPK75% (T5), NPK75%+compost (T6), NPK75%+cyanobacteria (T7), NPK75%+cyanobacteria-enriched compost (T8), NPK50% (T9), NPK50%+compost (T10), NPK50%+cyanobacteria (T11), NPK50%+cyanobacteria-enriched compost (T12). ■: 2 WAP; ■: 4 WAP; ■: 6 WAP; ■: 8 WAP.

(53.83 cm). The plant height at 2 WAP in the NPK100% treatment was 47.67 cm. It proved that cyanobacteria and compost affect maize height. The increase in plant height at 2 WAP by cyanobacteria in NPK 100% treatment was 12.80% compared to NPK 100%.

The highest plant height at 4 WAP was in the NPK75%+compost (123.83 cm), while the plant height in the NPK100%+compost was 114.67 cm. At 6 WAP, the highest plant height (177.67 cm) was achieved by NPK50%+cyanobacteria. Although at 8 WAP, the highest plant height was in the NPK50%+compost. Compared to NPK100%, applying compost can save NPK fertilizer by 50% and increase the plant height of maize at the end of the vegetative phase (8 WAP) by 9.97%.

The effect of level dose NPK fertilizers, organic fertilizers, and cyanobacteria can affect the plant height of maize. It is presumably due to the addition of N elements, both from compost and N derived from N-fixing activity by cyanobacteria. Research by Lelu et al. (2018) reported that compost increases the retention and availability of nutrients for plants and increases plant height. In addition, he stated that some of the benefits of compost containing macro and micronutrients, humic acid (humus), will increase the cation exchange capacity of the soil and increase the activity of soil microorganisms. Widodo et al. (2018) reported that the provision of organic matter increased the plant height of maize plants. The research result by Paudel et al. (2012) found that blue-green algae (cyanobacteria) inoculums combined with low doses of NPK fertilizer increase all rice yield parameters higher than without cyanobacteria.

Number of leaves

The effect of applied NPK, compost, and cyanobacteria on the number of maize leaves is present in Figure 2. The NPK75 % and NPK75%+compost achieved the highest number of maize leaves at 2 WAP. Both treatments gave the number of maize leaves 5.67 sheets plant^{-1}, while the NPK treatment averaged the number of maize leaves as much as 5.0 sheets plant^{-1}. Observation of the number of leaves at 4 WAP, the treatment that gave the highest number of leaves was the NPK100%+cyanobacteria-enriched compost treatment, giving an average number of leaves of 9.7 sheets plant^{-1}, number of leaves in the NPK100% was 9.0 sheets plant^{-1}. The leaves number observation on maize plants at 6 WAP, the number of maize leaves achieved in the NPK100%+compost and NPK75%+compost treatments, namely 10.33 sheets plant^{-1}. In the final observation of the vegetative phase (8 WAP), most maize leaves were in the NPK75%+compost treatment, namely 14.0 sheets plant^{-1}.

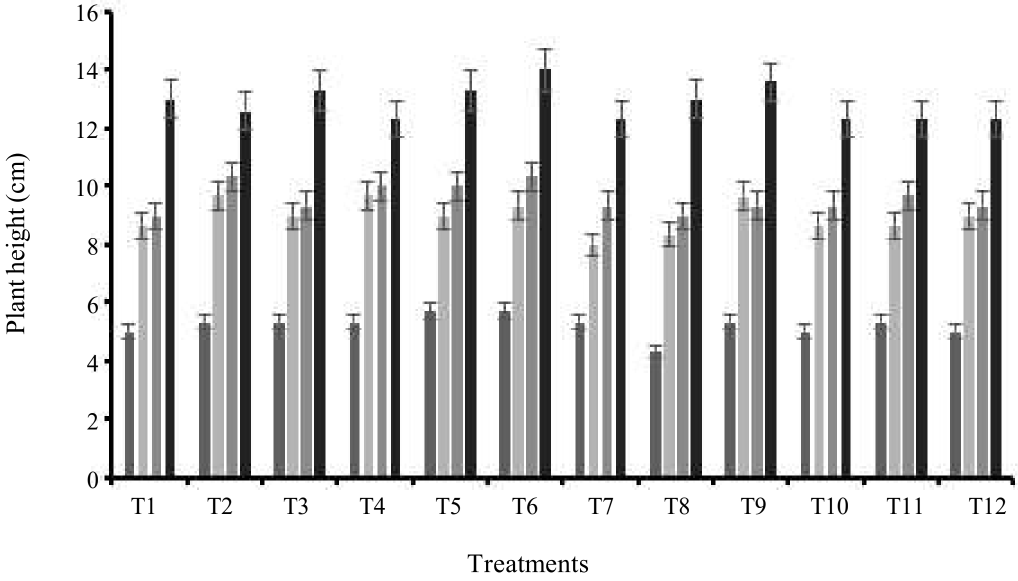

Figure 2. Effect of level doses of NPK combined with compost and cyanobacteria on leaves number at 2, 4, 6, and 8 weeks after planting (WAP). NPK100% (T1), NPK100%+compost (T2), NPK100%+cyanobacteria (T3), NPK100%+cyanobacteria-enriched compost (T4), NPK75% (T5), NPK75%+compost (T6), NPK75%+cyanobacteria (T7), NPK75%+cyanobacteria-enriched compost (T8), NPK50% (T9), NPK50%+compost (T10), NPK50%+cyanobacteria (T11), NPK50%+cyanobacteria-enriched compost (T12). ■: 2 WAP; ■: 4 WAP; ■: 6 WAP; ■: 8 WAP.

Nazirah's research (2019) states that nitrogen plays a role in leaf formation, so nitrogen dose must be carefully considered. Excessive administration of N elements can result in suboptimal generative organs, decreasing productivity and quality. The process of leaf formation is also inseparable from the role of other nutrients, such as phosphorus and potassium. Phosphorus affects new cell formation and is the main component that affects the number of leaves. The NPK 75%+compost provided the highest number of corn leaves compared to other treatments.

Maize Yield Parameters

Cob weight, husk weight, cob length, and cob diameter of maize

Treatment of various doses of NPK fertilizer, compost, and cyanobacteria-enriched compost showed significantly different effects on the cob and husk weight. However, these treatments showed no significant differences in cob length and cob diameter (Table 3). Corn cob weight ranged from 170.63 - 209.86 g cob^{-1} and showed significant differences in the treatment. The heaviest cob was achieved by NPK75%+compost (T6) treatment, while the lowest cob weight was achieved by NPK50%+cyanobacteria-enriched compost (T12) treatment. Gil et al. (2020) found that applying organic matter gave higher yields, while applying inorganic fertilizers gave lower yields of maize. Treatment of NPK75%+cyanobacteria (T7), NPK75%+cyanobacteria-enriched compost (T8), and NPK50%+cyanobacteria (T11) showed that the cob weight was similar to the NPK100% treatment. It indicates that Urea, SP36, and KCl fertilizers could be reduced by 25-50%. All treatments tested showed no significant differences in cob length and cob diameter.

Grain yield

The application of NPK, compost, and cyanobacteria gave significantly different results on the yield of maize grains and the weight of 100 grains (Table 4). Treatment of NPK50%+compost (T10) had the highest effect on maize grains weight (163.46 g plant^{-1}), showing that the maize grains yield was not significantly different with the NPK100% (T1) maize grains 159.23 g plant^{-1}. The best effect of the treatments tried on corn yield was the NPK75%+compost (T6), which showed results equivalent to the 100% NPK treatment. It is shown that applying compost to corn dry land reduces the use of NPK fertilizers (Urea, SP-36, and KCl) by 25%.

The treatment NPK50%+compost (T10) gave the highest weight of 100 maize grains of 29.56 g plant^{-1}. These results did not show a significant

Table 3. Effect of level dose of NPK fertilizer combined with compost and cyanobacteria on cob weight, husk weight, cob length, and cob diameter of maize

Treatments	Cob Weight	Husk Weight	Cob Length	Cob Diameter
	.... g cob^{-1}………		.... cm …………	
NPK100% (T1)	204.73 ^{bc}	15.96 ^{b}	19.33 ^{a}	42.26 ^{a}
NPK100%+compost (T2)	190.10 ^{abc}	14.93 ^{ab}	19.33 ^{a}	42.13 ^{a}
NPK100%+cyanobacteria (T3)	175.86 ^{ab}	11.20 ^{ab}	18.33 ^{a}	41.43 ^{a}
NPK100%+cyanobacteria-enriched compost (T4)	181.26 ^{abc}	9.50 ^{a}	20.00 ^{a}	42.56 ^{a}
NPK75% (T5)	197.30 ^{abc}	13.23 ^{ab}	19.16 ^{a}	43.20 ^{a}
NPK75%+compost (T6)	209.86 ^{c}	16.16 ^{b}	19.00 ^{a}	44.13 ^{a}
NPK75%+cyanobacteria (T7)	184.20 ^{abc}	10.20 ^{ab}	19.16 ^{a}	43.60 ^{a}
NPK75%+ cyanobacteria-enriched compost (T8)	185.33 ^{abc}	10.26 ^{ab}	18.00 ^{a}	42.56 ^{a}
NPK50% (T9)	189.86 ^{abc}	14.90 ^{ab}	19.00 ^{a}	44.03 ^{a}
NPK50%+compost (T10)	181.93 ^{abc}	16.20 ^{b}	18.83 ^{a}	43.36 ^{a}
NPK50%+cyanobacteria (T11)	186.13 ^{abc}	14.13 ^{ab}	19.33 ^{a}	42.30 ^{a}
NPK50%+ cyanobacteria-enriched compost (T12)	170.63 ^{a}	13.36 ^{ab}	18.33 ^{a}	42.46 ^{a}
CV (%)	9.46	27.2	5.82	3.72

*The number followed by the same letter shows no significance in the DMRT test level of 5%.

difference in treatment in the 100 grains weight, in the NPK75% treatment with 100 grains weight of corn of 25.10 g and the NPK50% treatment with a weight of 100 grains of 25.00 g. It shows that adding compost will increase soil fertility and the availability of nutrients for plants so that plants can grow optimally on the maize yields. Applying NPK fertilizer added with organic compost enriched with cyanobacteria can increase the yield of maize grains.

It is in line with Pratama's research (2021), in which his research results explained that an increase usually follows the application of compost or cow manure in crop yields. Compost applied regularly to the soil can increase water holding capacity, so groundwater is beneficial because it will make it easier for plant roots to absorb nutrients for their growth and development. Apart from playing a role in nitrogen fixation, cyanobacteria also improve soil

Table 4. Effect of level dose of NPK fertilizer, compost, and cyanobacteria on grain yield and 100 seeds weight.

Treatments	100 seed weight	Grains Yield
	… g ...	.. g $plant^{-1}$…
NPK100% (T1)	27.70 ^{ab}	159.23 ^{b}
NPK100%+compost (T2)	27.10 ^{ab}	145.33 ^{ab}
NPK100%+cyanobacteria (T3)	27.13 ^{ab}	142.50 ^{ab}
NPK100%+cyanobacteria-enriched compost (T4)	25.80 ^{ab}	138.23 ^{ab}
NPK75% (T5)	25.10 ^{a}	152.96 ^{ab}
NPK75%+compost (T6)	25.53 ^{ab}	163.46 ^{b}
NPK75%+cyanobacteria (T7)	27.30 ^{ab}	142.56 ^{ab}
NPK75%+cyanobacteria-enriched compost (T8)	28.16 ^{ab}	132.80 ^{a}
NPK50% (T9)	25.00 ^{a}	145.86 ^{ab}
NPK50%+compost (T10).	29.56 ^{b}	131.16 ^{a}
NPK50%+cyanobacteria (T11)	26.67 ^{ab}	139.80 ^{ab}
NPK50%+cyanobacteria-enriched compost (T12)	26.46 ^{ab}	129.36 ^{a}
CV (%)	8.34	10.75

*The number followed by the same letter shows no significance in the DMRT test level 5%

Table 5. Effect of level dose of NPK fertilizer, compost, and cyanobacteria on plant fresh weight, plant dry weight, root fresh weight, and root dry weight.

Treatments	Plant fresh weight	Plant dry weight	Root fresh weight	Root dry weight
	…………………….. g plant^{-1}……………………..			
NPK100% (T1)	179.23 ^{ab}	55.43 ^{a}	42.83 ^{ab}	18.30 ^{b}
NPK100%+compost (T2)	191.33 ^{bc}	76.80 ^{c}	40.23 ^{ab}	13.26 ^{ab}
NPK100%+cyanobacteria (T3)	158.33 ^{ab}	63.80 ^{a}	37.42 ^{ab}	13.06 ^{ab}
NPK100%+cyanobacteria-enriched compost (T4)	170.83 ^{ab}	72.67 ^{ab}	52.90 ^{b}	16.56 ^{ab}
NPK75% (T5)	180.23 ^{ab}	80.76 ^{c}	39.67 ^{ab}	13.20 ^{ab}
NPK75%+compost (T6)	185.36 ^{bc}	77.50 ^{c}	36.56 ^{ab}	13.23 ^{ab}
NPK75%+cyanobacteria (T7).	167.56 ^{ab}	56.90 ^{ab}	31.50 ^{a}	11.40 ^{a}
NPK75%+cyanobacteria-enriched compost (T8)	196.63 ^{bc}	68.10 ^{a}	36.40 ^{ab}	11.73 ^{a}
NPK50% (T9)	138.03 ^{a}	61.63 ^{a}	29.20 ^{a}	10.56 ^{a}
NPK50%+compost (T10)	226.30 ^{c}	78.63 ^{c}	37.43 ^{ab}	14.43 ^{ab}
NPK50%+cyanobacteria (T11)	173.83 ^{ab}	60.76 ^{ab}	29.86 ^{a}	11.03 ^{a}
NPK50%+cyanobacteria-enriched compost (T4)	170.96 ^{ab}	54.67 ^{a}	37.53 ^{ab}	11.30 ^{a}
CV (%)	18.36	22.45	26.37	26.78

*The number followed by the same letter shows no significance in the DMRT test level 5%

physical properties by improving soil particle aggregation, accumulation of organic content, and increased water-holding capacity (Garlapati et al., 2019). The results of this study did not show a significant difference between the treatments, but the NPK75%+compost treatment gave corn yields similar to the 100% NPK treatment.

The results of this research using manure compost increased the yield of corn seeds higher with 75% NPK fertilization compared to 100% NPK. In line with Soelaeman's research results (2008), applying manure increased plant weight and corn seed yield compared to without manure. This research shows that application compost at NPK75% gives a similar corn yield with 100% NPK treatment and 25% efficiency of NPK fertilizer. The administration of cyanobacteria did not significantly increase maize yield compared to the administration of NPK100%.

According to Sofyan and Sara's research in 2018, sweet corn crops had higher yields when grown in plots with applied organic matter and inorganic fertilizer rather than just inorganic fertilizer alone. Additionally, organic fertilizer can reduce the amount of inorganic fertilizer required for cultivating sweet corn.

The weight of the plant and root

The effect of various doses of NPK fertilizer combined with compost or cyanobacteria on plant and root weight is present in Table 5. The newly-harvested plant weights ranged from 138.03-226.30 g plant^{-1}, while the dry plant weights ranged from 54.67-77.50 g plant^{-1}. The newly-harvested plant weight showed a significant difference between the treatments. The NPK50%+compost (T10) of 226.30 g plant^{-1}, or an increase of about 26.26% compared to the NPK100% (T1) obtained the highest newly-harvested plant weight.

The newly harvested root weight varied from 29.20-52.90 g plant^{-1}; the heaviest root weight was in the 100% NPK+cyanobacteria-enriched compost (T4) treatment. While the highest dry root weight was from 10.56-18.30 g plant^{-1}, the highest was in the NPK100% (T1) treatment. The root dry weight in the NPK100% (T1) treatment was not significantly different from the NPK75%+compost (T6) and NPK50%+compost (T10).

Increasing the content of humic and nutrient substances, plant and root growth, and improving soil aeration are caused by adding organic matter to the soil (Canellas et al., 2000). Agusni et al. (2014) stated that organic matter might porously enter the soil ground, increasing the number of soil pores, affecting soil aggregates, and reducing soil bulk density. Organic matter in the soil increases macro and micro pore space, thus stimulating soil aggregate formation, which causes a decrease in soil bulk density (Habi, 2015).

N, P, and K uptake by plant

The results of observations on N, P, and K nutrient uptake are presented in Figures 3, 4, and 5.

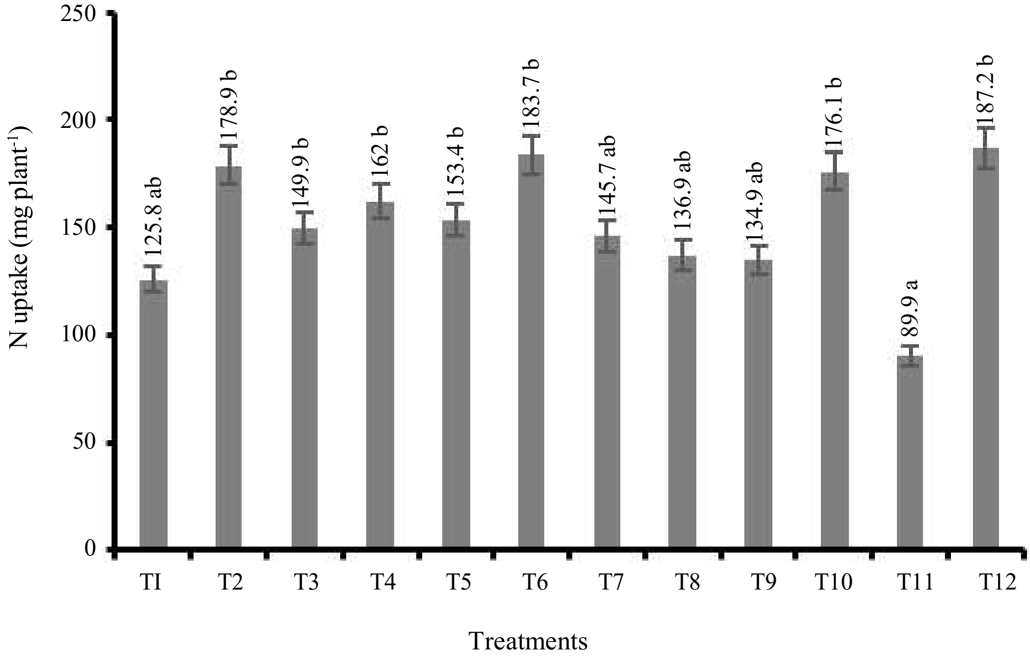

Figure 3. Effect of level dose of NPK fertilizer combined with compost and cyanobacteria on N uptake with NPK100% (T1), NPK100%+compost (T2), NPK100%+cyanobacteria (T3), NPK100%+cyanobacteria-enriched compost (T4), NPK75% (T5), NPK75%+compost (T6), NPK75%+cyanobacteria (T7), NPK75%+cyanobacteria-enriched compost (T8), NPK50% (T9), NPK50%+compost (T10), NPK50%+cyanobacteria (T11), NPK50%+cyanobacteria-enriched compost (T12).

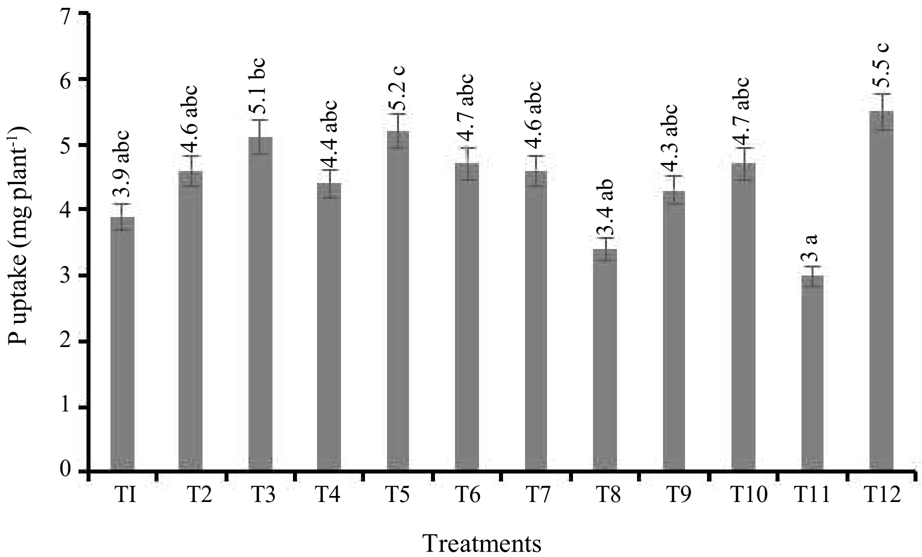

Figure 4. Effect of level dose of NPK fertilizer combined with compost and cyanobacteria on P uptake with NPK100% (T1), NPK100%+compost (T2), NPK100%+cyanobacteria (T3), NPK100%+cyanobacteria-enriched compost (T4), NPK75% (T5), NPK75%+compost (T6), NPK75%+cyanobacteria (T7), NPK75%+cyanobacteria-enriched compost (T8), NPK50% (T9), NPK50%+compost (T10), NPK50%+cyanobacteria (T11), NPK50%+cyanobacteria-enriched compost (T12).

The average N nutrient uptake ranged from 89.9-187.2 mg plant^{-1}, NPK 50%+cyanobacteria-enriched compost (T12) gave the highest N uptake followed by NPK 75%+compost (T6) treatment. The NPK50%+cyanobacteria (T11) treatment of 89.9 mg plant^{-1} had the lowest N uptake. The results

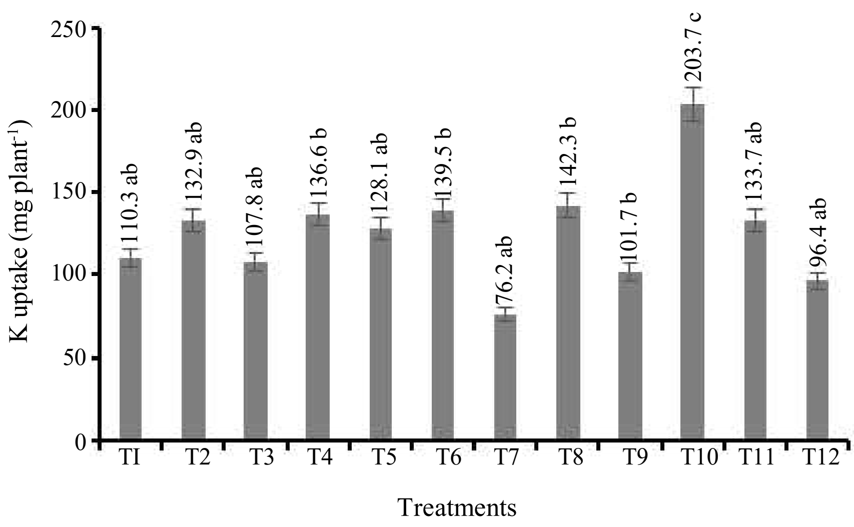

Figure 5. Effect of level dose of NPK fertilizer combined with compost and cyanobacteria on K uptake with NPK100% (T1), NPK100%+compost (T2), NPK100%+cyanobacteria (T3), NPK100%+cyanobacteria-enriched compost (T4), NPK75% (T5), NPK75%+compost (T6), NPK75%+cyanobacteria (T7), NPK75%+cyanobacteria-enriched compost (T8), NPK50% (T9), NPK50%+compost (T10), NPK50%+cyanobacteria (T11), NPK50%+cyanobacteria-enriched compost (T12).

indicated N nutrient uptake by enriching the compost with cyanobacteria. The N uptake in the NPK75%+compost (T6) treatment was 183.7 mg plant^{-1}, while in the NPK50%+cyanobacteria-enriched compost (T12) treatment, the N uptake was 187.2 mg plant^{-1}. It shows that N nutrient uptake by enriching compost with cyanobacteria increased by 3.5 mg plant^{-1} in that treatment. Compared to the NPK100% (125.8%), N nutrient uptake increased by 61.4 mg plant^{-1} or 48.81%.

The highest P uptake was achieved in the NPK50%+cyanobacteria-enriched compost (T12) treatment of 5.5 mg plant^{-1} and the lowest in the NPK50%+cyanobacteria (T11) treatment, P uptake was 3.0 mg plant^{-1}. In the NPK50%+compost (T10) treatment, the K nutrient uptake was 4.7 mg plant^{-1} compared to NPK50%. Application of cyanobacteria-enriched compost increased the P nutrient uptake by 0.8 mg plant^{-1} or an increase of 17.0%. The average increase in P uptake of cyanobacteria at various doses of NPK fertilizer either directly or as an enrichment for compost increased P uptake by 17.54%.

At 100% NPK fertilization, the provision of compost enriched with cyanobacteria K nutrient uptake increased from 110.3 mg plant^{-1} to 136.6 mg plant^{-1}, or an increase of 23.84%. Meanwhile, at 75% NPK fertilization, application of cyanobacteria-enriched compost increased K nutrient uptake from 128.1 mg plant^{-1} to 142.3 mg plant^{-1}. The average K uptake increased by 11.08%. At NPK50% fertilization, application compost and cyanobacteria showed higher nutrient K uptake than compost enriched with cyanobacteria. Applying compost to NPK50% fertilization increased K uptake by 94.71% and increased cyanobacteria by 31.46%. Hendarto et al. (2021) state that compost is an organic fertilizer that contains nutrients, and it works to improve soil quality and help plant growth processes. Compost organic matter is a material that supplies nutrients (C, N, P, K, S, and other compounds) in the form of simple compounds that are quickly utilized by microorganisms (Kaya, 2019).

CONCLUSIONS

Plant growth was indicated by various observation times, and the maximum vegetative phase was 8 weeks after planting (WAP). The highest plant height achieved on (NPK50%+compost) was 224 cm, and the highest number of leaves obtained from (NPK100%+compost) was 14 plant^{-1}. Treatment (NPK75%+compost) gave the heaviest corn cob yield and grain yield of 209.86 g cob^{-1} and 163.49 g plant^{-1}, (NPK75%+compost) increased corn cob 8.55% and grain yield 6.42% compared to NPK100%. From these results, applying compost reduces the use of NPK fertilizer by 25% or the equivalent of 87.50 kg ha^{-1} Urea, 43.75 kg ha^{-1} SP36, and 12.5 kg ha^{-1} KCl. (NPK50%+compost enriched cyanobacteria) treatment increased N uptake 61.4 mg plant^{-1} or 48.81% compared to NPK100%. The treatment of (NPK50%+cyanobacteria-enriched compost) increased P uptake by 0.8 mg plant^{-1} or 17.0%

compared to NPK50%+compost. At NPK50%, added cyanobacteria affected the increase in K uptake by about 31.46%.

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REFERENCES

Agusni M dan H Satriawan. 2014. Pengaruh olah tanah dan pemberian pupuk kandang terhadap sifat fisik tanah dan produksi tanaman jagung. *Lentera* 14: 1-6.

Ahmad AA, NV Hue, and TJK Radovich. 2014. Nitrogen release patterns of some locally made composts and their effects on the growth of Chinese cabbage (*Brassica rapa*, Chinensis group) when used as soil amendments. *Compost Sci Util* 22: 199-206.

Aslihah, MS Mega and F Ahmad. 2020. Pelatihan pemanfaatan limbah rumah tangga organik menjadi pupuk kompos. *J Pengabdian Masyarakat Bidang Pertanian* 1: 30-33.

Canellas LP, FL Olivares, AL Okorokova and RA Facanha. 2000. Humic acids isolated from earthworm compost enhance root elongation, lateral root emergence, and plasma membrane H^+-ATPase activity in maize roots. *Int J Plant Physiology* 130: 1951-1957

Dhanushkodi V and K Subrahmaniyan. 2012. Soil management to increase rice yield in salt-affected coastal soil - A Review. *Int J Res Chem Environ* 2: 1-5.

Eginarta WS, Y Nuraini and J Purwani. 2021. Efektivitas berbagai bahan formula pupuk hayati sianobakteri terhadap pertumbuhan dan hasil padi gogo varietas situ bagendit. *J Tanah Sumberdaya Lahan* 8: 415-426.

Garlapati D, M Chandrasekaran, A Devanesan, T Mathimani and A Pugazhendhi. 2019. Role of cyanobacteria in agricultural and industrial sectors: An outlook on economically important byproducts. *Appl Microbiol Biot* 103: 4709-4721. doi: 10.1007/s00253-019-09811-1.

Gil G, R Dries, P Pieter, S Johan, M Roel and V Bernard. 2020. Combining organic and mineral fertilizers as a climate-smart integrated soil fertility management practice in sub-Saharan Africa: A meta-analysis. *PLoS ONE* 15: e0239552.

Habi ML. 2015. Pengaruh aplikasi kompos granul ela sagu diperkaya pupuk Ponska terhadap sifat fisik tanah dan hasil jagung manis di Inceptisol. *Biopendix* 1: 121-134.

Harmoko and Sepriyaningsih. 2019. Keanekaragaman sianobakteri di Sungai Kelingi kota Lubuk Linggau Sumatera Utara. *J Biologi* 12: 56-62.

Hendarto K, W Setyo, R Sri and SM Fitria. 2021. Pengaruh pemberian dosis pupuk NPK dan jenis pupuk hayati terhadap pertumbuhan dan produktivitas tanaman bawang merah (*Allium ascalonicum* L*). J Agrotropika* 20: 110-119.

Hughes O and JH Venema (eds). 2005. *Integrated soil, water, and nutrient management in semi-arid Zimbabwe*. Farmer Field Schools Facilitators' Manual 1. Harare, Zimbabwe: FAO. 122 p.

Joseph KX, D Matey and AAR Dhobia. 2019. Organic and inorganic fertilizer use for increased maize yield. *Int J Agr Res Rev* 7: 865-868.

Kaya E. 2019. Pengaruh kompos jerami dan pupuk NPK terhadap N-tersedia tanah, serapan N, pertumbuhan dan hasil padi sawah (*Oryza sativa* L). *J Agrologia* 2: 43-50.

Lelu PK, PS Yohanes and S Made. 2018. Aplikasi biochar dan kompos terhadap peningkatan hasil tanaman jagung *(Zea mays* L*.). J Gema Agro* 23: 24-32.

Nazirah L. 2019. Pertumbuhan dan produksi beberapa varietas kedelai (Glycine max L. Merrill) pada Aplikasi Kompos Azolla. *J Pertanian Tropik* 6: 255-261. doi: https://doi.org/10.32734/jpt.v6i2.3171. (in Indonesian).

Ningsih DN, M Nani and H Erni. 2015. Pengaruh jenis pupuk organik terhadap pertumbuhan dan produksi beberapa jenis varietas jagung manis (*Zea mays saccharata* Sturt). *J KLOROFIL* 10: 93-100.

Paudel YP, S Pradhan, B Pant and BN Prasad. 2012. Role of blue green algae in rice productivity. *Agric Biol J N Am* 3: 332-335.

Pratama P. 2021. Respon pemberian kompos sapi dan kombinasi media arang sekam dengan tanah latosol terhadap pertumbuhan bibit tembakau Deli (*Nicotiana tabaccum* L). Kumpulan Karya Ilmiah Mahasiswa Fakultas sains dan Tekhnologi. [Skripsi]. Universitas Pembangunan Panca Budi.

Septian NAW, A Nurul and H Ninuk. 2015. Pengaruh pemberian pupuk organik terhadap pertumbuhan hasil tanaman jagung manis (*Zea mays* Saccharata) pada tumpang sari dengan tanaman kangkung (*Ipomea reptans*). *J Produksi Tanaman* 3: 141-148.

Silalahi SH and YT Setyono. 2020. Uji Efektivitas pupuk organik cair pada pertumbuhan dan hasil tanaman cabai besar (*Capsicium annum* L). *J Produksi Tanaman* 8: 321-328.

Soelaeman Y. 2008. Efektivitas pupuk kandang dalam meningkatkan ketersediaan fosfat, pertumbuhan dan hasil padi dan jagung pada lahan kering masam. *J Trop Soils* 13: 41-47.

Sofyan ET and DS Sara. 2018. Effect organic and inorganic fertilizers on sweet corn. *J Trop Soils* 23: 111-116.

Song T, L Martensson, T Eriksson, W Zheng and U Rasmussen. 2005. Biodiversity and seasonal variation of the cyanobacterial assemblage in a rice paddy field in Fujian, China. *FEMS Microbiol Ecol* 54:131-140.

Tyagi R and A Bhardawaj. 2013. Cyanobacterial biofertilizer production and analysis. Conference: 2nd National Conference on Advancements in the era of multidiciplinary system. AEMDS-2013. AT: TERII, Kurukshetra, Hayyana, India. pp 301-304.

Widodo KH and K Zaenal. 2018. Pengaruh kompos terhadap sifat fisik tanah dan pertumbuhan tanaman jagung di Inceptisol. *J Tanah Sumberdaya Lahan* 5: 959-967.

Yovita. 2012. Pengaruh pemberian tiga jenis kompos dan dosis NPK terhadap hasil tanaman jagung manis di pedalaman gambut. [Thesis], Universitas Lambung Mangkurat, Banjarbaru.