International Journal of Agriculture System
Vol. 11 Issue 2, December 2023
Nationally Accredited Journal Decree No. 48a/E/KPT/2017
P-ISSN: 2337-9782, E-ISSN: 2580-6815. DOI: 10.20956/ijas.v11i2.4402

The Effect of Combination of Phosphate Solubilizing Microbes, Organic Pellet Fertilizers, and Inorganic Fertilizers on Nutrient Uptake of Maize

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How to Cite: Jayadi, M., Rahmadi, S. Laban and R. Nurhikmayani. (2023). The Effect of Combination of Phosphate Solubilizing Microbes, Organic Pellet Fertilizers, and Inorganic Fertilizers on Nutrient Uptake of Maize. *Int. J. Agr. Syst.* 11(2): 102-116.

ABSTRACT

The low uptake of N and P nutrients by maize plants can be caused by the low availability or levels of N and P nutrients in the soil used as the planting medium. The Alfisol soil used in the study had N-total levels of 0.15% (low) and P_2O_5 of 12.76 ppm (medium). The addition of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer can increase the availability of N and P nutrients in the soil, so that plant uptake of N and P nutrients can also increase. This study aims to determine the effect of a combination of phosphate-solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer on the nutrient uptake of maize. This research was conducted at the Experimental Farm, Faculty of Agriculture, Hasanuddin University, and plant samples were analyzed at Hasanuddin University's Soil Fertility Chemistry Laboratory, Department of Soil Science, Faculty of Agriculture. This study used a Randomized Group Design. The treatments consisted of a combination of phosphate solubilizing microbes (PSM) at concentrations of 0.0 and 10^9 cfu mL^{-1}, pelleted organic fertilizer (0.0, 5.0 and 10 ton ha^{-1}), and inorganic fertilizer (0% and 50% recommended dose). The results showed that the treatment of without PSM combine with pelleted organic fertilizer 5.0 ton ha^{-1} and without inorganic fertilizer produced plants with the highest level of N nutrient uptake, which was 633.33% higher than the control treatment. In comparison, the treatment of PSM (10^9 cfu mL^{-1}) combine with pelleted organic fertilizer 5.0 ton ha^{-1} and inorganic fertilizer (50% recommended dose) treatment had plants with the highest level of P nutrient uptake, which was 933.33% higher than the control.

Keywords:
Inorganic Fertilizer; Maize; Nutrient Uptake; Phosphate Solubilizing Microbe; Organic Pellet Fertilizer.

1. Introduction

Maize needs particular nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), in addition to secondary and micronutrients, to facilitate its growth and development (Batool, 2023). Maize plants are grown on fertile soil, including Alfisol soil (Lovitna et al., 2021). Alfisol is one of the relatively new and still-developing soil orders. Hence agriculture activities on Alfisol soils might cause issues. For instance, land frequently abandoned will experience reduced soil fertility chemically and physically (Ilham et al., 2014).

Soil is the earth's surface layer that chemically functions as a storehouse and supplier of nutrients or nutrients and biologically functions as a habitat for biota (organisms) that actively participate in the provision of these nutrients for plants to support soil productivity in order to produce biomass and crop production (Hanafiah, 2005). Extensive use of agricultural land may result in a deterioration in soil fertility. The loss in chemical fertility of soil is characterized by the lack of available nutrients, particularly nitrogen, phosphorus, and potassium (Chiti et al., 2018). Nitrogen and phosphorus nutrient losses on agricultural land can also be induced by fixation, leaching, and harvesting of these two nutrients (Sukristiyonubowo et al., 2015; Sieczko et al., 2023). Due to the fixation of Al and Fe elements to generate Al-P and Fe-P, which plants cannot absorb, the soil contains a low amount of available P nutrients (Ilham et al., 2014). Hence, it is necessary to boost the availability of nitrogen and phosphorus in the soil to prevent deficiency symptoms in plants growing there.

Fertilization is a method for enhancing the availability of soil nutrients (Lovitna et al., 2021). The use of phosphate-solubilizing microorganisms is one of the efforts to improve fertilizer efficiency (Campos et al., 2018). Phosphate-solubilizing microorganisms are one type of bacteria in biofertilizers that contribute to the transformation of phosphorus nutrients in the soil. Phosphate-solubilizing microbes (PSM) such as *Pseudomonas sp.* produce organic acids that solubilize insoluble phosphate phosphate (Oteino et al., 2015). Research on phosphate-solubilizing microbes has long been carried out and provides varying results. Experiments on the combination of phosphate-solubilizing microbial treatments and inorganic fertilizers on corn plants in ultisol and Alfisol soils showed a positive correlation with soil chemical properties, phosphate-solubilizing bacterial populations, and corn plant yields (Fitriatin et al., 2017; Lovitna et al., 2021).

Inorganic fertilizers are frequently used to meet the nutrient needs in maize cultivation. Utilizing inorganic fertilizers precisely, such as applying them in bands or along the sides of plants, helps optimize the absorption of nutrients and minimize their loss (Batool, 2023). Nevertheless, the persistent application of inorganic fertilizers in the absence of organic fertilizers will lead to a decline in soil fertility and crop yield (Liu et al., 2021).

In order to preserve soil fertility, the utilization of organic fertilizers can be employed as a means to mitigate the issues linked to synthetic fertilizers. Utilizing organic fertilizers inappropriately might result in soil over-fertilization or nutritional deficiencies, making it an impractical option (Shaji et al., 2021). One can achieve the dual goal of sustaining agricultural productivity and reducing these consequences by employing advanced and efficient techniques, such as utilizing controlled organic fertilizers like pelleted organic fertilizers. According to Alemi et al. (2010), the preparation of fertilizer in the form of pellets has a slow-release effect, the slow-release method of fertilizer increases nutrient uptake. Therefore, pelleted fertilizer emerges as a more favorable substitute due to its gradual and uninterrupted nutrient release, facilitating plant absorption throughout various growth phases (Reza-Bagheri et al., 2011). This research aims to determine the effect of a combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer on the nutrient uptake of maize plants in Alfisol soil.

2. Materials and Methods

2.1 Experimental Location

This research was a pot experiment carried out at the Experimental Farm. The Preparation and propagation of phosphate solubilizing microbes were carried out based on the method of Fitriatin et al. (2017) in the Soil Microbiology Laboratory, while the manufacture of organic fertilizer pellets and analysis of plant samples were carried out in the Chemistry and Soil Fertility Laboratory, Department of Soil Science, Faculty of Agriculture, Hasanuddin University.

2.2 Material

The bacterial isolate used for this study was phosphate-solubilizing microbial (PSM) from the culture collections of the Soil Microbiology Laboratory, Department of Soil Science, Faculty of Agriculture, Hasanuddin University. Other materials used in this study were organic fertilizer pellets (straw compost, gliricidia leaf compost, chicken manure, clay, and water), inorganic fertilizers (urea fertilizer 150 kg ha^{-1}, KCl fertilizer 50 kg ha^{-1}, and SP36 fertilizer 50 kg ha^{-1}), and the BISI 21 maize variety.

The preparation of organic fertilizer pellets was carried out by mixing materials with a combination of 315 g of gliricidia leaf compost, 315 g of straw compost, 315 g of chicken manure, 50 g of clay and 1 litre of water. All materials that have been mixed are then moulded using a printing tool made from a modified syringe. The pressure used during moulding is about 8 kg cm^{-2}. Fertilizer pellets that are still wet are dried using an oven at 60 ^{o}C for 2 to 3 hours.

2.3 Methods

This research method was designed using a randomized block design (RBD). In this study, there were 12 combination treatments of phosphate solubilizing microbes (M) as first factor; organic fertilizer pellets (B) as second factor, and inorganic fertilizers (A) as third factor. In details the treatment levels as follow:
M_0 : without phosphate-solubilizing microbial;
M_1: with phosphate-solubilizing microbial (10^9 cfu mL^{-1});
B_0: without organic fertilizer pellets;
B_1: organic fertilizer pellets 5 ton ha^{-1};
B_2: organic fertilizer pellets 10 ton ha^{-1};
A_0: without inorganic fertilizers;
A_1: with 50% dose of inorganic fertilizer recommendation
Each treatment was repeated 3 times. The total number of research samples is 36 units.

2.4 Preparation of Plant Growing Media

Pots filled with sifted Alfisol soil (Table 1), each pot containing 10 kg of soil. After that, the pots filled with soil was arranged and labelled based on the research plan. The application of pellet fertilizer was done by mixing it directly into the soil according to the dose of each treatment. The application of phosphate-solubilizing microbes was carried out using two different methods: mixing with pellet fertilizer (the carrier) and not mixing it with fertilizer. The phosphate solubilizing microorganism used was *Pseudomonas sp.*, at a concentration of 10^9 cfu mL^{-1} which was included in the carrier material (pellet fertilizer). The carrier material was inoculated with PSM at a concentration of up to 10% by volume relative to the weight of the carrier material (Fitriatin et al., 2017). For treatments without pellet fertilizer, phosphate-solubilizing microbes were directly applied to the planting medium.

Table 1. Initial soil properties of Alfisol soil

Parameters	Value
Structure	Crumbs
Bulk Density ($g.cm^{-3}$)	1.35
CEC	42.90
pH (H_2O)	5.31
P_2O_5 –Olsen (ppm P)	12.76
N-total (%)	0.15
C-organic (%)	0.98
K ($cmol(+)kg^{-1}$	0.12
Ca $cmol(+)kg^{-1}$	21.70
Mg $cmol(+)kg^{-1}$	0.50
Na $cmol(+)kg^{-1}$	0.28
% Alkaline Saturated	52.68

2.5 Planting

Planting was carried out after the growing medium had been prepared and arranged by the established plan. The seeds were planted in the traditional way, with holes drilled into each container with a wooden stick. Following the placement of up to three seeds per hole into the prepared holes, the seeds were covered with extra soil. After growth, thinning was performed by retaining one plant per container as the subject of observation.

2.6 Fertilization

The soil was fertilized with Urea, SP36, and KCl fertilizers according to the treatment given 14 days after planting. The recommended dose of each fertilizer was Urea 300 kg ha^{-1}, SP36 150kg ha^{-1}, and KCl 100kg ha^{-1}, where the treatment with inorganic fertilizer (A1) is 50% of the recommended dose. The method of fertilization was by dissolving Urea and KCl in water, while SP36 fertilizer was given in the solid form. The Urea and KCl fertilizers were applied by watering them around the plants, while the SP36 fertilizer was simultaneously applied via drilling. This fertilization was performed in phases; during the first fertilization, Urea, KCL, and SP36 were applied; during the second and third fertilizations, only Urea was applied.

2.7 Plant Maintenance

Plant maintenance was carried out by paying attention to watering, weeding, and pest control. The plant was watered under environmental circumstances, herbicide was applied to weeds surrounding the plant, and pest control was carried out using the pesticide Detacron 500EC.

2.8 Analysis of N and P Content of Plant Tissue

N analysis of plant tissue used the Kjehdal method of alkaline ash of H_2SO_4, while the analysis of P of plant tissue used the spectrophotometer method of alkaline ash of HNO_3 and H_2SO_4. The plant tissue used for nutrient content analysis is the leaves from the top part of the plant.

2.9 N and P Uptake of Plant

Plant nutrient uptake resulted from the multiplication of nutrient content and plant dry weight. Calculation of plant nutrient uptake can be written following Godebo et al. (2021):

$$\text{Nutrient uptake} = (\text{Nutrient level x Plant dry weight}) / 100$$

2.10 Observation Parameters

The observation parameters were: Plant height and number of leaves; fresh weight and dry weight of plants; Plant N and P nutrient uptake; and soil analysis before planting

2.11 Data Processing

Data was analysis by the ANOVA test at a 5% level to determine the effect of treatment on the observation variable, followed by distinguishing between treatments using the Duncan/DMRT test at a 5% level.

3. Results and Discussion

3.1 Result

3.1.1 *Combination treatment of microbial phosphate solubilizer, pelleted organic fertilizer, and inorganic fertilizer on maize plant height and number of leaves*

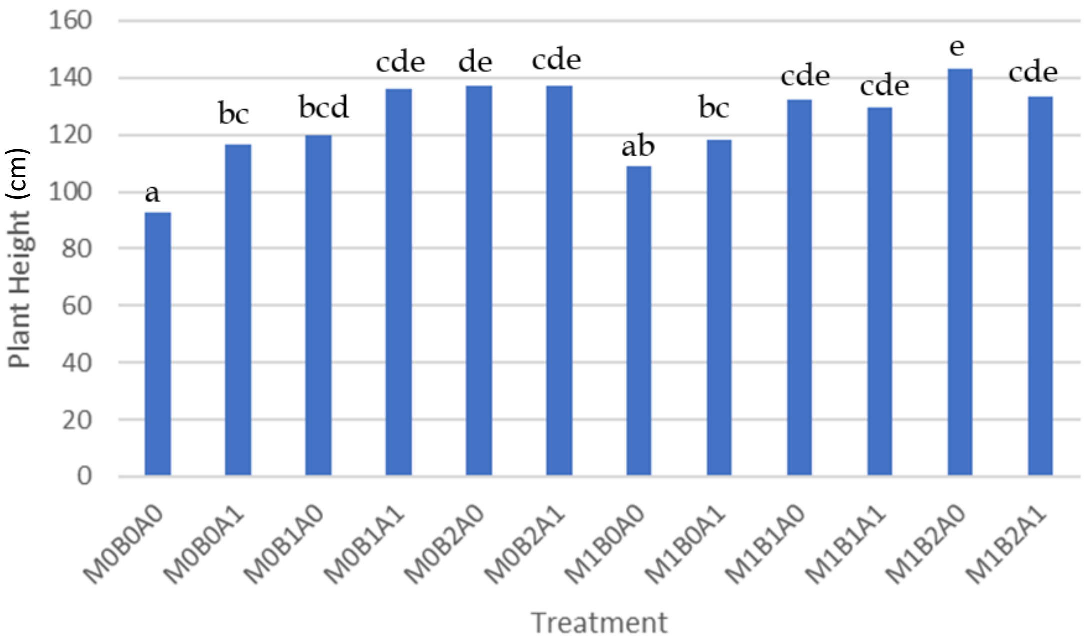

Figure 1. Graph of average plant height in each treatment combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer. M0= without phosphate-solubilizing microbial; M1= with phosphate-solubilizing microbial; B0= without organic fertilizer pellets; B1= with organic fertilizer pellets 5 ton ha^{-1}; A0= without inorganic fertilizers; A1= with 50% dose of inorganic fertilizer.

The results of the DMRT test at the 5% level showed that each treatment combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer produced different plant heights between treatments. The $M_1B_2A_0$ treatment had the highest average plant height of 143.2 cm, significantly different from the $M_0B_0A_0$,

$M_1B_0A_0$, $M_0B_0A_1$, $M_1B_0A_1$, and $M_0B_1A_0$ treatments. The $M_0B_0A_0$ treatment produced plants with the lowest average height of 92.73 cm. The graph of plant height is presented in Figure 1.

The results of measuring the average number of plant leaves showed that the combined treatment of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer had no significant effect on the number of leaves of maize plants. The average number of leaves of maize plants presented in Figure 2 shows that all treatments are not significantly different from other treatments. The $M_0B_2A_1$ treatment produced plants with the highest number of leaves at 9.7 leaves/plant, while the $M_0B_0A_0$ and $M_1B_0A_0$ treatments produced plants with the lowest number of leaves at 7.3 leaves/plant.

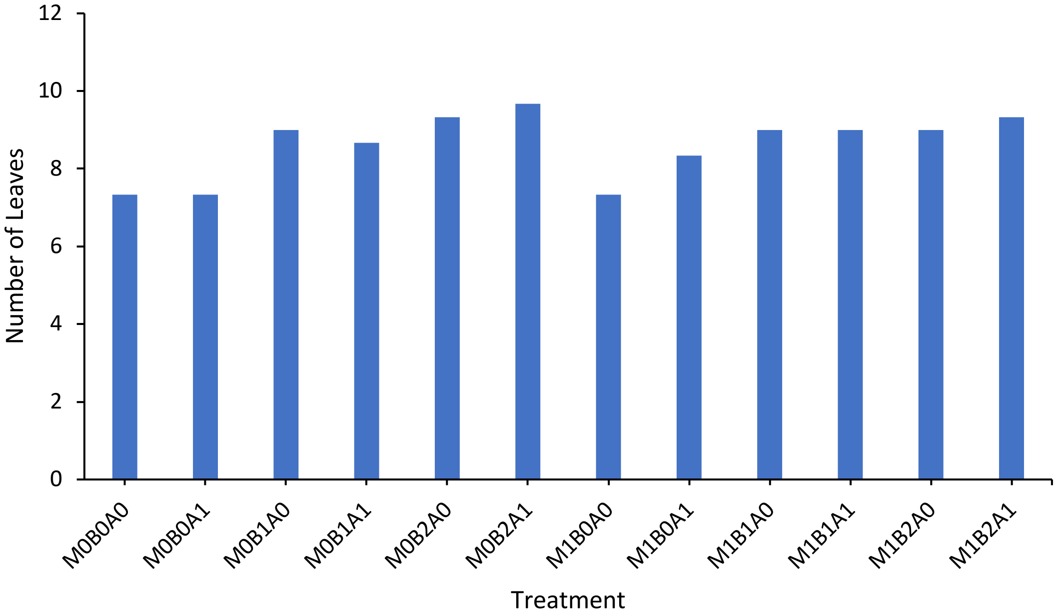

Figure 2. Graph the average number of leaves of maize plants in each treatment combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer. M0= without phosphate-solubilizing microbial; M1= with phosphate-solubilizing microbial; B0= without organic fertilizer pellets; B1= with organic fertilizer pellets 5 ton ha^{-1}; A0= without inorganic fertilizers; A1= with 50% dose of inorganic fertilizer.

3.1.2 *Combination treatment of microbial phosphate solubilizer, pelleted organic fertilizer, and inorganic fertilizer on fresh and dry-weight of maize plant*

Analysis of variance based on the results of the DMRT test at the 5% level showed that each treatment combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer was able to produce different plant fresh weights between treatments. The $M_1B_2A_1$ treatment made the highest average plant fresh weight of 123.5 g, significantly different from the $M_0B_0A_0$ treatment, which had an average plant fresh weight of 73.9 g, and the $M_1B_0A_0$ treatment, which produced an average plant fresh weight of 88.3 g (Table 2).

The DMRT test results at the 5% significance level demonstrated that each treatment combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer produced different plant dry weights among treatments. Significantly different from $M_0B_0A_0$, $M_1B_0A_0$, $M_1B_0A_1$, $M_0B_0A_1$, and $M_0B_1A_0$, the $M_1B_2A_1$

treatment yielded the highest average plant dry weight of 29.9 g. The $M_0B_0A_0$ treatment produced the lowest plant dry weight, 11.5 g. Table 3 provides additional details.

Table 2. The average fresh weight of plants in each treatment combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer.

Treatment	**Fresh Weight (g)**			**Average**
	I	**II**	**III**	
$\mathbf{M_0B_0A_0}$	60.2	97.2	64.4	73.9[a]
$\mathbf{M_0B_0A_1}$	122.2	131.6	98.2	117.3[c]
$\mathbf{M_0B_1A_0}$	100.2	99.6	101.4	100.4[abc]
$\mathbf{M_0B_1A_1}$	126.6	112.4	97.4	112.1[bc]
$\mathbf{M_0B_2A_0}$	125	108.8	123.4	119.1[c]
$\mathbf{M_0B_2A_1}$	110.8	132.2	109.4	117.5[c]
$\mathbf{M_1B_0A_0}$	89.2	91.2	84.8	88.4[ab]
$\mathbf{M_1B_0A_1}$	102	111.8	83.4	99.1[abc]
$\mathbf{M_1B_1A_0}$	150.4	102.8	100.6	117.9[c]
$\mathbf{M_1B_1A_1}$	96	98	100	98.0[ab]
$\mathbf{M_1B_2A_0}$	121.6	116.8	119.2	119.2[c]
$\mathbf{M_1B_2A_1}$	114.6	113	143	123.5[c]

Remark: M0= without phosphate-solubilizing microbial; M1= with phosphate-solubilizing microbial; B0= without organic fertilizer pellets; B1= with organic fertilizer pellets 5 ton ha^{-1}; A0= without inorganic fertilizers; A1= with 50% dose of inorganic fertilizer. Treatments followed by the same letter mean the effect is not significantly different according to the DMRT test at the 5% level.

Table 3. Dry weight of plants in each treatment

Treatment	**Dry weight (g)**			**Average**
	I	**II**	**III**	
$M_0B_0A_0$	11	14.4	9.2	11.5[a]
$M_0B_0A_1$	20.8	24.2	19.4	21.5[abc]
$M_0B_1A_0$	21.4	23.8	21.2	22.1[abc]
$M_0B_1A_1$	29.6	27	25.6	27.4[de]
$M_0B_2A_0$	30	26.4	31.6	29.3[e]
$M_0B_2A_1$	21.8	33	27.2	27.3[de]
$M_1B_0A_0$	16.3	18.8	14	16.4[ab]
$M_1B_0A_1$	26	19.2	14.4	19.9[bc]
$M_1B_1A_0$	27.2	32.4	28.4	29.3[e]
$M_1B_1A_1$	23.4	25.3	27.2	25.3[cde]
$M_1B_2A_0$	30.2	26.8	28.6	28.5[e]
$M_1B_2A_1$	26.4	28	35.4	29.9[e]

Remark: M0= without phosphate-solubilizing microbial; M1= with phosphate-solubilizing microbial; B0= without organic fertilizer pellets; B1= with organic fertilizer pellets 5 ton ha^{-1}; A0= without inorganic fertilizers; A1= with 50% dose of inorganic fertilizer. Treatment followed by the same letter means the effect is not significantly different according to the DMRT test at the 5% level.

3.1.3 Combination treatment of microbial phosphate solubilizer, pelleted organic fertilizer, and inorganic fertilizer on Nitrogen and Phosphorus nutrient uptake of maize plant

The analysis of variance revealed that the treatment factor of the combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer affected the N uptake of maize plants. The DMRT test results at the 5% significance level demonstrated that each treatment combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer resulted in distinct plant N nutrient uptake. The $M_0B_2A_0$ treatment produced the highest average plant N nutrient uptake of 0.95 g per plant, significantly different from the $M_0B_0A_0$, $M_1B_0A_0$, $M_0B_0A_1$, $M_0B_1A_0$, $M_0B_2A_1$, and $M_1B_2A_0$ treatments. The lowest N nutrient uptake was 0.15 g per plant in plants produced under the $M_0B_0A_0$ treatment. Figure 3 provides additional details.

The results of the calculation of the average P nutrient uptake of corn plants can be seen in Figure 4. Analysis of variance showed that the treatment factor of the combination of phosphate solubilizing microbes, pelleted organic fertilizer and inorganic fertilizer affected the P nutrient uptake of corn plants. The M1B2A1 treatment produced the highest average P nutrient uptake of 0.28 grams/plant, significantly different from the $M_0B_0A_0$, $M_0B_0A_1$, $M_0B_1A_0$, $M_1B_0A_0$ and $M_1B_2A_0$ treatments. The $M_0B_0A_0$ treatment produced plants with the lowest P nutrient uptake of 0.04 grams/plant.

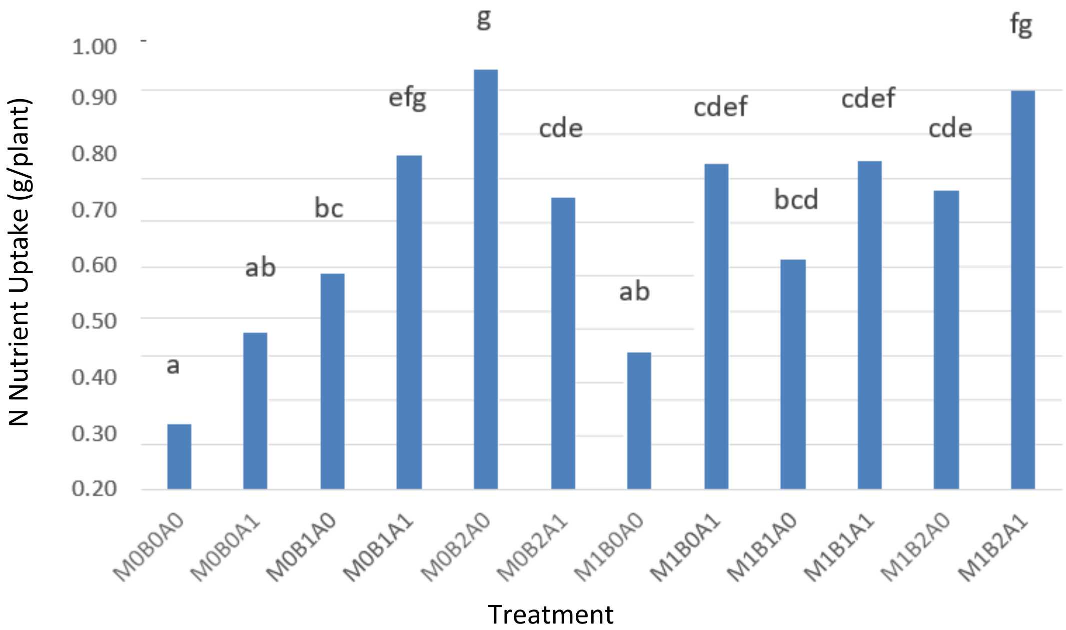

Figure 3. Graph average plant N nutrient uptake in each treatment combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer. Treatments followed by the same letter mean the effect is not significantly different according to the DMRT test at the 5% level. M0= without phosphate-solubilizing microbial; M1= with phosphate-solubilizing microbial; B0= without organic fertilizer pellets; B1= with organic fertilizer pellets 5 ton ha^{-1}; A0= without inorganic fertilizers; A1= with 50% dose of inorganic fertilizer.

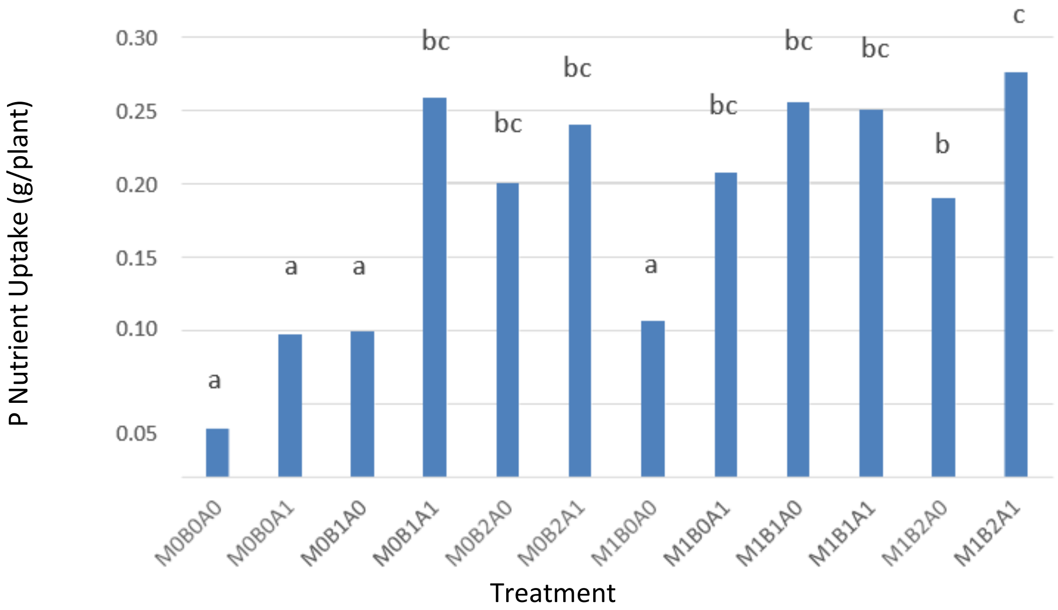

Figure 4 Graph of the average P nutrient uptake of plants in each treatment. (Treatments followed by the same letter mean the effect is not significantly different according to the DMRT test at the 5% level). M0= without phosphate-solubilizing microbial; M1= with phosphate-solubilizing microbial; B0= without organic fertilizer pellets; B1= with organic fertilizer pellets 5 ton ha^{-1}; A0= without inorganic fertilizers; A1= with 50% dose of inorganic fertilizer.

3.2 Discussion

3.2.1 Combination treatment of microbial phosphate solubilizer, pelleted organic fertilizer, and inorganic fertilizer on maize plant height and number of leaves

Maize plant growth is closely related to nutrients absorbed from the soil through applying fertilizers containing macro and micronutrients to meet the nutrient needs of corn plants. Based on the results of variance analysis, the combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer significantly affected the parameters of maize plant height. Based on the results of the DMRT test at the 5% level for plant height shown in Figure 1, The $M_1B_2A_0$ treatment (combination of microbial phosphate solubilizer, organic fertilizer pellets at a rate of 10 tons ha^{-1}, and no inorganic fertilizer) resulted in an average plant height of 143.2 cm. Lovitna et al. (2021), reported a positive correlation between PSM populations, soil chemical properties, and maize yield in a fertilizer treatment that applied phosphate-dissolving bacteria combined with SP-36 fertilizer on Alfisol soil. Susilowati et al. (2022) reported that the biological-phosphate fertilizer treatment combined with three types of fertilizers (biological-phosphate, NPK, and organic) showed the highest maize plant growth rate. Adding phosphate-solubilizing microbes and organic fertilizer to the planting media can increase the availability of nutrients for plants, especially P and N. Available N helps accelerate overall plant growth, especially the stem (Salisbury and Ross, 1995). While the element P plays a role in all plants' metabolic processes, P deficiency will inhibit plant growth (Malhotra et al., 2018). According to Alori et al. (2017), phosphate-solubilizing microorganisms secrete organic and inorganic compounds that play a role in converting insoluble phosphorus into a form that plants can use. Soluble forms of P for plants in the soils, mainly HPO_4^{2-} or $H_2PO_4^-$ depending upon soil pH (Kalayu, 2019), while the insoluble forms consist of ferric phosphate (Fe-P), aluminum phosphate (Al-P), fluorapatite (FAP) and rock phosphate (RP) (Zhao et al., 2002). The addition of PSM inoculation to plants improved plant yield and phosphorus uptake in both pot trials and field conditions (Wang et al. 2015). Wani et al. (2007) conducted experiments on corn by adding PSM inoculation and showed superior growth in nutrient availability in roots and shoots compared to plants that were not added with PSM inoculation. PSM functions as a biofertilizer by rendering P available to growing plants. Phosphorus-solubilizing microorganisms can stimulate plant growth through the synthesis of phytohormones, improvement of biological nitrogen fixation efficiency, and increased availability of zinc and iron (Wani et al., 2007; Alori et al., 2017).

3.2.2 *Combination treatment of microbial phosphate solubilizer, pelleted organic fertilizer, and inorganic fertilizer on fresh and dry-weight of maize plant*

The variance analysis results showed that the combination of phosphate solubilizing microbes, pelleted organic fertilizer, and inorganic fertilizer significantly affected the fresh and dry weight of corn plants. The highest value of fresh plant weight was obtained in the $M_1B_2A_1$ treatment (combination of phosphate solubilizing microbes, organic fertilizer pellets at the rate of 10 tons ha^{-1}, and inorganic fertilizer at 50% of the recommended dose), producing an average of 123.5 g. The highest value of plant dry weight was also obtained in the $M_1B_2A_1$ treatment (combination of phosphate solubilizing microbes, organic fertilizer pellets at the rate of 10 ton ha^{-1}, and inorganic fertilizer at 50% of the recommended dose), producing an average of 29.9 g. Amanullah et al. (2010) showed a positive correlation between available P and the dry matter of corn plants.

Adding microbial phosphate solubilizers, pelleted organic fertilizer, and inorganic fertilizer will increase the availability of macro and micronutrients that are useful in tissue formation and plant metabolism. According to Fahmi et al. (2010), the P element works with the organic N element to assist plant growth and development; the more significant the plant's dry weight value, the better it grows and develops. According to Gardner (1991), fertilization in the effective zone will enhance plant dry weight, whereas fertilization in the excessive zone will increase the concentration of certain nutrients in plant tissue. This is further backed by the opinion of Hanafiah (2005), who believes that the availability of nutrients required by plants in adequate condition and supported by environmental conditions enables rapid expansion, extension, and cell division.

3.2.3 *Combination treatment of microbial phosphate solubilizer, pelleted organic fertilizer, and inorganic fertilizer on Nitrogen and Phosphorus nutrient uptake of maize plant*

Nutrient uptake is the number of nutrients that enter the plant tissue. A plant's nutrient uptake can be calculated by multiplying its nutrient levels by the amount of dry matter it produces (Senthivalavan and Ravichandran, 2016). The highest N uptake analysis results were obtained in the $M_0B_2A_0$ treatment (no microbial phosphate solubilizer, organic fertilizer pellets dose of 10 tons ha^{-1}, and no inorganic fertilizer), which was 0.95 g per plant or equivalent to 3.25% of the dry weight of the plant (medium). In contrast, The $M_0B_0A_0$ (control) treatment had the lowest N uptake, at 0.15 g per plant or 1.44% of plant dry weight (deficient). The results of the DMRT test at the 5% level showed that the $M_0B_2A_0$ treatment was significantly different from the $M_0B_0A_0$ treatment. The $M_0B_2A_0$ treatment produced plants with the highest nutrient uptake rate of 0.95 g per plant. The high degree of nutrient uptake in the $M_0B_2A_0$ treatment is due to the input of organic fertilizer pellets into the soil, which can enhance soil N levels such that the rise in soil nutrient levels will be directly proportionate to plant nutrient uptake. According to

Widyowanti et al. (2019), Pellet organic fertilizer is slow release and can increase the amount of soil NPK by 7-8%, and on day 10, the release of N to the soil reaches 1-3%.

Based on the results of the nutrient uptake analysis of maize plants, the highest P nutrient uptake was obtained in the $M_1B_2A_1$ treatment, which was 0.275 g per plant or equivalent to 0.86% of plant dry weight (very high). At the same time, the $M_0B_0A_0$ treatment (control) produced plants with the lowest nutrient uptake rate of 0.035 g per plant or equivalent to 0.34% of plant dry weight (medium). The DMRT test results at the 5% significance level also revealed a significant difference between the $M_1B_2A_1$ and $M_0B_0A_0$ treatments. The high level of plant P nutrient uptake in the $M_1B_2A_1$ treatment compared to other treatments was due to the treatment's ability to increase P availability in the soil significantly. Sitanggang et al. (2017) evaluated the application of phosphate-solubilizing microorganisms and numerous sources of P fertilizer on maize plants grown in Andisol soil. The test results demonstrated that applying phosphate-solubilizing microbes with various phosphate fertilizers significantly affected plant P uptake. This is similar to Silitonga et al. (2019) research that phosphate solubilizing fungus and P fertilizer could enhance P availability by 1.4 and 15.4%, plant dry weight by 21.4% and 42%, and plant P content by 1.3 and 8.9%. Phosphate-solubilizing bacteria boost the soil phosphorus bioavailability to plants (Ai, et al., 2009). They mineralize insoluble organic phosphates and dissolve insoluble inorganic phosphorus (Sharma et al., 2013). PSBs are believed to be capable of dissolving insoluble phosphates by the secretion of organic acids with low molecular weight (Patel et al., 2008). According to Anand et al. (2016), organic acids produced by microorganisms dissolve insoluble phosphate through a decrease in pH, chelation of cations, and interaction with phosphate at soil sorption sites.

4. Conclusion

The addition of PSM 10^9 cfu mL^{-1} treatment when added with organic fertilizer 5.0 to ha^{-1} and inorganic fertilizer at 50% recommendation dose ($M_1B_2A_1$) produced plants with the highest fresh weight of 123.53 g and dry weight 29.93 g. The highest plant nitrogen (N) nutrient uptake, measuring 0.945 grams per plant, was achieved with a combined treatment involving the absence of phosphate solubilizing microorganisms, the application of organic fertilizer pellets at a rate of 10 tons ha^{-1}, and the absence of inorganic fertilizer ($M_0B_2A_0$). In contrast, when phosphate solubilizing microorganisms, pellets, and 50% recommended doses of inorganic fertilizer ($M_1B_2A_1$) were used together, the plants showed the maximum uptake of phosphorus at a rate of 0.275 grams per plant.

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