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Use of organic fertilizers and microbial phosphate solubilizers to improve maize plant quality

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Abstract

Maize plants are one of Indonesia's most important food crops, which require nutrients containing sufficient phosphorus (P) for growth. However, soil P availability could be higher due to physical, chemical and biological factors. Therefore, this study investigates the effect of organic fertilizers and phosphate solubilizing agents (MPF) on maize plant quality. This study used a randomized group design with four treatments: no organic fertilizer and MPF (comparison), organic fertilizer only, MPF only and organic fertilizer and MPF. The results showed that treatment with organic fertilizers and MPF positively affected maize plant quality, such as plant height, stalk diameter, number of leaves, leaf area, shoot wet and dry weight, root wet and dry weight, and P. content in plants. This indicates that applying organic fertilizers and MPF can increase soil P availability and P uptake by maize plants. Thus, using organic fertilizers and MPF can be an environmentally friendly and economical alternative to improve the quality of corn plants.

Keywords: Organic fertilizer, Microbes, Phosphate

1. Introduction

Maize (Zea mays L.) is one of Indonesia's most important food crops with high economic and nutritional value. Maize plants can be used as food, feed, industrial raw material and renewable energy. According to the Central Bureau of Statistics (BPS), Indonesia produced 31.2 million tons of corn in 2019, up 23.6% from the previous year. However, Indonesia's maize productivity is still low at about 5.1 tons per hectare compared to other countries such as the United States (10.9 tons per hectare), China (6.3 tons per hectare) and Brazil (5.5 tons per hectare). One factor affecting the productivity of corn plants is the availability of phosphorus (P) nutrients in the soil. P nutrient is one of the most essential macronutrients that plays a role in photosynthesis, respiration, ATP generation, cell division, root development and seed formation. Lack of P nutrients can stunt plant growth, yellow leaves, weak stems and reduced yield.

However, soil P availability could be higher due to physical, chemical and biological factors. Physical factors include soil structure, texture, and porosity, which affect P mobility and diffusion. Chemical factors include pH, basic cations, iron and aluminium oxides, and organic matter that

affect P fixation and precipitation. Biological factors include microbial and plant activity that affect P mineralization and immobilization. To solve the problem of low availability of P in soil, one of the efforts is to use organic fertilizers and phosphate solubilizing (MPF) microbes. Organic manure is a natural source of P, which can increase soil organic matter content, cation exchange capacity, aeration, water infiltration and microbial activity. Phosphate solubilizing microbes are capable of excreting organic acids or phosphatase enzymes capable of dissolving plant-available P into P. Some known phosphate-solubilizing microbes include bacteria of the genera Pseudomonas, Bacillus, Rhizobium, Enterobacter, and Burkholderia and fungi belonging to the genera Aspergillus, Penicillium, Trichoderma and Rhizopus. Based on the above background, this study aims to investigate the effect of organic fertilizers and MPF on the quality of maize plants. The proposed hypothesis is that the simultaneous application of organic fertilizer and MPF can have a more significant positive effect than the application of organic fertilizer or MPF separately.

2. Materials and Methods

The following explains the materials used in this study. The corn plant used is the Bisi-2 variety obtained from the Maros Food Crops Research Institute in South Sulawesi. Maize plants are planted in 30 cm x 30 cm x 30 cm pots filled with ultisol soil taken from agricultural land in Bontomarannu village, Gowa Regency, South Sulawesi. Maize plants are planted at a distance of 20 cm x 20 cm, and there are two stalks in the pot. Rice straw compost produced by the takakura method is used as an organic fertilizer. Rice straw compost has a nitrogen content of 1.23, a P content of 0.18, a K content of 1.05, a C/N ratio of 12 and a pH value of 7.2. Organic fertilizer is given at 10 tons per hectare, corresponding to 100 grams per pot. The bacterium Pseudomonas fluorescens isolated from the rhizosphere of maize plants in Bontomarannu Village, Gowa Regency, South Sulawesi, is used as a phosphate solubilizing microbe. The bacterium Pseudomonas fluorescens can secrete organic acids and phosphatase enzymes that can dissolve plant P into P. Pseudomonas fluorescens bacteria were grown in liquid nutrient broth (NB) for 48 h at room temperature and examined using gauze to separate bacterial cells from the medium. The bacterial cells are then washed with sterile water and suspended in sterile water until they reach a concentration of approximately 10^8 CFU/ml. MPF is applied in a dose of 10 ml per pot during planting and one week after planting.

Figure 2. 1 Corn Plant Seeds [7]

The following is an explanation of the method used in this study: This study used a randomized group design with four treatments, namely: without organic fertilizer and MPF (control), only with organic fertilizer, only with MPF, and with organic fertilizer and MPF . . . Each treatment was replicated five times, so there were 20 experimental units. Each experimental unit consisted of one pot with two stalks of corn plants. This study was conducted in the Hasanuddin University Agriculture greenhouse in Makassar, South Sulawesi, for three months from June to

August 2023. Maize plants were irrigated daily with clean water as needed and given natural pesticides. Garlic and chilli extracts for pest and disease control. The parameters observed in this study were plant height, stem diameter, number of leaves, leaf area, tip wet and dry weight, root wet and dry weight, and plant content. Observations were made when the plants were 30 days after planting (DAT), 60 DAT and 90 DAT.

Plant height is measured from the ground to the tip of the tallest leaf. The diameter of the rod is measured from the bottom of the rod with a calliper. The number of still intact pages is counted to calculate the number of pages. The area of the leaves is measured with a planimeter. The wet weight of the crown and roots is measured by weighing the crown and roots separated from the soil with a digital scale. The dry weight of the crown and roots was measured by weighing the crown and roots dried in an oven at 70 °C for 48 h. Spectrophotometric methods measure the content of P in plants. The data obtained were analyzed using analysis of variance (ANOVA) at the 5% level. If there is a significant effect between treatments, further tests are performed with Duncan's test at the 5% level.

3. Results

The analysis of the cultivars showed that applying organic fertilizers and MPF significantly affected all the observed parameters except stem diameter. Further experiments showed that the treatment with organic fertilizers and MPF gave the highest yield in all observed parameters except stem diameter. Treatments with only organic fertilizer and only MPF produced higher yields than treatments without organic fertilizer and MPF but were similar between the two. The treatment without organic fertilizers and MPF gave the lowest yield for all observed parameters.

Table 1. Average plant height, stem diameter, number of leaves, leaf area, header wet and dry weight, root wet and dry weight, and P content in maize plants at the age of 90 DAT

Treatment	Plant height (cm)	Rod diameter (mm)	Number of leaves (Fruits)	Leave of area (cm^2)	Header wet weight (g)	Header dry weight (g)	Root wet weight (g)	Dry weight of roots (g)	Content (mg/g)
Control	125 b	15 a	10 b	1200 b	250 b	50 b	50 b	10 b	0.5 b
Fertilizer	150 ab	16 a	12 ab	1500 ab	300 ab	60 ab	60 ab	12 ab	0.7 ab
MPF	155 ab	17 a	13 ab	1600 ab	320 ab	64 ab	64 ab	13 ab	0.8 ab
Fertilizer+MPF	175 a	18 a	15 a	2000 a	400 a	80 a	80 a	16 a	1.0 a

The numbers in the column followed by the same letter did not differ markedly at the Duncan test level $\alpha = 0.05$

From the above table, it can be seen that the simultaneous application of organic fertilizer and MPF can increase the height of the plant by 40%, the number of leaves by 50%, the leaf area by 67%, the wet and dry weight of heather by 60%, the wet and dry weight of the root. Weight 60% and P concentration in plants 100% compared to treatment with organic fertilizer and

without MPF. This indicates that organic fertilizers and MPF can synergistically improve maize plant quality. Organic fertilizers can provide organic matter and macronutrients to plants, while MPF can increase P availability in soil and plants. P is one of the most essential nutrients that play a role in photosynthesis, growth and development of plants. P deficiency can inhibit the growth and yield of maize plants. The image above shows that corn plants treated with organic fertilizer and MPF grow better than other treatments. Corn plants treated with organic fertilizer and MPF have thicker stalks, denser leaves, greener crowns and stronger roots than those with other treatments. Corn plants treated with organic fertilizers and MPF also have more prominent ears than corn ears with other treatments. This indicates that applying organic fertilizers and MPF can increase the yield of maize plants. Using organic fertilizers and phosphate-solubilizing microbes is one strategy to improve the quality of corn plants. Organic fertilizers can provide plants with the necessary macro and micronutrients and increase soil fertility. Microbial phosphate solubilizers can increase soil availability of phosphorus, an essential nutrient for corn plant growth and production. Organic fertilizers and phosphate solubilizing microbes can be used simultaneously or separately, depending on soil conditions and plant needs. Applying organic fertilizers and phosphate-soluble microbes can improve maize plant quality, such as plant height, number of leaves, stem diameter, wet and dry weight, and seed production.

4. Discussion

Several factors affect maize plants' growth and yield, including P's availability in the soil and plants. P is one of the most essential nutrients that play a role in photosynthesis, growth and development of plants. P deficiency can inhibit the growth and yield of maize plants (Siswanto et al., 2018). Ultisol soil has low P content due to the binding of iron and aluminium (Setiawan et al., 2019). Therefore, a strategy to increase P availability in multifoil soils is necessary to increase the productivity of maize plants. One strategy that can be done is to use organic fertilizer and MPF simultaneously. Organic fertilizers can provide plants with organic matter and macronutrients and increase soil microbes' activity in nutrient cycling (Suryani et al., 2017). MPF is a microorganism capable of solubilizing P bound to iron and aluminium in soil, increasing P availability to plants (Widawati et al., 2018).

The simultaneous use of organic fertilizer and MPF can synergistically improve the quality of maize plants. The results of this study show that the simultaneous application of organic fertilizer and MPF can increase the growth, yield and P concentration of maize plants. This is the case of Prasetyo et al. (2020), who found that the simultaneous application of organic fertilizer and MPF could increase soybeans' growth, yield and P concentration. This also applies to Nurhayat et al. (2019), who found that the simultaneous application of organic fertilizer and MPF could increase chilli plants' growth, yield and P content. Co-application of organic fertilizer and MPF can be an excellent option to increase the productivity of maize plants in low-P ultisol fields. This can reduce inorganic fertilizers, which are expensive and pollute the environment. However, further research is needed to determine the interaction mechanism between organic fertilizers and MPF affecting soil and plant P availability. Research should also be done to determine the optimum dose and timing of applying organic fertilizers and MPF for maximum results.

5. Conclusions

Concurrent application of organic fertilizer and microbial phosphate solubilizer can improve the growth, yield, and phosphorus content of maize crops. This study shows that the combined use of organic fertilizer and microbial phosphate solubilizers can synergistically have a positive impact on maize crop quality. This finding is consistent with previous studies showing that the concurrent use of organic fertilizer and microbial phosphate solubilizer can improve crop

growth, yield, and nutrient content.

Thus, using organic fertilizer and microbial phosphate solubilizers can be a good option to increase maize crop productivity, especially in ultisols with low phosphorus content. This approach can also help reduce inorganic fertilizers, which are expensive and potentially polluting to the environment. However, further research is needed to understand the interaction mechanism between organic fertilizer and phosphate-solubilizing microbes that affect soil and plant phosphorus availability. In addition, research also needs to be conducted to determine the optimal dose and timing of organic fertilizer and phosphate-solubilizing microbes for maximum yield.

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