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Biofertilizers and Cow Urine Affect Growth, Nutrient Absorption and Yield of Caisim (*Brassica chinensis* var. parachinensis) on Peat Soil

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ABSTRACT

Background: Caisim is a vegetable commodity with commercial potential and promising prospects. Considering the climatological, technical, economic and social aspects, Caisim is feasible to cultivate in Indonesia. The research aims to determine the interaction of biofertilizer and cow urine concentration on the morpho-physiological and yield of Caisim on peat soil.

Methods: Research was conducted in Tanjungpura University, Pontianak City, Indonesia. The research period from March 15th to November 30th 2024. The research used a completely randomized factorial design. The first factor consisted of the concentration level of biofertilizer, namely 2, 4 and 6 ml L^{-1}. The second factor was the concentration level of cow urine 200, 300 and 400 ml L^{-1}.

Result: The application of biofertilizer and cow urine supported the growth and yield of caisim. The interaction of biofertilizer at a concentration level of 4 ml L^{-1} and liquid organic fertilizer of cow urine 300 ml L^{-1} can increase the absorption of nitrogen, phosphorus and potassium of Caisim. In addition, the interaction can increase the root volume, plant biomass and leaf area of caisim on peat soil.

Key words: Biological fertilizer, Organic fertilizer, Plant productivity, Soil fertility.

INTRODUCTION

Caisim (*Brassica chinensis* var. parachinensis) is a horticultural commodity and is part of the mustards group with good prospects and high economic value in Indonesia. Caisim is easy to cultivate and develop, many people like and use it. Caisim has commercial potential and has good prospects. Reviewed from the climatological, technical, economic and social aspects, Caisim can be cultivated in Indonesia. Caisim is now included in the group of commodities grown on a large scale (Haryanto, 2003).

Based on data from the Ministry of Agriculture (2023), the amount of consumption of mustard in Indonesia from 2020 to 2023 has always increased, where in 2020 amount of mustard consumption was 681,778.8 tons $year^{-1}$, in 2021 it increased to 789,987.2 tons $year^{-1}$, in 2022 mustard consumption was 783,985.6 tons $year^{-1}$ and in 2023 it increased to 796,358.4 tons $year^{-1}$. Meanwhile, the supply of mustard in 2020 was 667,000 tons, in 2021 it was 727,467 tons, in 2022 it was 760,608 tons and in 2023 it was 686,876 tons (Central Statistics Agency, 2024). This indicates that the increasing demand for mustard has not been met yearly, so a strategy to increase mustard productivity is still necessary.

Peat soil, widespread in West Kalimantan, Indonesia, is a potential land for Caisim cultivation because it has a high organic content. Using peat soil as a Caisim planting medium has obstacles, namely limited soil fertility (Radian *et al.,* 2024; Samson and Mahmudi, 2024). The levels of macro and micronutrients are low (Purwanto *et al.,* 2014). The high C/N ratio results in most of the nutrients from the decomposition process of organic matter being unavailable to plants because soil organisms utilize them. Healthy plant growth and development are reflected by optimal nutrient status, nutrient concentration and the amount of absorption of nitrogen, phosphorus and potassium nutrients in plant tissue (Aryanto *et al.,* 2015).

Fertilization is an effort to meet the nutrient needs of plants. Efforts to obtain high Caisim yields require a lot of balanced nutrient levels for plants. The nutrient content of plants depends on the nutrients available in the soil (Indrakusuma, 2000; Bekele *et al.,* 2023). The efficient and effective use of fertilizers must meet the right type and dose criteria (Yuwono, 2006). So far, many biological fertilizers in circulation are indicators that biological fertilizers have good prospects. In addition, adding nutrients to the soil can be done with organic fertilization.

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Organic fertilization aims to increase fertility and soil biological activities, which are carried out by adding organic materials in sufficient quantities. Organic fertilizers can be made by utilizing livestock waste or existing plant residues. Organic fertilizer of cow urine is an alternative application of environmentally friendly and sustainable agricultural cultivation technology (Patra and Bharti, 2024). Cow urine can be used as liquid organic fertilizer and is a source of nutrients for plants, such as macronutrients such as nitrogen, phosphorus and potassium, as well as micronutrients such as iron, magnesium and copper, which are needed for plant growth (Ansari *et al.,* 2016; Patra and Bharti, 2024). Biological fertilizer contains various microorganisms that can provide more balanced nutrition for plants by fixing and dissolving nutrients and decomposing organic matter in the soil (Sahu *et al.,* 2024). Biofertilizers contain soil-fertilizing microorganisms that can increase and restore soil fertility naturally.

The provision of cow urine is expected to provide Caisim with sufficient nutrients. The higher the dose and concentration of fertilizer given, the higher the nutrient content received by the plant. However, excessive doses and concentrations will cause plant wilting symptoms (Kusumawati *et al.,* 2020). The study aims to determine the interaction of biofertilizer and cow urine concentration on the morpho-physiological and yield of Caisim on peat soil.

MATERIALS AND METHODS

The research was conducted at the Experimental Field of Agriculture Faculty, Tanjungpura University, Pontianak City, Indonesia. The research period from March 15th to November 30th 2024. The research used peat soil with a hemic maturity level and Bio Optifarm fertilizer, which contains microorganisms *Rhizobium* sp, *Lactobacillus* sp., *Pseudomonas* sp., *Azotobacter*, *Streptomyces* sp., *Actinomycetes* sp., *Mikorizae*, *Bacillus* sp. and *Tricodherma* sp. The research used a field experiment that implemented a completely randomized factorial design. The first factor consisted of the concentration level of biofertilizer, namely 2 ml L^{-1}, 4 ml L^{-1} and 6 ml L^{-1}. The second factor was the concentration level of cow urine, namely 200 ml L^{-1}, 300 ml L^{-1} and 400 ml L^{-1}.

The observation variables consisted of nitrogen absorption of plants (mg), phosphorus absorption of plants (g), potassium absorption of plants (g), root volume (cm^3), plant biomass (g), number of leaves (blades), leaf area (cm^2) and fresh weight of plants (g). The data obtained were then analyzed of variance with a 95% confidence level. If there was a significant difference between treatments in the analysis of variance, further testing was carried out using Tukey's test at the α level of 0.05.

RESULTS AND DISCUSSION

Nitrogen absorption

The analysis of variance showed that the interaction of biofertilizer and cow urine significantly affected the absorption of nitrogen by caisim plants. Caisim plants, in the interaction of biofertilizer 4 ml L^{-1} and cow urine 300 ml L^{-1}, showed the highest absorption of nitrogen, namely 0.0093 mg. They are significantly differed from the absorption of nitrogen nutrients in the interaction of biofertilizers 2 ml L^{-1} and 4 ml L^{-1} to cow urine 400 ml L^{-1} (Table 1). Biofertilizers containing microorganisms such as phosphate-solubilizing bacteria or nitrogen binders can increase the availability of nutrients in the soil. The combination with cow urine, which is rich in nitrogen, can accelerate the mineralization and nitrification process, resulting in nitrate (NO_3^-), which plants quickly absorb.

The amount of nitrogen absorption by plants is closely related to the growth and yield of Caisim plants. Increased nitrogen absorption in plants is also closely related to nitrogen levels in plant tissue (Patti *et al.,* 2018). Nitrogen nutrients stimulate the synthesis of vegetative growth and amino acids (Iswiyanto *et al.,* 2022). Nitrogen absorption in plants is greatly influenced by the availability of these elements and the amount of organic matter in the soil because nitrogen is one of the sources (Putra *et al.,* 2022).

Phosphorus absorption

The analysis of variance showed that the interaction of biofertilizer and cow urine significantly influenced the phosphorus absorption of Caisim. The highest phosphorus absorption of Caisim plants was produced in the interaction of biofertilizer 4 ml L^{-1} and cow urine 300 ml L^{-1}, which was 0.0117 g and was significantly different when compared to phosphorus absorption in the interaction of biofertilizer 2 ml L^{-1} to cow urine 300 ml L^{-1} and 400 ml L^{-1}, the interaction between biofertilizer 4 ml L^{-1} and cow urine 400 ml L^{-1}, the interaction between biofertilizer 6 ml L^{-1} and cow urine 200 ml L^{-1} and 300 ml L^{-1} (Table 1).

Microorganisms in biofertilizers, such as phosphate-solubilizing bacteria (*Pseudomonas* spp., *Bacillus* spp.), produce organic acids or enzymes that can dissolve phosphorus bound in the soil. With the presence of cow urine, which contains nitrogen and organic compounds, the activity of these microorganisms can increase so that more phosphorus is available to be absorbed by Caisim plants. According to Erlambang *et al.* (2018), microorganisms in biofertilizers effectively provide nutrients in the soil, including phosphorus. The potential of biofertilizers as a provider of nutrients, including phosphorus, can increase their availability, ultimately increasing phosphorus absorption (Firdausi *et al.,* 2016).

Potassium absorption

The analysis of variance showed the interaction of biofertilizer and cow urine significantly influenced potassium absorption. Caisim produced the highest potassium absorption with the interaction of biofertilizer 4 ml L^{-1} and cow urine 300 ml L^{-1}, which was 0.024 g and was significantly different when compared to potassium absorption in the interaction of biofertilizer 2 ml L^{-1} and cow urine 400 ml L^{-1}, the interaction of biofertilizer 6 ml L^{-1} and cow urine 200 ml L^{-1}

(Table 1). Certain microorganisms in biofertilizers can dissolve potassium from soil minerals unavailable to plants, such as feldspar or mica. Cow urine, which contains nitrogen and organic compounds, supports the activity of these microorganisms by providing additional nutrients (Oladipupo and Ayorinde, 2015).

Root volume

The analysis of variance showed a significant effect on the root volume of Caisim caused by the interaction of biofertilizer and cow urine. Caisim plants given biofertilizer 4 ml L^{-1} and cow urine 300 ml L^{-1} obtained the highest root volume of 6.00 cm^3 and were significantly different from the root volume in the interaction of biofertilizer 2 ml L^{-1} to cow urine 200 ml L^{-1} and 300 ml L^{-1} and the interaction of biofertilizer 6 ml L^{-1} and cow urine 400 ml L^{-1} (Table 2).

Roots are the main vegetative organs that absorb water, minerals and dissolved essential materials for plant growth and development. The research show that biofertilizers can cause an increase in root volume and cow urine can provide good growth in the roots of Caisim. According to Virk *et al.* (2022), biofertilizers can increase plant growth. The microorganisms in this biofertilizer can act as decomposers, thus accelerating the process of breaking down organic matter in the soil so that the soil becomes fertile and stimulates plant root growth (Sudiarti, 2017). Cow urine and biofertilizers can increase land productivity because they can improve the chemical properties of the soil (Nuraini and Asgianingrum, 2017; Ghimirey *et al.,* 2024).

According to Hendriyatno *et al.* (2020) and Ataribaba *et al.* (2021), biofertilizers and cow urine will improve soil fertility and increase the soil's ability to retain nutrients. By improving soil fertility and increasing the soil's ability to absorb nutrients, the availability of nutrients that plants will absorb will also increase. The element nitrogen plays a role in increasing the vegetative growth of plants, especially leaves, increasing protein content and the ability of plants to absorb other nutrients such as phosphorus and potassium. Plants that lack nitrogen will grow poorly, have few branches, have sparse leaves and cannot develop young shoots (Kalay *et al.,* 2015). Phosphorus plays a role in forming young plant parts such as roots, stems and new leaves. Potassium acts as a catalyst for plant metabolism processes, so its deficiency can inhibit the formation of new leaves (Haidlir *et al.,* 2019; Khan *et al.,* 2023).

Table 1: The effect of interaction biofertilizer and cow urine on the absorption nutrients of nitrogen (mg), phosphorus (g) and potassium (g) in Caisim.

Biofertilizer	Cow urine	Absorption nutrients of plants		
(ml L^{-1})	(ml L^{-1})	Nitrogen (mg)	Phosphorus (g)	Potassium (g)
2	200	0.0053 ab	0.0060 ab	0.018 ab
2	300	0.0047 ab	0.0047 b	0.014 ab
2	400	0.0027 b	0.0033 b	0.008 b
4	200	0.0050 ab	0.0053 ab	0.002 ab
4	300	0.0093 a	0.0117 a	0.024 a
4	400	0.0027 b	0.0057 b	0.010 ab
6	200	0.0033 ab	0.0050 b	0.008 b
6	300	0.0033 ab	0.0047 b	0.011 ab
6	400	0.0053 ab	0.0057 ab	0.012 ab
HSD 5%		0.0065	0.0063	0.016

Note: The numbers followed by different letters are significantly different based on the Tukey's test at the α level of 0.05.

Table 2: The effect of interaction biofertilizer and cow urine on root volume (cm^3) and plants biomass (g) and leaf area (cm^2).

Biofertilizer (ml L^{-1})	Cow urine (ml L^{-1})	Root volume (cm^3)	Plants biomass (g)	Leaf area (cm^2)
2	200	2.00 b	1.71 ab	171.94 ab
2	300	2.17 b	1.74 ab	117.05 b
2	400	2.67 ab	1.07 b	175.51 ab
4	200	3.83 ab	1.84 ab	171.66 ab
4	300	6.00 a	3.40 a	314.67 a
4	400	4.00 ab	1.26 b	180.57 ab
6	200	2.83 ab	1.62 ab	188.30 ab
6	300	4.83 ab	1.41 ab	169.22 ab
6	400	2.50 b	1.79 ab	188.47 ab
HSD 5%		3.36	2.12	181.81

Note: The numbers followed by different letters are significantly different based on the Tukey's test at the α level of 0.05.

Plant biomass

The variance analysis showed a significant effect on plant biomass caused by biofertilizer and cow urine interaction. The biomass of Caisim in the interaction of biofertilizer 4 ml L^{-1} and cow urine 300 ml L^{-1} was 3.40 g, the result was significantly different when compared to the biomass of plants in the interaction of biofertilizers 2 ml L^{-1} and 4 ml L^{-1} with cow urine 400 ml L^{-1} (Table 2). Various factors, such as the availability of nutrients for plants, environmental conditions and plant genetics, influenced the plant biomass obtained in this study. The interaction of biofertilizer and cow urine proves that plant growth will be more optimal by giving various concentrations of these two factors to the soil. Microbial activity in the soil increases when given various doses of inorganic fertilizer and biofertilizer so that the nutrients in the soil also increase (Setiawati *et al.,* 2017).

Leaves number

The variance analysis showed the number of Caisim leaves in the biofertilizer and cow urine showed no significant effect. The average value of the number of Caisim leaves in various treatments of biofertilizer and cow urine concentrations ranged from 10.42 to 12.50 (Table 3). The absence of differences in the speed of cell division, multiplication and enlargement can cause the absence of an effect on the number of Caisim leaves.

According to Dewi *et al.* (2023) and (Sumarna *et al.,* 2024), plants on the number of leaves are due to Caisim plants genetic factors and their ability to adapt to the environment. This is also thought to be due to the root response to the absorption of nutrients in amounts that are not different so that the microbes given to the soil can function optimally to help the roots absorb the nutrients given so that the provision of biofertilizer and cow urine has been able to meet the nutrient needs for plants in supporting the increase in the number of Caisim leaves. According to Kairiyah *et al.* (2017), stated that the relatively fast response of Caisim and Tomatoes to HEG and BTC biofertilizers is thought to be related to the high density of the microbial population, so several functional characteristics of microbes in binding N_2, dissolving phosphorus or stimulating plant growth work optimally.

Leaf area

The analysis of variance showed that the area of Caisim leaves in the treatment of biofertilizer and cow urine showed a significant effect from their interaction. The widest Caisim leaves were produced in the interaction of biofertilizer 4 ml L^{-1} and cow urine 300 ml L^{-1}, 314.67 cm^2. They were significantly different compared to the area of Caisim leaves in the interaction of biofertilizer 2 ml L^{-1} and cow urine 300 ml L^{-1} (Table 2).

Beneficial microorganisms in biofertilizers play a role in nitrogen fixation, phosphate dissolution and production of plant growth regulators. This directly increases the availability of nutrients for plants and stimulates vegetative growth, including leaf formation. Microorganisms in biofertilizers can help convert organic nitrogen in cow urine into a form that plants more easily absorb. Plants can grow and produce ideally if sufficient nutrients are required (Kurniawan *et al.,* 2023). Nutrients are essential for plants to form compounds needed for plant growth through cell division and enlargement. The nutrient that plays a significant role in leaf growth and development is nitrogen.

Weight of fresh plants

The analysis of variance showed no significant effect on the weight of fresh Caisim caused by the treatment of biofertilizer and cow urine. The provision of biofertilizer and cow urine can increase soil fertility, especially phosphorus and potassium nutrients, by improving the chemical properties of the soil so that the availability of nutrients is sufficient for the weight of fresh Caisim. The provision of biofertilizer and cow urine has been able to increase the fresh weight of Caisim because the available nutrients, especially phosphorus, are sufficient.

According to Hendriyatno *et al.* (2020) and Ataribaba *et al.* (2021), the provision of biofertilizer and cow urine to the soil can increase soil fertility by improving the soils chemical properties by increasing the content and availability of nutrients, especially nitrogen. Increasing the availability of nitrogen, phosphorus and potassium nutrients can increase the weight of fresh plants. This increase in the weight of fresh plants that is not different is due to improvements in the chemical properties of the soil, including increasing levels of nitrogen and phosphorus in the soil (Novizan, 2017).

The larger the leaf organs of the plant that are formed, the more water content can be bound by the plant (Pramitasari *et al.,* 2016). In addition, the increasing number of leaves and the wider the leaves, the higher the weight of fresh plant. According to Huang *et al.* (2019), the fresh weight of the plant is influenced by the number of leaves and leaf area, the more the number of leaves and the larger the leaf area, the higher the weight of fresh plant. The weight of fresh Caisim at various concentrations of biofertilizer and cow urine ranged from 33.47 g to 61.98 g (Table 3).

Table 3: The average value of number of leaves (strands) and weight of fresh plants (g) in Caisim with biofertilizer and cow urine treatments.

Biofertilizer (ml L^{-1})	Cow urine (ml L^{-1})	Leaves number (strands)	Weight of fresh plants (g)
2	200	10.67	33.57
2	300	10.58	38.67
2	400	11.50	38.15
4	200	11.50	33.47
4	300	11.33	40.98
4	400	11.25	42.37
6	200	12.42	37.15
6	300	12.50	34.75
6	400	10.42	37.91

CONCLUSION

The results can be concluded that the interaction of biological fertilizer at a concentration of 4 ml L^{-1} and cow urine at a concentration of 300 ml L^{-1} can increase nitrogen, phosphorus and potassium absorption and increase the root volume, plant biomass and leaf area of caisim on peat soil.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All animal procedures for experiments were approved by the Committee of Experimental Animal Care and Handling Techniques were approved by the University of Animal Care Committee.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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