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APPLICATION OF NANO-VERMICOMPOST IMPROVES NPK NUTRIENT UPTAKE, CHLOROPHYLL CONTENT AND YIELD OF CAISIM MUSTARD

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ABSTRACT
The application of organic farming systems in the field is often constrained by the slow release of nutrients from organic fertilizers so that the synchronization between plant nutrient requirements and the release of nutrients from organic fertilizers becomes inappropriate. Therefore, efforts are needed to accelerate the release of nutrients from organic fertilizers so that they can be absorbed quickly by plants. A pot experiment was conducted to test the application of nano vermicompost on NPK uptake, chlorophyll content and yield of Caisim mustard compared to inorganic fertilizers and some organic fertilizers. This experiment used a Simple Randomized Block Design (RBD). There were seven treatments tested, including: T0 = without fertilizer application, T1 = inorganic fertilizer, T2 = conventional compost, T3 = cow manure, T4 = chicken manure, T5 = vermicompost, and T6 = nano vermicompost. The dose of organic fertilizer applied to all treatments tested is equivalent to the N nutrient content of inorganic fertilizers. The results showed that the application of nano vermicompost provided higher N, P and K nutrients uptake and chlorophyll content compared to the inorganic fertilizers and the others organic fertilizers, as well as to the Caisim mustard yields. Percentage of increase in nutrient uptake of N, P and K to control (T0) by 190%, 73% and 143%, respectively. The increase in leaf chlorophyll content was 11.7% and the total fresh weight of plant and marketable yield increased by an average of 20.7% to control (T0). Thus, in cultivation of Caisim mustard organically is suggested to use of nano-vermicompost fertilizer to increase plant uptake and yield.

Keywords:
Nano-vermicompost; Nutrient Uptake; Chlorophyll Content; Yield of Caisim Mustards

INTRODUCTION

Caisim mustard is a type of leafy green vegetable that is liked by many Indonesian consumers because it contains various nutrients that are beneficial to human health. The ingredients in Caisim mustard are protein, fat, carbohydrates, Ca, P, Fe, Vitamin A, B, and Vitamin C. According to Lestari (2015) in general consumers consume caisim leaves both as the main ingredient in cooking and as a complement to traditional dishes and Chinese food. Apart from being a food ingredient, caisim is believed to relieve itching in the throat of cough sufferers. Caisim mustard also functions as a headache remedy and can work as a blood purifier.

Based on data from the Central Bureau of Statistics (2021), the total production and harvested area of green mustard in Indonesia reached 635,982 tons with a harvested area of 61,047 hectares in 2018, and 652,723 tons with a harvested area of 60,871 hectares in 2019. In 2020, the total harvest reached 667,473 tons with harvested area of 63,464 hectares. The productivity of green mustard increased from 10.28 tonnes/ha in 2018 to 10.72 tonnes/ha in 2019, but decreased again to 10.52 tonnes/ha in 2020. In general, green mustard cultivation in Indonesia is carried out conventionally using agrochemicals. All over the world, both in developing and developing countries, an increase in use of external input factors, e.g. fertilizers and pesticides, has resulted in significant increases in productivity, but simultaneously in a higher environmental pressure (Mondelaers et al., 2009). This is particularly true in terms of land degradation, water use and greenhouse gas emissions (Wood et al., 2006). Dewanto et al., (2013) added that the use of inorganic fertilizers has an impact on good soil fertility from the physical aspect of the soil as indicated by soil compaction. From the chemical aspect of the soil, there is a decrease in soil pH and the availability of nutrients in the soil. From the aspect of soil biology, there has been a decrease in the population and activity of soil microorganisms (Nurhidayati, 2022).

To meet consumer needs in a sustainable manner, it is necessary to adopt a healthy cultivation method that can increase the quantity and quality of crop yields. One of the efforts made is through the application of organic fertilizers to reduce the use of inorganic fertilizers. However, the availability of nutrients from organic fertilizers takes place gradually over a long time. This means that organic fertilizers are slow release so they can have a residual effect on the next crop (Yulia et al., 2011; Nurhidayati et al., 2017, C; Nurhidayati et al., 2018). The slow availability of nutrients from organic fertilizers often has an impact on the out-of-synch of plant nutrient needs with the release of nutrients from organic fertilizers, especially short-lived vegetable plants, resulting in nutrient deficiencies in plants (Singh et al., 2020).

The role of organic fertilizers for soil fertility is able to provide nutrients for plants all the time. Organic fertilizers increase the activity of microorganisms in the soil (Singh et al., 2020). Microorganisms in agro-ecosystem by degrading soil organic matter, nutrient cycling and bioremediation of pollutant of soil (Shaheen et al., 2007; Dong et al., 2014; Luo et al., 2015; Matulich & Martiny, 2015). The microbial population of soil is influenced by soil organic matter that helps to improve soil fertility (Ge et al., 2010). Decomposition of organic fertilizers in the soil is carried out by rhizospheric microbes such as cellulase, pectinase and protease, releasing mineral nutrients such as nitrogen (N), phosphorus (P), potassium (K) and sulfur (S) (Gianfreda & Bollag, 1996; Zhang et al., 2012; Dong et al., 2012; Patil et al., 2014; Liu et al., 2014).

To reduce the degradation of soil fertility and increase the productivity of sustainable yields, it is necessary to use adequate organic fertilizers in quantity, quality and continuity. Organic fertilizers are widely known by Indonesian farmers, in fact this has become a government program to increase fertility and plant production (Hartatik et al., 2015). There are several types of organic fertilizers that can be used in plant cultivation, including compost, manure, vermicompost, etc. Recently, nano-technology has also been applied to various kinds of fertilizers. In this study also used nano vermicompost. Each type of organic fertilizer has advantages and disadvantages due to differences in the chemical composition of the organic fertilizer. Therefore, it is necessary to conduct research aimed to test the effect of nano-vermicompost application on NPK uptake, chlorophyll content and yield of Caisim mustard compared to various kinds of organic fertilizers and inorganic fertilizers.

METHOD

This research was carried out in November 2021 to April 2022 at the Plastic House located in Dinoyo Village, Lowokwaru District, Malang Regency. With an altitude of ± 550 meters above sea level and an average air temperature ranging from 22°C–33°C. Plant analysis was carried out at the Laboratory of the Agrotechnology Laboratory, Agriculture Faculty, university of Islam Malang, East Java, Indonesia.

The experimental design used in this study was a simple randomized block design consisting of seven different treatments, including T0=without fertilizer, T1=inorganic fertilizer (NPK 1 gram pot^{-1}), T2 = conventional compost, T3 = cow manure, T4 = chicken manure, T5 = vermicompost, and T6 = nano vermicompost. The amount of organic fertilizer applied is equivalent to the N content of NPK fertilizer (16:16:16) by 1 g pot^{-1}. Each organic fertilizer has a different amount applied depending on the N content of each organic fertilizer. Each treatment was repeated 5 times. there were 3 plant samples. Each replication

The equipment used in this study were polybags, scales, ovens, grinders, SPAD meters etc. The materials used included soil samples, residue of hydroganic media containing cocopeat, rice husk biochar, sand and vermicompost. The fertilizer materials used were NPK 16:16:16 fertilizer, conventional compost, cow manure, chicken manure, vermicompost, nano-vermicompost fertilizer and Caisim mustard seeds.

The planting medium used is a mixture of soil and residue of hydroganic media or a ratio of 1:1 with a total weight of 4 kg/polybag. The process of making vermicompost was carried out at the Compost Laboratory, Faculty of Agriculture, University of Islam Malang, using a vermicompost bin made from a wooden box measuring 80 x 120 cm with a height of 30 cm. The stages of making vermicompost consist of five stages, namely preparation of organic matter, mixing media, worm inoculation, maintenance and vermicomposting and composting processes (Nurhidayati et al, 2017a). Meanwhile, nano-vermicompost is obtained by grinding dry vermicompost (10% moisture content) using a Grinder Mill to nano-sized particles (100 nm-1000 nm). The results of laboratory analysis of chemical content in organic fertilizers are presented in Table 1.

Table 1. Chemical composition of organic fertilizers used in this research.

No	Organic fertilizer	Chemical Composition					
		C-Organic (%)	N-Total (%)	P-Total (ppm)	K-Total (ppm)	C:N ratio	Moisture content (%)
1	Conventional compost	20,03	1,37	7.20	1258	14,62	54,7
2	Cow manure	29,24	1,75	16.4	555.4	16,71	68,22
3	Chicken manure	34,06	0,95	19.9	2301	35.85	38,30
4	Vermicompost	29.14	1,94	10370	11370	15,02	72,68
5	Nano- vermicompost	31,09	1,75	2712	2820	17,77	14,29

The collected data were analyzed for variance (F-test) with a level of 5% to determine the effect of the treatments. If the results of the F test have a significant effect, then proceed with further tests using the LSD test with a level of 5% for differences between treatments.

RESULT AND DISCUSSION

The Effect of Types of Organic Fertilizers on NPK Nutrient Uptake in Caisim Mustard Plant

The results of the analysis of variance showed that the treatments tested had a significant effect on the nutrient uptake of caisim mustard plants. The LSD test results ($P<0.05$) for the average NPK nutrient uptake are presented in Figure 1.

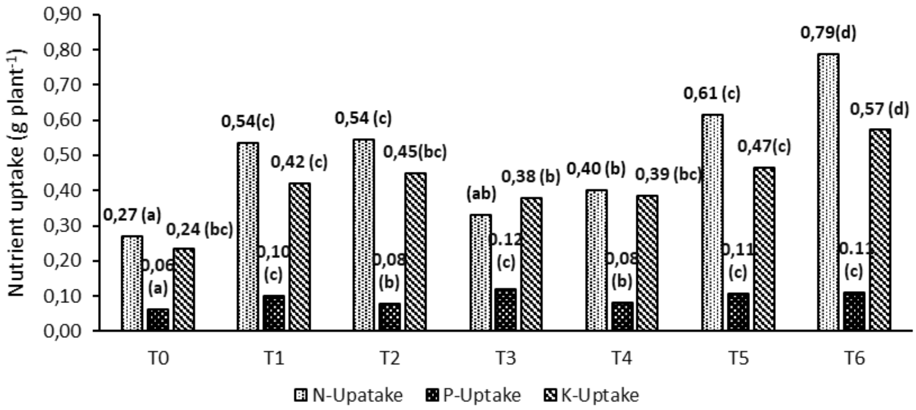


***Figure 1**. The average NPK nutrient uptake of Caisim mustard in the seven treatments tested (Remark : T0 = without fertilizer, T1 = inorganic fertilizer, T2 = conventional compost, T3 = cow manure, T4 = chicken manure, T5 = vermicompost, and T6 = nano vermicompost; LSD 5% for N-uptake=0.09; P-uptake=0.02; K-uptake=0.08)*

The LSD test results (P<0.05) on the N, P and K nutrient uptake variables showed that the T6 treatment (nano vermicompost) provided the highest N and K nutrient uptake (P<0.05), whereas the inorganic treatment had the same P nutrient uptake with the treatment using cow manure, vermicompost and nano-vermicompost. The LSD test results (P<0.05) on the N, P and K nutrient uptake variables showed that the T6 treatment (nano vermicompost) provided the highest N and K nutrient uptake (P<0.05), whereas the inorganic treatment had the same P nutrient uptake. The percentage increase in N, P and K uptake in the application of nano vermicompost was 190%, 73% and 143% respectively compared to T0 (without fertilizer).

The manufacture of nano fertilizer basically aims to increase the efficiency of fertilizer use by regulating the release of nutrients according to the needs of each plant. The nutrient uptake capacity of plants for fertilizer increases with the smaller the vermicompost particle size. This is because the surface area of the fertilizer material is bigger than common organic fertilizer. In addition, the pores in plants also have sizes on the nanoscale so that there is a match between the size of the fertilizer particles and the pores in plants (Shang, et al, 2019).

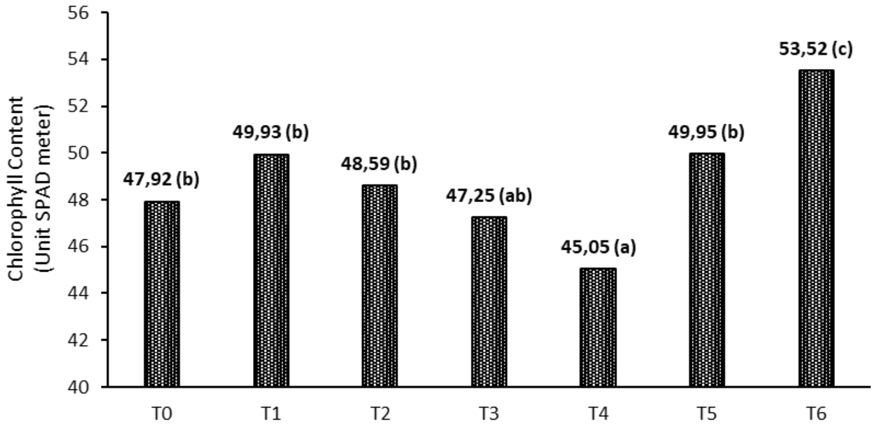
Vermicompost contains complete nutrients, so that it can meet the nutrient needs of plants (Nurhidayati et al., 2017a). Another positive effect of vermicompost is that the auxin content in vermicompost can stimulate plant growth and yield as well as quality of plant yield (Lazcano and Dominguez, 2011; Nurhidayati et al., 2017b; 2017c). The rate of nutrient release from organic fertilizers determines the rate of nutrient uptake of plant. The release of nutrients from the solid phase to the soil solution is controlled by the physiochemical processes of desorption and dissolution. It is also a biochemical process by way of mineralization (Comerford, 2005). The sufficient availability and balanced amounts of nutrients for the processes of plant growth, cell division, photosynthesis, and cell elongation will take place quickly resulting in several plant organs growing well, especially in the vegetative phase. When nitrogen availability is sufficient, the auxin work will be accelerated and it will induce cell elongation (Rayle and Cleland, 1992; Yamamoto, 1996; Perrot-Rechenmann, 2010). Auxin influences stem elongation and regulates the formation, activity, and fate of meristems (Gallavotti, 2013).

Effect of Types of Organic Fertilizers on Chlorophyll Content of Caisim Mustard

The types of organic fertilizers also had a significant effect on the chlorophyll content of caisim mustard plant. The LSD test results (P<0.05) on the chlorophyll content of caisim mustard showed that the T6 treatment (nano vermicompost) gave the highest chlorophyll content (P<0.05) (Fig. 2). The increase in chlorophyll content in the treatment using nano vermicompost was 11.7% compared to T0 (without fertilizer).

Chlorophyll is an important photosynthetic pigment to the plant, largely determining photosynthetic capacity and hence plant growth (Li et al., 2018). The formation of chlorophyll in plant leaves is influenced not only by sunlight but also by the availability of Nitrogen in the form of Nitrate. Nitrate is a form of soil N obtained from the results of organic N mineralization. The faster the release of Nitrate from organic fertilizers, the higher the plant's N uptake and the higher the plant's chlorophyll content (Wen et al., 2019).

Figure 2. Average Chlorophyll content of caisim mustard in the seven treatments tested (Remark : T0 = without fertilizer, T1 = inorganic fertilizer, T2 = conventional compost, T3 = cow manure, T4 = chicken manure, T5 = vermicompost, and T6 = nano vermicompost)



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The Effect of Types of Organic Fertilizers on Yields of Mustard Greens

Types of organic fertilizers also have a significant effect on the yield of caisim mustard plants. The LSD test results (P<0.05) showed that the T6 treatment (nano vermicompost) had the highest total fresh weight of plant and fresh weight of marketable yield (P<0.05) (Fig. 3). The increase in total fresh weight of plant and fresh weight of marketable yield in nano-vermicompost applications was 20.6% and 20.9% respectively compared to T0 (without fertilizer). These results indicate that nano-vermicompost organic fertilizer is able to provide the nutrients needed by caisim mustard plant, especially the N nutrient which is needed for leafy green vegetables. Organic fertilizers are the main source of nitrogen for plants. Increasing the availability of N in the soil in the form of nitrate from the mineralization of organic fertilizers, increases the accumulation of nitrate in plants which greatly affects the growth of the vegetative parts of leafy green vegetable plants. However, if the nitrate concentration is too high in plant tissue, it will reduce the yield of short-lived vegetable crops (Wang and Li, 2004; Erel et al., 2008; Stefanelli et al., 2010; Albornoz, 2016). Caisim mustard includes short-lived plants that are harvested at 30 days old, so that an increase in nitrate content in the soil has a positive effect on plant growth and yield.

Chemical fertilizers actually also provide a high release of nitrate because they dissolve easily in the soil, but if the solubility of a fertilizer is too fast, this affects the synchronization between the release of nutrients from fertilizers and plant nutrient needs, thereby reducing the effectiveness of nutrient uptake by plants (Agyeman et al., 2013).

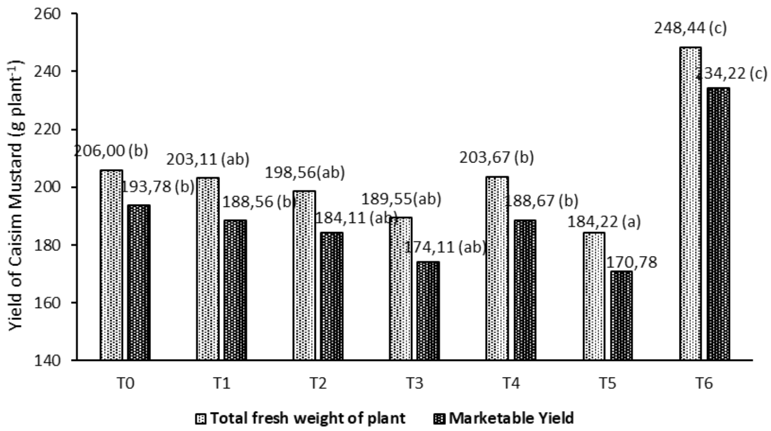

Figure 3. Average Total fresh weight of plant (TFWP) and fresh weight of marketable yield (FWMY) caisim mustard in the seven treatments tested (Remark: T0 = without fertilizer, T1 = inorganic fertilizer, T2 = conventional compost, T3 = cow manure, T4 = chicken manure, T5 = vermicompost, and T6 = nano vermicompost; LSD 5% for TFWP= 17.10; FWMY=16.67)

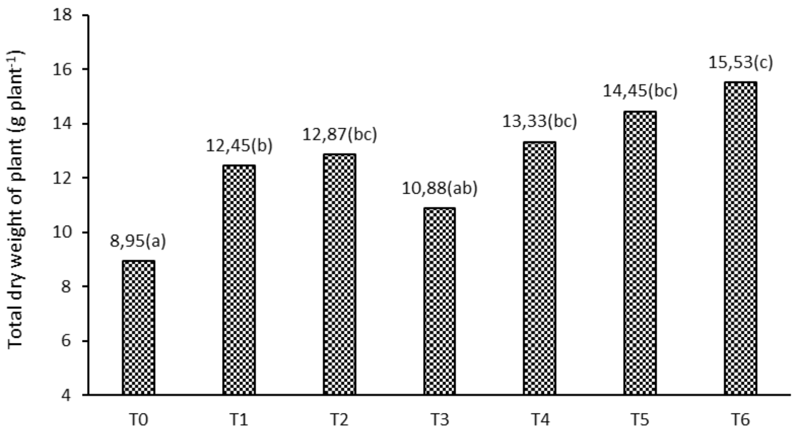

Figure 4. Average Total dry weight of plant caisim mustard in the seven treatments tested (Remark: T0 = without fertilizer, T1 = inorganic fertilizer, T2 = conventional compost, T3 = cow manure, T4 = chicken manure, T5 = vermicompost, and T6 = nano vermicompost; LSD 5%=2.76)

Types of organic fertilizers also have a significant effect ($P<0.05$) on the total dry weight of caisim mustard plant. The LSD test results ($P<0.05$) on the total dry weight of caisim mustard showed that there were several treatments that had the same total dry weight statistically, namely treatments T6 (nano vermicompost), T5 (vermicompost), T4 (chicken manure) and T2 (Conventional compost) ($P<0.05$) (Fig. 4). This shows that the use of organic fertilizers can increase plant dry weight. Measurement of plant dry weight is strongly influenced by the water content of plant tissue. Dry weight can be a very useful and reliable tool when looking to evaluate crop performance, especially after applying any treatment looking to improve yield or quality. Dry weight is also the representative of the photosynthetic capacity of a plant. This is influenced by internal and external plant factors including the availability of nutrients, water and sunlight (Huang et al., 2019). Thus the nutrients released by several organic fertilizers in this experiment can meet the nutrient needs of plants for the process of C assimilation in plants.

CONCLUSION

The application of nano vermicompost fertilizer gave the best effect to caisim mustard plants as measured by N, P and K uptake, chlorophyll content, and plant yields compared to the other organic fertilizer (conventional compost, cow manure, chicken manure and vermicompost) and inorganic fertilizer. However, the use of other organic fertilizers also statistically produced the same dry weight of plant as the use of nano-vermicompost. The results of this study suggest that to increase nutrient uptake and yield of mustard caisim, the appropriate fertilizer is nano-vermicompost fertilizer.

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