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Original Paper

Effectiveness of Sludge Organic Fertilizer and its Combination with Inorganic Fertilizer on Growth, Nutrient Uptake, and Yield of Mustard (*Brassica rapa* L.)

Sri Hariningsih Pratiwi*[1], Fajar Hidayanto[2], Retno Tri Purnamasari[1]

[1]*University of Merdeka Pasuruan, Faculty of Agriculture, Pasuruan, Indonesia*
[2]*State Polytechnic of Cilacap, Cilacap, Central Java, Indonesia*

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Liquid waste from the dairy industry becomes an environmental problem if it is not processed properly, so several technologies have been created from this waste, one of them is sludge organic fertilizer. The aim of this research is to determine the combination of organic and inorganic fertilizers to support the growth, nutrient uptake and yield of mustard. The factors of this research include S0 = NPK 100% (300 kg·ha^{-1}), S1 = 25% sludge organic fertilizer + 75% NPK (6.25 t·ha^{-1} + 225 kg·ha^{-1}), S2 = 50% sludge organic fertilizer + 50% NPK (12.5 t·ha^{-1} + 150 kg·ha^{-1}), S3 = 75% sludge organic fertilizer + 25% NPK (18.75 t·ha^{-1} + 75 kg·ha^{-1}) and S4 = sludge organic fertilizer 100% (25 t·ha^{-1}). The research result shows that the combination treatment of sludge organic fertilizer with NPK inorganic fertilizer can increase the uptake of nitrogen, phosphorus, and potassium nutrients and enhance mustard growth and yield. Treatment of sludge organic fertilizer 25% + NPK 75% being the best in nutrient uptake, growth, and yield of mustard. Meanwhile 75% sludge organic fertilizer + 25% NPK treatment produces better soil chemical properties. This research reveals that mustard still need organic and inorganic fertilizers.

Keywords: inorganic fertilizer, mustard, sludge organic fertilizer, yield

1 Introduction

The presence of industrial liquid waste is one of the dominant environmental problems currently. Before being discharged into rivers, liquid waste must undergo processing first to prevent environmental pollution. Untreated industrial waste can cause the death of many microorganisms that live in the waters (Ayilara and Babalola, 2023).

The dairy industry is also not free from the problem of waste produced, such as liquid waste originating from the dairy industry which has special characteristics, namely its susceptibility to bacteria so that if it is not processed, it can harm the environment (Liu et al., 2020). This processing will produce sludge which is generally used as fertilizer or planting medium. According to Costa et al. (2021) milk waste sludge contains a high source of 34.98% crude protein, 4.42% lactose, 9.77% crude fibre, 11.04% crude fat, 2.33% calcium, 1.05% phosphorus, and 0.4% magnesium on a dry matter basis. The use of milk waste sludge as organic fertilizer has been carried out in many research studies Desai et al. (2016) producing vermicompost with a mixture of milk sludge. However, the general problems faced by organic fertilizers are low levels of nutrients, low solubility, a relatively longer time to produce nutrients available to plants, and the response of plants to the application of organic fertilizer is not as good as the application of inorganic fertilizer (Hidayanto et al., 2020). Therefore, organic fertilizer is not widely used because it is considered unable to meet the nutritional needs of plants (Purnamasari et al., 2023).

Inorganic fertilizers have become a tradition in the current agricultural system. This began to be done since the green revolution spread throughout the world in the early 1960s. Initially, the use of inorganic fertilizers had a positive impact on farmers by increasing crop production. However, long-term use of this fertilizer can result in the soil hardening, being less able to store water, and lowering the soil pH which will ultimately reduce crop production (Arifin et al., 2022). The addition of inorganic fertilizers is increasingly being increased as

***Corresponding Author:** Sri Hariningsih Pratiwi, University of Merdeka Pasuruan, Faculty of Agriculture, Pasuruan-67129, Indonesia; srihariningsihpratiwi@gmail.com https://orcid.org/0000-0001-8756-0075

a solution to this problem, but the production costs are increasing and farmers' profits are decreasing.

The agricultural sector is an important sector that must be maintained continually. One of them is the availability of vegetables. Mustard (*Brassica* sp.) is a plant whose leaves can be consumed fresh or processed. The need for mustard has increased by 4–7% in 2016–2020 due to the increasing of population and people income as well as the increasing of the health awareness (Hayati et al., 2023). This crop's economic value resulted in its wide dispersal, and it has been grown as an herb in Asia, North Africa, and Europe for thousands of years (Divakaran and Babu, 2016).

Efforts to increase green biomass (leaveas) mustard production can be developed using organic fertilizer or a combination with inorganic fertilizer. Maintaining optimal levels of soil organic matter can avoid several nutrient deficiencies in the soil (Divakaran and Babu, 2016). In general, mustard is planted on land with coarse textured soil, very low in organic matter, and a pH of 5.5 to 6.8 (Moerman, 2012). In such situations, organic fertilizers can be utilized to increase mustard productivity and to increase the efficiency of fertilizer use. However, considering the slow-release nature of organic fertilizer, balanced fertilization is necessary, even at low levels of fertilizer use, to maintain long-term fertility. According to the report of Anggraini et al. (2021), the result of the treatment of organic and inorganic fertilizers significantly increases the growth of mustard. Based on the description above, this research is carried to determine the best combination of organic and inorganic fertilizers on growth, nutrient absorption, and yield of mustard.

2 Material and Methods

2.1 Location Characteristics

This research was carried out in 2 stages, namely the field stage and the laboratory stage. At the field stage, mustards were planted in Mulyorejo Village, Pasuruan (7° 41′ 8.46″ S and 112° 51′ 45.67″ E), Indonesia, from September to November 2022 with an altitude of 25 meters above the sea level, sandy clay soil texture. The average annual rainfall and temperature of the province during the year were 269 mm and 28.1 °C, respectively. Meanwhile, the laboratory stage was carried out at the Agricultural Instrument Standardization Agency, Malang, East Java, Indonesia.

2.2 Reaearch Procedure

Sludge organic fertilizer (SOF) comes from a milk factory in the Pasuruan district and the inorganic fertilizer used is NPK compound fertilizer (16 : 16 : 16). This study was designed using a randomized block design (RBD) consisting of four treatments that were repeated six times, with the following treatments: S0 = NPK 100% (300 $kg \cdot ha^{-1}$), S1 = 25% sludge organic fertilizer + 75% NPK (6.25 $t \cdot ha^{-1}$ + 225 $kg \cdot ha^{-1}$), S2 = 50% sludge organic fertilizer + 50% NPK (12.5 $t \cdot ha^{-1}$ + 150 $kg \cdot ha^{-1}$), S3 = 75% sludge organic fertilizer + 25% NPK (18.75 $t \cdot ha^{-1}$ + 75 $kg \cdot ha^{-1}$) and S4 = sludge organic fertilizer 100% (25 $t \cdot ha^{-1}$). Transplantation is carried out when the plant is about one month old after sowing, when the plant has 4 or 5 leaves. Planting was carried out in plots measuring 120 × 180 cm with a spacing of 20 × 20 cm. Sludge organic fertilizer is given two weeks before planting, while inorganic fertilizer (NPK) is applied when the plants are 7 and 14 DAT.

2.3 Research Data

2.3.1 Soil and Fertilizer Analysis

Before the experiment, chemical analysis of sludge organic fertilizer was carried out with the following parameters: pH H_2O (electrometric method), organic carbon (muffle furnace method), total nitrogen (Kjeldahl method), total phosphorus (spectrophotometric method), and total potassium (Atomic Absorption Spectrophotometric method). Furthermore, soil analysis was carried out at the before and after of the experiment by analysing soil chemical properties such as pH H_2O (electrometric method), soil organic carbon (Walkley and Black method), soil total nitrogen (Kjeldahl method), available phosphorus (Olsen method), and exchangeable potassium (NH_4OAc extraction percolation method 1 M,

Table 1 Analysis of chemical properties of sludge organic fertilizer

Variable	Value	Minimum requirements for pure organic fertilizer based on INS(*)
pH H_2O	5.45	4–9
Organic carbon (%)	32.61	minimum 15
Total nitrogen (%)	1.33	minimun 2
Total phosphorus (ppm)	0.04	minimun 2
Total potassium (ppm)	0.78	minimun 2

*Source of minimum requirements for pure organic fertilizer based on INS (Soil Research Institute, 2009)

Table 2 Soil analysis before the experiment

Variable	Method	Value	Category*
pH H_2O	electrometers	6.04	slightly acid
Soil organic carbon (%)	Walkley & Black; spectrophotometer	1.59	low
Total nitrogen (%)	Kjeldahl; titrimetry	0.20	low
Available phosphorus (ppm)	Olsen; spectrophotometer	53	very high
Exchangeable potassium (cmol(+)·kg^{-1})	percolation (NH_4OAc 1 M, pH 7); AAS	0.87	height

*Categories based on Soil Research Institute (2009)

pH 7). The initial soil analysis was not repeated, different from the final soil analysis because the initial soil condition was declared homogeneous or experimental plots had not been made according to the treatment and the data collection was carried out after the mustards were harvested.

2.3.2 Plant Uptake Analysis

After the experiment, the plant sample were analysed for the nutrient content nitrogen, phosphorus, and potassium by air-drying them first and then drying them in an oven at a temperature of 70 °C until constant weight. The nitrogen analysis method uses the Kjeldahl method, while phosphorus, and potassium in plant tissue using the H_2SO_4 and H_2O_2 wet-ashing method.

2.3.3 Vegetative and Yield Components

Ten representative sample plants were randomly selected per plot for measurement of plant height and number of leaves. Measurements were carried out after the plants were 7 DAT at 7-day intervals until the plants were 35 DAT. Plant yield measurements were carried out by weighing the weight of the mustard remaining in the plot. There are several criteria for plants that are ready to be harvested, such as stems that have not hardened and mustard flowers that have not yet grown (Thomas et al., 2004).

2.4 Data Analysis

Data analysis was conducted in analysis of variance (ANOVA) using the software package IBM SPSS 25 for Windows (SPSS Inc., Chicago, USA), and the difference between the treatments means were separated by Least Significant Difference (LSD) at a probability of 95%.

3 Results and Discussion

3.1 Characteristics of the Chemical Properties of the Sludge Organic Fertilizer

Sludge organic fertilizer is an organic fertilizer that comes from a by-product of milk waste processing in the form of sludge to solid with quite high protein content. The method for processing liquid waste from the dairy industry into solid is done by filtering the organic materials dissolved in the waste through several stages which then produce milk waste sludge through a sedimentation process. Based on the results of the chemical properties analysis, sludge organic fertilizer shows that this fertilizer does not comply with the minimum requirements for organic fertilizer of the Indonesian National Standard (Table 1). Therefore, it is necessary to reformulate by enriching microbes and adding organic materials that have a higher nutrient content so that the fertilizer content of milk waste sludge can increase and comply with the minimum requirements for organic fertilizer based on Indonesian National Standards (INS).

Organic fertilizer is an organic material that is completely fermented to produce sufficient minerals and nutrients to improve the soil and support plant growth. Milk waste sludge is mud or solids that contain quite high organic levels but are easily decomposed. Biological oxygen demand levels in milk wastewater ±4,000 mg·L^{-1}, Chemical oxygen demand levels of ±2,000 mg·L^{-1}, and the suspended solids content of milk wastewater is ±800 mg·L^{-1} (Mintarsih, 2006).

Sludge organic fertilizer is a pure solid organic fertilizer that has undergone physical, chemical, and biological processing, followed by a final fermentation process which involves oxidation and reduction reactions resulting in the breakdown of complex compounds into simpler ones by microorganisms (Costa et al., 2021). The results of chemical analysis show pH H_2O and organic carbon comply with the minimum requirements for pure organic fertilizer according to INS with values of 5.56 and 32.61% respectively. Meanwhile, the total nitrogen, phosphorus and potassium contents were respectively 1.33%, 0.04 ppm, and 0.78 ppm which were not in accordance with INS, namely a minimum of 2 (Table 1).

3.2 Soil Properties before the Experiment

Soil is a medium for plant growth and a place for essential nutrients that plants need. The physical, chemical, and biological properties of soil are limiting factors for plant growth and of these three factors, the chemical properties of soil are the main factor because they relate to the availability of nutrients such as nitrogen, phosphorus, and potassium for plant growth. Before research is carried out, it is necessary to first know the initial condition of the soil in order to determine the treatment and uptake of fertilizer applied to the soil.

The results of soil analysis before the experiment showed that plant nutrient concentrations were classified as low-very high (Table 2). The nitrogen, phosphorus, and potassium contents are 0.20%, 53 ppm, and 0.87 cmol(+)·kg^{-1} respectively. The nitrogen nutrient contained in the soil is relatively low, while plants whose leaves are harvested require higher nitrogen nutrients than other macro nutrients such as phosphorus, potassium, magnesium, and calcium. Nitrogen is essential for vigorous growth, high yield, and quality of mustard. Nitrogen is essential in the production of plant proteins and chlorophyll, and is needed in the largest amounts compared to the other macronutrients (Divakaran and Babu, 2016).

Soil organic carbon content and pH H_2O were classified as low and slightly acidic at 1.59% and 6.04 respectively. These soil conditions explain the reason that farmers in these areas obtain lower yields when growing crops whose leaves are harvested. This may be caused by the use of a monoculture system used by farmers and also dependence on inorganic fertilizers Hidayanto et al. (2020). There are reports that the continuous use of inorganic fertilizers in vegetable fields can reduce soil quality.

3.3 Soil Properties after the Experiment

Several studies have indicated that the combination of organic and inorganic fertilizer treatments can produce higher crop yields than organic or inorganic fertilizers alone (Khaliq et al., 2006) and can increase soil fertility (Wei et al., 2016). In contrast to the results of this study, there are several soil chemical properties that are lower than the initial soil conditions before the experiment, such as pH H_2O and soil organic carbon (Table 3).

It is clear from the results in Table 3 that the treatment showed significant results on soil pH (p <0.05). The 100% NPK treatment has a significantly different value from the 100% sludge organic fertilizer treatment and is 56% higher so that the application of organic fertilizer can actually increase soil acidity. This can be caused by the pH value of sludge organic fertilizer being classified as acidic, namely 5.45. It is supported by Kang et al. (2022) that giving organic fertilizer will lower the soil pH compared to treatment that only gives inorganic fertilizer. Even though the soil pH has decreased, the pH is still considered optimal to support the growth of mustard plants, as reported by Hannaway and Larson (2004) that the growth of mustard requires soil pH conditions between 4.8–8.5.

On the other hand, the treatment did not show significant results on soil organic carbon (p <0.05). This condition can be expected because organic and inorganic fertilizers have been maximally absorbed by plants, so their availability at the end of the planting period tends to be low to very low. The 75% sludge organic fertilizer treatment combined with 25% inorganic fertilizer has a 22% higher value than the 100% inorganic fertilizer treatment, so the application is 18.75 t·ha^{-1} sludge organic fertilizer is able to substitute NPK fertilizer by 25%. As stated by Chivenge et al. (2011) and Zhang et al. (2012) that The combined application of organic amendments and fertilizers (organics + fertilizers) has been gaining increasing recognition as a feasible and practical approach in boosting crop yields in the short term and enhancing soil organic carbon (SOC) in the long term.

The treatment did not show significant results on the soil total nitrogen after the experiment and was classified as low, only 0.14–0.20% (Table 4). This was indicated because the initial total soil nitrogen was relatively low and the total nitrogen content of sludge organic fertilizer did not meet INS standards, causing the addition of organic and inorganic fertilizers to not be able to increase the total N of the soil at the end of the research. However, the 75% sludge organic fertilizer + 25% NPK treatment can provide the highest total N compared to other treatments. Total N in the soil is strongly influenced by the availability of soil organic matter (Hidayanto et al., 2020). According to Yuniarti et al. (2020), NPK fertilizer is

Table 3 Soil pH H_2O and soil organic carbon after the experiment

Treatment	pH H_2O	Category	Soil organic carbon (%)	Category
NPK 100%	5.87a	slightly acid	0.90a	very low
SOF 25% + NPK 75%	5.57ab	slightly acid	0.96a	very low
SOF 50% + NPK 50%	5.45ab	acid	0.96a	very low
SOF 75% + NPK 25%	5.75ab	slightly acid	1.10a	low
SOF 100%	5.31b	acid	0.95a	very low

* Means followed by the same letter was not significantly different based on the LSD test at a significance level of 5%

quickly available by plants but is easily lost and cannot be stored in the soil.

The treatment significantly affected the final soil available P (p <0.05) and was classified as very high, namely 95.33–142.67 ppm. Based on the results in Table 4, it shows that the 75% sludge organic fertilizer + 25% NPK treatment has a value that is not significantly different from 100% NPK, but is higher than the other treatments. An increase in soil available P is caused by the application of organic fertilizer which is further decomposed or mineralized which will release minerals in the form of base cations which causes the acidic pH H_2O to rise towards neutral due to the increase in the concentration of ion OH^- (Baghdadi et al., 2018). This is in line with the soil pH value of the 75% sludge organic fertiizer + 25% NPK treatment which is higher than other combination treatments (Table 3).

The final soil available potassium based on Table 4 shows that the 75% sludge organic fertilizer + 25% NPK treatment has a value that is not significantly different from 100% NPK but has the highest value of 4.90 ppm compared to other combination treatments. Providing fertilizer with a larger NPK dose compared to organic fertilizer or 100% NPK can increase the K available in the soil. However, the nature of inorganic fertilizer can be absorbed quickly by plants but it is easily lost by evaporating, leaching, and so on. So, it cannot store available phosphorus in the soil. According to Baghdadi et al. (2018), high K availability occurs if the nutrient has not been maximally absorbed by the plant. It is in line with the nature of organic fertilizer which is slowly available by plants (Purnamasari et al., 2023). The 100% sludge organic fertilizer treatment is significantly different from the 100% NPK treatment because inorganic fertilizer can dissolve quickly in the soil, so it can provide nutrients more quickly than organic fertilizer (Hidayanto et al., 2020).

3.4 Nutrient Uptake of Nitrogen, Phosphorus, and Potassium from Plants

The effect of applying inorganic and organic fertilizers on the uptake of N, P, and K nutrients by mustard is presented in Table 5. Nutrient uptake is greatly influenced by the chemical properties of the soil and the soil as a plant growth medium is expected to be able to supply nutrients to the plants growing on it. The total amount of nutrients absorbed by mustard during their growth can be used as the indicator of the plant's nutrient needs throughout its life.

The treatment did not show significant results on N uptake of mustard plants (p <0.05). This was related to the final N availability in the soil which was not significantly different (Table 4). Nutrient uptake by plants depends on the concentration of nutrients in the soil. The concentration of nutrients in the soil is affected by the rate of mineralization (Wijanarko et al., 2012). The highest nitrogen uptake in the 25% sludge organic fertilizer + 75% NPK treatment was 7.47 mg·kg^{-1} compared to other treatments because it is indicated that inorganic fertilizer is able to quickly provide nitrogen nutrients and organic fertilizer that has been mineralized quite well so that it can increase the availability of nitrogen nutrients

Table 4 Soil total nitrogen, available phosphorus and exchangeable potassium after the experiment

Treatment	Total nitrogen (%)	Category	Available phosphorus (ppm)	Category	Exchangeable potassium (cmol (+)·kg^{-1})	Category
NPK 100%	0.17a	low	133.67a	very high	4.95a	very high
SOF 25% + NPK 75%	0.14a	low	95.33b	very high	4.02c	very high
SOF 50% + NPK 50%	0.17a	low	116.67ab	very high	4.78b	very high
SOF 75% + NPK 25%	0.20a	low	142.67a	very high	4.90a	very high
SOF 100%	0.18a	low	133.00a	very high	4.44bc	very high

* Means followed by the same letter was not significantly different based on the LSD test at a significance level of 5%

Table 5 Effect of treatments on plant uptake of nitrogen, phosphorus, and potassium nutrients

Treatment	N-uptake (mg·kg^{-1})	P-uptake (mg·kg^{-1})	K-uptake (mg·kg^{-1})
NPK 100%	6.52a	0.62ab	2.07ab
SOF 25% + NPK 75%	7.47a	0.87a	2.12a
SOF 50% + NPK 50%	6.67a	0.58b	1.85ab
SOF 75% + NPK 25%	6.75a	0.63ab	1.97ab
SOF 100%	6.84a	0.76ab	1.66b

* Means followed by the same letter was not significantly different based on the LSD test at a significance level of 5%

in the soil. Most of the total N in organic fertilizers and composts is in the organic form, which for the most part is not directly available to the plant. Nitrogen mineralization, the transformation from organic N to ammonium N, is mediated by soil microorganisms. Different factors can affect N mineralization, including temperature, water content, soil properties, as well as the properties of the organic material (Geisseler et al., 2021).

The highest phosphorus uptake of mustard greens in the 25% sludge organic fertilizer + 75% NPK treatment was 0.87 mg·kg^{-1} but there was no real effect with 100% NPK treatment. Providing a combination of inorganic and organic fertilizers can speed up the availability of nutrients in the soil if the organic fertilizer has undergone mineralization and the inorganic fertilizer has not experienced evaporation or leaching. The 25% sludge organic fertiizer + 75% NPK treatment had lower final soil available P conditions compared to other treatments, indicating that the P in the soil was able to be absorbed by the mustard plants. It is in line with Yuniarti et al. (2020) that high P availability occurs if this nutrient has not been maximally absorbed by plants.

The addition of organic fertilizer combined with inorganic fertilizer into the soil can increase the potassium uptake of mustard plants in the 25% sludge organic fertilizer + 75% NPK treatment, showing a significantly different value from 100% sludge organic fertilizer (p <0.05) and 22% higher so that organic fertilizer cannot be replaced by the use of a combination of organic and inorganic fertilizers on the land. As the research of Baghdadi et al. (2018) that the use of inorganic and organic will increase fertilization efficiency and produce greater yields because organic fertilizer can replace half of inorganic fertilizer without affecting crop yields. The potassium uptake of mustard is in line with the value of the availability of potassium nutrients in the soil. According to Purnamasari et al. (2023), relates to the nature of inorganic fertilizer which is able to provide nutrients more quickly for plants that have a short lifespan so that when combined with organic fertilizer, it is able to speed up the availability of nutrients for plants.

3.5 Mustard Growth and Yield Components

Observations of plant growth and yield were carried out at the time of mustard harvest (35 DAT). It is clear from the results in Figure 1a that the treatment has the capacity to increase vegetative growth. Compared to the 100% sludge organic fertilizer treatment, corn height increased significantly (p ≤0.05) in the 100% NPK treatment and the combination of inorganic and organic fertilizers. The 25% sludge organic fertilizer + 75% NPK treatment produced the highest mean of 26.74 cm and was significantly different from the other treatments. This performance may be due to the high dose of NPK and not experiencing high levels of leaching and evaporation, so it can be absorbed quite well by plants. Nitrogen is a principal constituent of protein, chlorophyll, and hormones which causes cell elongation and an increase in vegetative apparatus in plants (Nsoanya and Nweke, 2015). With sufficient availability of chlorophyll, the photosynthesis process increases so that the carbohydrates produced increase and can accelerate the increase in plant height (Azarpour et al., 2014)

Figure 1b also shows that there was a significant change in the number of leaves of mustard with the highest average in the 25% sludge organic fertilizer + 75% NPK treatment of 19.36 pieces.week-1 and the difference is significant with 100% NPK and 100% sludge organic fertilizer treatment. It is in line with the research of Ngantung et al. (2018) that the combination of inorganic and organic fertilizers gave the best response for height, number of leaves and fresh weight of green mustard plants, respectively 24.00 cm, 9 strands, and 67.50 g. This situation may be because the nitrogen elements in organic and inorganic fertilizers are sufficiently available in the soil during the mustard growth process. Plants carry out the process of photosynthesis to increase leaf growth. The number of leaves on a plant affects the chlorophyll content, where the chlorophyll in the leaves plays a role in absorbing light to carry out the photosynthesis process (Hayati et al., 2023). If the chlorophyll content in the leaf is sufficient, the resulting photosynthesis will increase. According to Barokah (2017) the growth of mustard requires an adequate supply of nitrogen, which can affect the number of leaves and maintain balance with other nutrients, and every available nutrient must also be applied according to acceptance so that it can be absorbed by the plant.

The combination of organic and inorganic fertilizers provided was able to increase soil nutrients and had a significant effect on the fresh weight of mustard (Figure 1c). The 25% sludge organic fertilizer + 75% NPK treatment produced the best fresh weight of 281.04 g with an increase of 29% compared to the 100% NPK treatment and 38% compared to the 100% sludge organic fertilizer treatment. The findings are also in line with Berenguer et al. (2008) who argue that the integration of organic and inorganic fertilizers promotes synergistic and complementary effects on crop yields. Besides, Wei et al. (2016) also showed that organic and inorganic fertilizer significantly increased corn yields on average by 29% relative to organic fertilizer alone and by 8% relative to inorganic fertilizer alone. Besides, the nutrients N, P, and K are important factors in activating enzymes, stimulating the translocation of carbohydrates from leaves to other plant organs, and strengthening plant roots and stems.

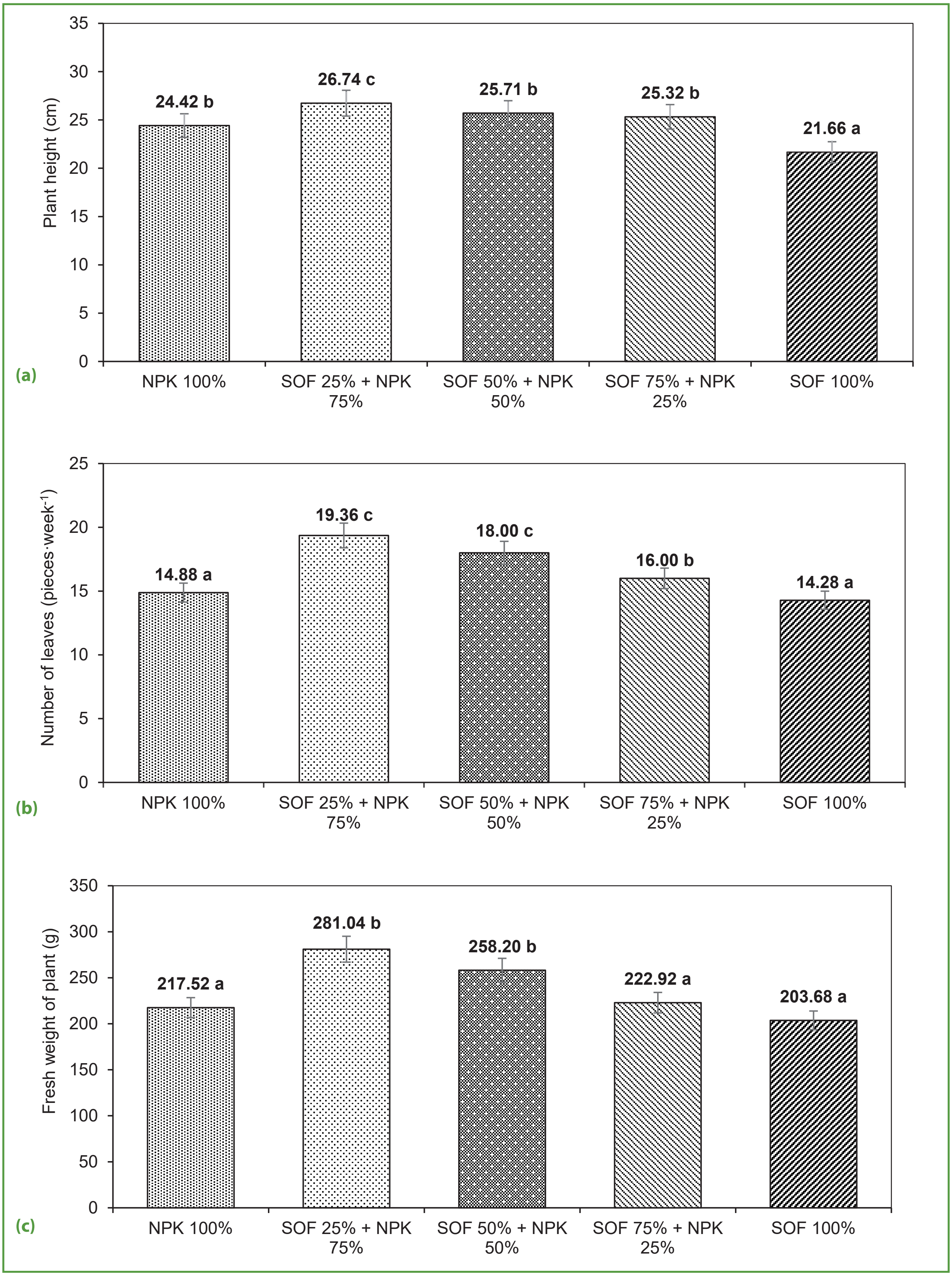

Figure 1 Effect of treatment on (a) plant height; (b) number of leaves and (c) fresh weight of mustard
Error bars represent standard deviation. Mean followed by the same letter was not significantly different based on the LSD test at a significance level of 5%

4 Conclusions

The results of the research show that the combination treatment of sludge organic fertilizer with NPK inorganic fertilizer can increase the uptake of nitrogen, phosphorus and potassium nutrients, and enhance mustard growth and yield. In addition, the nutrient content of the soil after the experiment tends to be lower than the soil before the experiment, indicating that the nutrients can be absorbed by plants. Nutrient uptake, growth, and yield of mustard were highest in the 25% sludge organic fertilizer+ 75% NPK treatment. However, the treatment that can improve the chemical properties of the soil is the 75% sludge organic fertilizer + 25% NPK treatment. A significant increase in the provision of organic fertilizer can maintain soil organic matter and release macro nutrients so as to maintain soil quality.

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