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Effect of Organic Fertilizer Vermicompost and Effective Microorganisms (EM) Bokashi on Okra (*Abelmoschus esculentus*) Growth

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Abstract: Local demand for okra (*Abelmoschus esculentus*) is getting higher every year. Thus, the production of okra needs to be increased. A common method to increase crop yield is to use chemical fertilizers, but there are adverse side effects on the environment and humans if used continuously. The use of organic fertilizers is then being expanded. Therefore, this study aimed to identify the effects of vermicompost and effective microorganisms (EM) bokashi on the growth of okra compared to chemical fertilizers. The fertilizers used; (i) vermicompost (15.0g/plant), (ii) EM bokashi (10.0g/plant), (iii) NPK (15:15:15; 5.0g/plant), and (iv) control. The study involved 60 experimental units of okra seedlings up to 10 weeks of planting. The experimental design was CRD, and data was analyzed using SAS software. In the end (10th week), the results showed significant effects on the stem diameter, leaf surface area, canopy, shoot weight, bud number fruit number and weight ($P \leq 0.01$). Plants with EM bokashi produced the largest stem diameter and fruit number. Meanwhile, plants with NPK showed the largest leaf number, leaf surface area and canopy. Followed by plants with vermicompost, and the control, showed the lower growth rates. The results indicated significant response of vegetative growth for plants with NPK. Meanwhile, EM bokashi is seen to encourage vegetative and reproductive growth. Accordingly, the used of reduced amount of NPK, along with EM bokashi is recommended to promote more balanced vegetative and reproductive growth, together with the healthier environment. Vermicompost is seen as an added value to improve the structure and quality of soil for planting.

Keywords: Earthworm compost, bacterial compost, macronutrients, micronutrients

1. Introduction

Plants need light energy, water and minerals for growth, while carbon dioxide in plants comes from absorption from leaves. Plants need nutrients and water from the soil to spread throughout the plant. Nutrient sources are an important element in determining the development of a plant. There are three main nutrients namely nitrogen, phosphorus and potassium (Makinde et al., 2022). Nitrogen (N) is important for plant growth and development, phosphorus (P) is for root development and helps plants from extreme drought through the vigorous development of root. It is also important in the growth and development of plants such as the ripening of seeds and fruits. The element potassium (K) can help improve plant quality and prevent disease. The elements oxygen, nitrogen and carbon are usually found in air and water. Meanwhile, calcium, potassium, magnesium, and sulphur are obtained from fertilization (Timsina, 2018).

Plants need enough nutrients for good growth and increased production. However, the natural nutrients found in the soil are not enough to help improve plant quality. Therefore, there are several types of fertilizers that are often used to help the growth of trees, among them are chemical fertilizers and organic fertilizers. Chemical fertilizers are fertilizers designed to be absorbed by plants; these fertilizers are also chemical compounds with the main basis of NPK+TE (trace element) which are widely sold in the market at affordable prices. Usually, NPK 15:15:15 fertilizer is used at the plant growth stage and NPK 12:12:17:2 is suitable at the flower and fruit production stage (Solomon et al., 2012). However, the increased use of chemical fertilizers in agriculture causes many adverse effects. Therefore, as an alternative to the use of chemical fertilizers, farmers and farm operators began to use organic fertilizers that are more environmentally friendly (Kirchmann et al., 2016).

One of the advantages of organic fertilizers is the relatively slow absorption of nutrients in the soil. This slower process allows plants to process fertilizers in a more natural way and avoid damage to plants (Hasan & Othman, 2017). The use of vermicompost organic fertilizers (earthworm compost) and EM (effective microorganism) bokashi (bacterial

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compost) is an alternative to the use of chemical fertilizers and organic fertilizers have also been commercialized in Malaysia (Mukhtar et al., 2022).

Vermicompost is the product of a decomposition process that uses various species of worms, where the worms convert it into an organic substance called vermikas or worm excrement. Earthworms consist of three types namely Anecic, Endoqeic and Epigeic. Epigeic type worms are most suitable for use in the production of vermicompost. Among the types of worms that are often used are Tiger (*Eisenia fetida*), African Night Crawler (*Eudrilus eugeniae*), blue worm (*Perionynx excavates*) and red worm (*Lumbricus rubellus*). The use of vermicompost has been proven to improve the physical characteristics of soil and supply the nutrients required by plants (Gupta et al., 2021).

EM bokashi is a fertilizer that results from a fermentation process with a mixture of organic waste. It contains several types of good microbes such as lactic acid bacteria, phototrophic bacteria and yeast (Mukhtar et al., 2022). Lactic acid bacteria are tasked with being a barrier to the presence of pathogenic microorganisms. Meanwhile, phototrophic bacteria break down harmful gases such as hydrogen sulfide and turn them into odourless gases. The yeast will release hormones or enzymes to help increase root and cell activity. According to Novianto et al. (2018), EM bokashi can also increase yield and plant quality.

The demand for food crops such as vegetables is increasing worldwide due to the increase in human population (Kalsoom et al., 2020), as food needs will be doubled in 2050. Okra (*Abelmoschus esculentus*) is a plant that is easy to grow and quickly produces agricultural results. As a short-term vegetable crop and has a lot of demand for domestic needs, good okra crop yields are greatly influenced using fertilizers (Makinde et al., 2022). However, the widespread and uncontrolled use of chemical fertilizers is one of the main causes of water source pollution and resulting in ecosystem damage (Evanylo et al., 2008). The continuous use of chemical fertilizers such as NPK can also cause a decrease in soil pH, affecting soil quality and causing harm to human health (Agrawal et al., 2010). As an alternative to replace chemical fertilizers, the use of organic fertilizers is applied in agricultural practices such as the use of vermicompost and EM bokashi that have been commercialized in Malaysia. Thus, this study aimed to identify the effects of vermicompost and EM bokashi on the growth of okra compared to chemical fertilizers.

2. Materials and Methods

2.1 Experimental Site

This study was carried out under a rain shelter, located in the residential area of Lahad Datu, Sabah, Malaysia at coordinates 5.02943°N, 118.30707°E. The amount of 2.5 kg/polybag of soil is filled into a black polybag (25 cm x 22 cm), with a total of 60 polybags, and the distance between the polybags is 45 cm. Soil preparation is prepared a week before the seedlings were transferred to polybags. After 14 days, the first treatment of fertilizers application was carried out. Fertilizers applied by using the scattering method on the topsoil medium in each polybag.

2.2 Germination and Seed Planting

A total of 180 seeds (Brand: Crop Power; F1 Hybrid Okra Seeds OK663) were sown in a seed germination tray using topsoil medium. Okra seeds are soaked overnight to promote germination. A small hole is made using a skewer 2 to 4 mm deep in each nursery tray. Each hole is placed an okra seed and lightly dusted using the remaining topsoil. Then, the seeds were grown until it produced seedlings with two or three leaves and were then transferred into polybags.

2.3 Preparation of Organic Fertilizer Treatment and Chemical Fertilizer

The application of fertilizers was done during their vegetative and reproduction phases. After 14 days of transplanting, the plants were applied with: (i) vermicompost (15.0 g/plant), (ii) EM bokashi (10.0 g/plant), (iii) green NPK (15:15:15) (5.0 g/plant), and (iv) without fertilizer as a control. After flowering, the amount of fertilizer is increased to 22.5 g/plant for vermicompost (Barus et al., 2018), 25.0 g/plant for EM bokashi (Novianto et al., 2018), 10.0 g/plant for blue NPK (12:12:17:2) (Alam et al., 2021) and without fertilizer as a control.

2.4 Growth Measurement of Okra Seedlings

Parameter data was taken every week for 10 weeks of planting (started at 6^{th} until 10^{th} week), and the parameters measured were the; (i) plant height (cm); which measured from the base to the tip of the last leaf shoot using a measurement tape; (ii) number of leaves and the number of fruits (g); which were counted from the 28^{th} days after planting; (iii) stem diameter (cm); which the readings were taken at the lowest stem position (close to the ground) using a calliper; (iv) leaf surface area (cm); which measured by taking various parts of the leaf width; and (v) plant canopy (cm); which measured from the tip of the leaf bud to the tip of the leaf bud at the top of the plant canopy. Furthermore, the data taken in the final week (10^{th} week) of planting were as follows; (i) root length (cm); which measured from the tip of the stem to the tip of

the root; (ii) root weight (g); which were weighed using a digital scale; and (iii) plant bud; which the number of buds were calculated per plant (Ab Rauf & Shahruddin, 2022).

2.5 Experimental Design Layout and Statistical Data Analysis

The study was conducted using a completely randomized design (CRD), with three replications of each treatment. Data were analyzed using ANOVA (Analysis of Variance) and the mean separation using LSD (least significant difference) at P <0.05, in the statistical software Statistical Analysis System (SAS) version 9.4.

3. Results

3.1 Effects of Vermicompost Fertilizer and EM Bokashi on Okra Growth

In this study, the effect of using different fertilizers on okra growth showed significant effects for the parameters of stem diameter, leaf surface area, tree canopy, tree shoot weight, number of fruits and fruit weight at P≤0.01, as well as the plant height, leaf number, and bud number at P≤0.05, during the 10th week after planting. Whereas, for root weight and length showed no significant effect at P>0.05 (Table 1).

Table 1: Significance from ANOVA on the effect of different fertilizer application on okra growth (week 10th)

Source of variation	Plant height	Leaf number	Stem diameter	Leaf surface area	Plant canopy	Shoot weight	Bud number	Root weight	Root length	Fruit number	Fruit weight
Treatment	*	*	**	**	**	**	*	ns	ns	**	**

Note: **, significant at P ≤ 0.01; significant at P ≤ 0.05; ns, not significant

The used of NPK fertilizer has significantly greater values for the parameters of leaf number, leaf surface area and plant canopy compared to the other treatments (Table 2). Meanwhile, for EM bokashi showed the largest significant value for the parameters of stem diameter and fruit number, as compared to other treatments. Meanwhile, there is no significant difference for EM bokashi and NPK for the parameters of plant height, shoot weight, shoot number, root length and fruit weight. For the application of vermicompost and control, there were no significant difference for all parameters measured.

Table 2: The (mean) effects of using different fertilizers on okra growth in the final week of data collection (week 10th)

Treatment	Plant height (cm)	Leaf number	Stem diameter (cm)	Leaf surface area (cm^2)	Plant canopy (cm)	Shoot weight (g)	Bud number	Root weight (g)	Root length (cm)	Fruit number	Fruit weight (g)
Vermicompost	53.88^b	6.80^b	12.12^b	646.53^b	53.43^b	58.78^b	4.60^b	38.93^a	33.31^a	2.07^b	5.04^b
EM bokashi	56.75^a	7.06^b	14.02^a	744.21^b	60.81^b	70.68^a	5.60^a	44.79^a	36.77^a	3.93^a	8.92^a
NPK	54.62^a	7.40^a	11.83^b	856.08^a	63.83^a	76.39^a	5.47^a	43.47^a	34.49^a	3.40^b	12.18^a
Control	51.05^b	6.73^b	11.75^b	555.63^b	52.35^b	55.75^b	4.47^b	35.72^a	34.80^a	1.33^b	3.47^b

Note: Different superscripts (a, b) indicate significant differences between treatments

The effect of using different fertilizers and in different weeks had a significant effect (P≤0.01) on the leaf number, stem diameter, leaf surface area, plant canopy and fruit number in the growth week. However, there was no significant interaction (P>0.05) between different fertilizers application and planting week (F x W) (Table 3).

Table 3: Mean squared error from ANOVA on the use of different fertilizers for okra growth at weekly data collection

Source of Variation	Plant height (cm)	Leaf number	Stem diameter (cm)	Leaf surface area (cm^2)	Plant canopy (cm)	Fruit number
Fertilizer (F)	65.89^{ns}	2.55**	22.40**	92.57**	781927.32**	807.46**
Week (W)	14759.49^{ns}	99.11**	639.58**	276.73**	2035616.95**	4648.60**
F x W	18.355^{ns}	0.47^{ns}	2.73^{ns}	12.68^{ns}	59372.47^{ns}	143.08^{ns}

Note: **, significant at P ≤ 0.01; *, significant at P ≤ 0.05; ns, not significant

Figure 1 shows a graph of the leaf number against week of okra growth after being transferred into polybags. Plants with NPK treatment showed an increase in the leaf number by 23.19% from 7th to 8th week, and consistently higher than other fertilizer treatments up to 10th week with a difference of 4.46 to 10.14%. Next, plants with EM bokashi started leading plants with vermicompost at 9th week with a difference of 2.89% and was consistently higher until 10th week. Meanwhile, the difference between vermicompost and control was only 1.03 to 2.99% from 8th to 10th week.

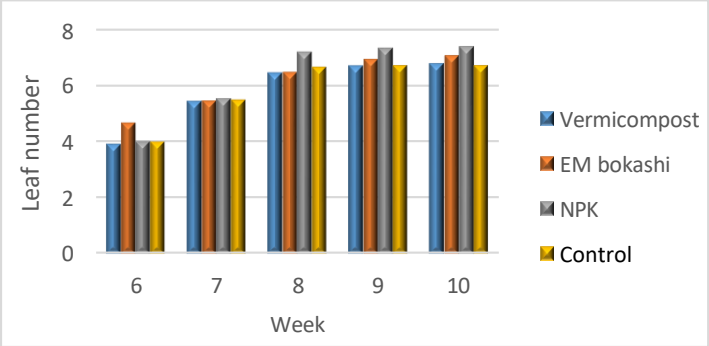

Fig. 1: Leaf number at 6th to 10th week for the use of different fertilizer treatments

Figure 2 shows a graph of the stem diameter against week of okra growth after being transferred into polybags. Plants with EM bokashi showed an increase in diameter of 28.83% started from 7th to 8th week, and was consistently higher than other fertilizer treatments until 10th week with a difference of 2.62 to 10.04%. As for plants with vermicompost, it was ahead of plants with NPK in 7th week with a difference of 5.38%. However, in 8th to 10th week, plants with vermicompost showed the lower values of stem diameter as compared to plants with NPK with a difference of 1.35 to 2.25%.

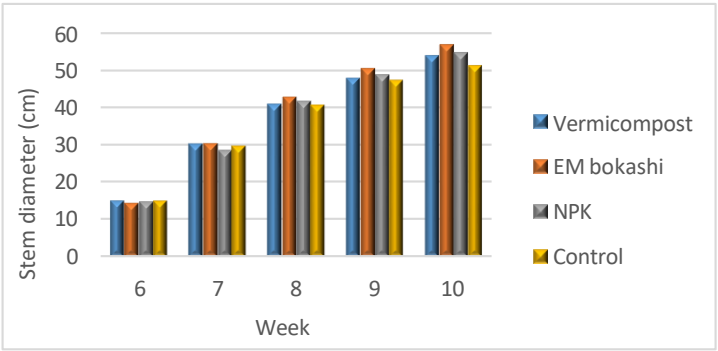

Fig. 2: Okra stem diameter at week 6th to 10th for the use of different fertilizer treatments

Figure 3 shows the graph of the fruit number against week of okra growth after being transferred into polybags. Plants with EM bokashi showed an increase of 9.53% from 8th to 10th week, and was consistently higher than other fertilizer treatments until 10th week with a difference of 5.17 to 63.78%. Meanwhile, the difference between vermicompost and control was 14.98 to 38.19% in 9th and 10th week.

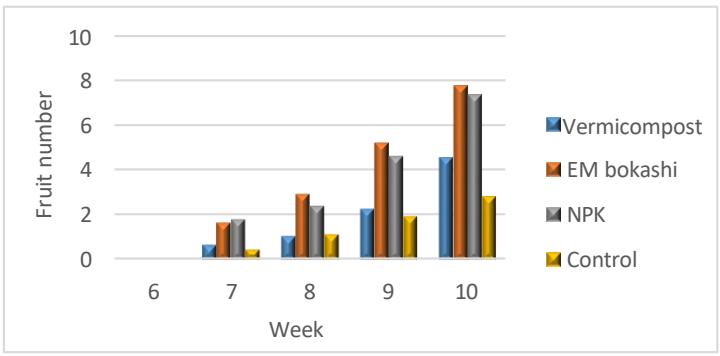

Fig. 3: Fruit number at 6th to 10th week for the use of different fertilizer treatments

Figure 4 shows a graph of leaf surface area against week of okra growth after being transferred into polybags. Plants with NPK produced leaf surface area with a total increase of 25.34% from 7th to 8th week, and consistently higher than other fertilizer treatments until 10th week with a difference of 13.07 to 46.49%. Whereas, plants with vermicompost leads plants with EM bokashi with a difference of 4.79 to 27.70% in 6th to 9th week. But, in 10th week plants with EM bokashi leads plants with vermicompost with a difference of 13.13%.

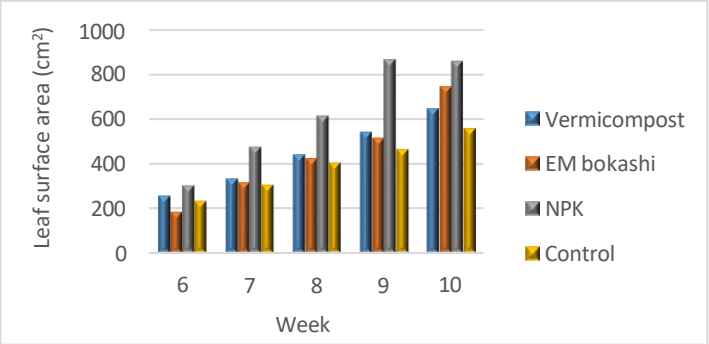

Fig. 4: Leaf surface area at 6th to 10th week for the use of different fertilizer treatments

Figure 5 shows a graph of plant canopy against week of okra growth after being transferred into polybags. Plants with NPK showed an increase in plant canopy by 31.70% from 8th to 10th week, followed by other fertilizer treatments with a difference of 4.73 to 17.98%. Whereas the difference between plants with vermicompost and control was only 2.02 to 5.44% from 8th to 10th week.

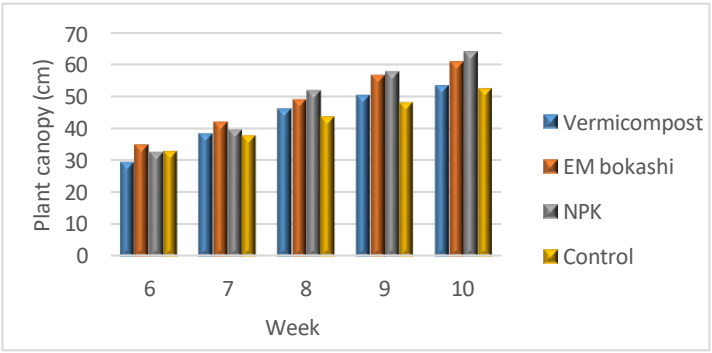

Fig. 5: Plant canopy at 6th to 10th week for the use of different fertilizer treatments

4. Discussion

The results of the study showed that the use of different fertilizer treatments had significant effects on the growth and production of okra plants. According to Joshi et al. (2015), the use of chemical fertilizers has a better effect on the growth, yield and quality of crops compared to vermicompost fertilizers. Whereas, according to Ansari & Sukhraj (2010), chemical fertilizers have a greater availability of salts such as nitrates, phosphates and potassium which increase the growth rate of plants significantly. In this study, the growth rate of plants with NPK treatment showed growth patterns of the vegetative part of the plant such as the leaf number, leaf surface area and plant canopy increased more consistently every week, followed by plants with EM bokashi treatment. In addition, according to Karimuna et al. (2020), the leaf surface area of a plant positively related to their leaf number. Thus, the greater leaf number on plants with NPK treatment leads to faster plant growth potential, due to the increased space for the physiological process of plant growth to develop. In addition to being influenced by genetic factors, the number and size of leaves are also influenced by environmental factors such as soil, water, light, and nutrients (Silitonga et al., 2018), and significant effects seen in this study further supported the importance of nutrient factors on plants.

Furthermore, plants with EM bokashi treatment showed the largest tree diameter and significantly more fruits than the other treatments. This might be due to the high content of potassium and phosphorus in EM bokashi could increase the number of fruit production and the formation of flowers (Aung et al., 2019). In addition, EM bokashi also helps to increase growth and improve leaf quality (Ginting, 2019). Thus, even with fewer leaves, and a smaller leaf surface area compared to plants with NPK treatment, plants with EM bokashi treatment could still produce more fruits as compared to plants with NPK treatment. According to Kusuma (2013), organic fertilizer such as EM bokashi needs time to decompose (slow release) so that the elements contained in them can be beneficial for plants. Therefore, the

growth especially of the vegetative part of the plants (number of leaves, leaf surface area, and canopy) is slower as compared to the plants with NPK treatment.

Vermicompost has humic acid and nutrients that are good for growth but not enough macronutrients such as nitrogen, phosphorus and potassium to produce maximum crop yield (Gupta, 2021). This makes it possible that among the main factors the lower growth rate was shown in plants treated with vermicompost in this study. According to the Mukhtar et al. (2022), the main content in vermicompost such as N, P and K is lower than chemical fertilizers but rich in trace element (micro) content that can provide nutrient balance to plants. However, if the concentration of trace elements is high, it will affect the health and fertility of the soil, plants, animals and humans because it will cause toxic effects or poisoning, especially for newly sown plants (Verma, 2024).

5. Conclusion

Okra plants with NPK treatment gave more significant responses, especially during their vegetative growth. Meanwhile, organic fertilizer EM bokashi is seen to encourage vegetative and reproductive growth of okra plants. Therefore, the reduced quantity of NPK, as well as the added quantity of EM bokashi, and applied together to okra plants have potential as the alternatives to reduce the use of NPK fertilizer, periodically. Giving vermicompost to okra plants is seen as an added value, especially in ensuring good soil fertility and structure for the physiology of plant growth to grow in a better way.

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Conflict of Interest
The authors declare no conflicts of interest.

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