Agronomy Research **20**(S1), 1090–1103, 2022
https://doi.org/10.15159/AR.22.071

Maize Growth and Yield characteristics with application of mushroom waste substrate vermicompost in Ultisol

A.M. Purnawanto[1,*] and Y.R. Ahadiyat[2]

[1]Universitas Muhammadiyah Purwokerto, Faculty of Agriculture and Fisheries, Jl. KH. Ahmad Dahlan, Kembaran, Banyumas, 53182 Jawa, Tengah Indonesia
[2]Universitas Jenderal Soedirman, Faculty of Agriculture, Laboratory of Agroecology, Jl. Dr. Soeparno No.63, Purwokerto Utara, Banyumas, 53122 Jawa, Tengah Indonesia
[*]Correspondence: agoesmp@gmail.com

Received: August 1st, 2022; Accepted: October 12th, 2022; Published: October 24th, 2022

Abstract. Improve maize production can be done by expanding the planting area in Ultisol. The main problems with planting maize in Ultisol are high soil acidity (pH < 4.5), high Al saturation (> 65%), and low P availability (± 1.7 ppm). The objective of this study was to know the effect of the application of mushroom waste substrate vermicompost on the characteristics of maize growth and yield. in Ultisol. Randomized Complete Block Design with the treatments of vermicompost at a dose of 0 t ha^{-1}, 15 t ha^{-1}, 30 t ha^{-1}, and 45 t ha^{-1} with six replications was tested. The observed variables were Ultisol's chemical and biological properties, maize growth, and yield. The soil characteristics of the pH, C-organic, P-available, and phosphate solubilizing microbes, and maize growth and yield characters viz. the number of leaves, shoot dry weight, flower emergence, leaf chlorophyll content, the efficiency of P use, the protein content of seeds, number and weight of maize seeds improved with the application of 45 t ha^{-1} of vermicompost. From the results it could be concluded that applying the vermicompost would enable farmers increase yield of maize in Ultisol soil.

Key words: maize growth performace, marginal land, organic compost, soil characters.

INTRODUCTION

Maize production in Indonesia increased by about 19 million tons in 2014 and 28.9 million tons in 2017 under 3.8 million hectares of harvested area. Improving maize production in Indonesia can be expanded to Ultisol as a potential area of 45.7 million hectares (Fitriatin et al., 2014).

Soils of Ultisol are not fit for crop production due to high soil acidity (pH < 4.5), high aluminum (Al) saturation (> 65%), and deficient availability of P (± 1.7 ppm) (Taisa et al., 2019), and deficiency of Ca, Mg, and K (Widiatmaka et al., 2016; Purwanto et al., 2021; Utami et al., 2021). In addition, Ultisol has low levels of C-organic, N-total, Cation Exchange Capacity (CEC), and Base Saturation (Syahputra et al., 2015).

Application of vermicompost improves soil conditions such as N-total, soil pH, and C-organic (Rakhmalia et al., 2015, Setiawan et al., 2015). Some researchers reported that the effect of vermicompost increases total N levels, soil pH, P-available, and C-organic

(Aryani et al., 2019, Fitria et al., 2018, Sianturi et al., 2019, Yuka et al., 2017), P content, cation exchange capacities (CEC) of K, Ca, Mg, soil fungi, and bacteria (Emalinda et al., 2005). According to Adhikary (2012) and Bellitürk et al.(2022), vermicompost increases 2.2% N, 2.2% P, 1.5% K, and some micronutrients such as Na, Ca, Zn, S, Mg, and Fe. Vermicompost can also reduce soil acidity and increase the number of microorganisms (Fernández-Gómez et al., 2010).

Some studies have done that the application of vermicompost improves the soil properties of Ultisols. However, a study of the application of pure mushroom waste substrate vermicompost without additional ingredients has not been revealed yet. Therefore, it is critical to investigate the impact of applying mushroom waste vermicompost to Ultisol on morpho-physiological characters, and yield components of maize.

MATERIALS AND METHODS

The study was done at the Experimental Garden of the Faculty of Agriculture, the Universitas Muhammadiyah Purwokerto, located in Karangsari Village, Kembaran District, Banyumas Regency from April - to November 2019. The vermicompost was made with the activity of *Eudrilus eugeniae* worms on the mushroom waste substrate. Ultisol was taken from Gorowong Village, Parungpanjang District, Bogor Regency, West Java. Soil samples were taken randomly at a depth of 0–20 cm with conditions of pH, C-organic, total N, total P_2O_5 and Al saturation of 4.21, 0.77%, 0.04%, 1,200 ppm and 66.07%, repectively. Then, the soil was air-dried and sieved with a 2 mm sieve. The application of vermicompost was by doses viz. 0 t ha^{-1}, 15 t ha^{-1}, 30 t ha^{-1}, and 45 t ha^{-1}. The chemical and biological compositions of vermicompost were 1.44% total N, 2.03% total P_2O_5, 3.19% total K_2O, 31.0×10^5 cfu ga^{-1} N-fixing microbes and 39.0×105 cfu ga^{-1} phosphate solubilizing microbes.

20 kg of sieved soil (30% moisture content) was mixed with vermicompost (17% moisture content) and then put into a 45 cm × 50 cm polybag (± 30 cm diameter). The soil and vermicompost mixture was watered until the field capacity was reached. Subsequent watering was applied according to conditions in the polybag. Sukmaraga maize seeds were planted in polybags at a depth of about 2–3 cm, with two seeds in each polybag and arranged distance among seed at a spacing of 20 cm. Nitrogen fertilizer with a dose of 92 kg ha^{-1} was given at seven days after planting (DAP) and 30 days after planting, in half dose each. Potassium (K_2O) fertilizer with a dose of 60 kg ha^{-1} was given seven days after planting (Wahyudi, 2009). Calculation of the fertilizer dose per polybag was the volume of soil in polybags divided by the volume of soil per hectare, multiplied by the dose of fertilizer for one hectare. Harvesting was done when the plant reached physiological maturity, with the criteria that the husks were dry and hard. Variables observed were chemical and biological properties of Ultisol, and morphological, physiological, and yield components of maize.

Soil chemical and biological analysis

Soil pH was analyzed by using a glass electrode, while C-organic analysis using the Walkley and Black method, the total P-level was extracted with HNO_3 and analyzed by Olsen and Bray method. The available P was analyzed by the Bray-II method (Sulaeman et al., 2005). Total Phosphate Solubilizing Microbial (PSM) was calculated using the Most Probability Number method (Saraswati et al., 2007).

Plant morphological observations

Plant height was measured when male flowers appeared by measuring plant height from the base of the stem to the base of the last flag leaf (Peiffer et al., 2014). Stem diameter was measured at the time of the end vegetative stage by measuring the diameter of the stem at the lowest internode at a distance of 15 cm from the base of the stem (Bintoro, 1989). The number of leaves, counting all the leaves that formed and have fully opened was done 56 days after sowing time (Sitompul & Guritno, 1995). Leaf Area Index was calculated by the formula:

$$Leaf\ Area\ Index = \frac{Leaf\ Area}{Ground\ Area} \tag{1}$$

The calculate of leaf area is leaf length x maximum leaf width × 0.75×9.39 (Bintoro, 1989). The ground area is the spacing used for maize plants with plant distance of 20 cm × 75 cm (Sitompul & Guritno, 1995). Dry shoot weight was weighed at the end of the vegetative stage. The weighing was carried out after the shoots were dried in the oven at a temperature of 60 °C until the weight was constant (Bintoro, 1989).

Plant physiological observations

Physiological analysis of the amount of chlorophyll was measured in the third leaf using the Arnon method (1949). The concentrations of proline were determined in the ear-leaf during the vegetative phase (35 days after planting) and the seed filling phase (60 DAP) using the Bates method (1973). The protein content of seeds was measured at harvest time using the Kjeldahl method (AOAC, 1990), absorption efficiency and efficiency of P use were measured at harvest time (Fageria & Baligar, 1997) with the formula as follows:

$$Uptake\ Efficiency\ P = \frac{Dry\ Seed\ Weight\ (g)}{Total\ P\ uptake\ of\ plant\ (g)} \tag{2}$$

$$Efficiency\ of\ using\ P = \frac{Dry\ plant\ weight\ (g)}{Total\ P\ uptake\ of\ plant\ (g)} \tag{3}$$

Observation of maize yield and yield components

The yield and yield components of maize were observed at the end of the study, which consisted of cob length, cob diameter, grain weight per cob, weight of 100 dry seeds, number of seeds per cob (Subaedah et al., 2021). Harvest index, calculated at harvest time with the formula:

$$Harvest\ Index = \frac{Oven\ Dry\ Seed\ Weight\ (ODSW)\ (g)}{ODSW + Oven\ Dry\ Canopy\ Weight\ (g)}\ x\ 100\% \tag{4}$$

Statistic analysis

The effect of vermicompost application on Ultisol's chemical and biological properties, morpho-physiological characters, yield, and maize yield components was analyzed using variance analysis (α = 0.05) with the SPSS 25. Multiple comparisons for treatments with a significant effect were using *Duncan's Multiple Range Test* (DMRT) with α = 0.05 (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

Chemical and biological properties of Ultisol

Vermicompost had a significant effect on Ultisol pH. Vermicompost was able to increase the pH by 67.5%. The application of vermicompost in soil about 45 t ha^{-1} showed the highest pH, 6.92. There was a significant difference in the C-organic content of the soil due to the addition of vermicompost along with the addition of 45 t ha^{-1} P_2O_5 (Table 1).

Table 1. Effect of dose of vermicompost from the mushroom waste substrate on pH, C-organic and P-total of Ultisol

Vermicompost dosage	pH	C-organic (%)	P-total (ppm)
0 t ha^{-1}	4.30 ± 0.10a	0.83 ± 0.017a	0.148 ± 0.013a
15 t ha^{-1}	6.70 ± 0.03b	0.89 ± 0.016b	0.210 ± 0.022b
30 t ha^{-1}	6.79 ± 0.04b	0.90 ± 0.020b	0.250 ± 0.018c
45 t ha^{-1}	6.92 ± 0.08c	0.96 ± 0.031c	0.264 ± 0.042c

Note: Value followed by the same letter in the same column showed no significant difference based on the Duncan Multiple Range Test with α = 0.05.

The high total P-total was shown in the treatment with vermicompost of 45 t ha^{-1}, but it was not significantly different with 30 t ha^{-1}. However, the available P was highest with the application of vermicompost of 45 t ha^{-1}. Meanwhile, dose of 45 t ha^{-1} vermicompost raised the number of phosphate solubilizing microbes from 4.6×10^8 cfu g^{-1} to 189.9×10^8 cfu g^{-1} and reduced Al saturation from 60.96% to 17.39% (Table 2).

Table 2. Effect of dose of vermicompost from the mushroom waste substrate on P-available, phosphate solubilizing microbes and Al saturation of Ultisol

Vermicompost dosage	P-available (ppm)	Phosphate solubilizing microbes (x10^8 cfu g^{-1})	Al saturation (%)
0 t ha^{-1}	5.42 ± 0.181a	4.6 ± 1.0a	60.96 ± 1.76d
15 t ha^{-1}	6.03 ± 0.627b	39.7 ± 14.8b	34.78 ± 6.77c
30 t ha^{-1}	6.08 ± 0.706c	70.8 ± 8.03c	24.76 ± 2.49b
45 t ha^{-1}	6.40 ± 0.782d	189.9 ± 90.2d	17.39 ± 1.06a

Note: Value followed by the same letter in the same column showed no significant difference based on the Duncan Multiple Range Test with α = 0.05.

The increase in soil pH due to the application of vermicompost was in line with Mahmud et al. (2018), which stated that the application of vermicompost can increase soil pH. According to Butterly et al. (2010), the application of organic matter to acid soils (with high Al saturation) can raise soil pH because Al is bound by organic acids resulting from decomposition and forms complex compounds (chelates) so that Al is not hydrolyzed anymore.

Some studies mentioned that the addition of organic matter increases the C-organic content of the soil and improves the physical, chemical and biological properties of soil (Mekki et al., 2017). Soil C-organic can be improved by application of organic materials such as manure, compost, agro-industrial waste and urban waste (Vicente-vicente et al., 2016). The amount of P-total and P-available increased with increasing vermicompost.

The application of organic matter has been reported to increase P availability in the soil (Sharif et al., 2014). According to Mekki et al. (2017) , the increasing amount of P-total and P-available is related to the amount of carbon as a food source for soil microorganisms. An increase in the amount of carbon can stimulate the activity of microorganisms for the process of decomposition, P dissolution, and N fixation. According to Opala et al.(2012), the increase in soil P availability is due to the presence of soil microorganisms that can mediate the mineralization of organic P into inorganic P.

The increase in available P is also caused by the decomposition of organic matter, which produces organic acids that act as chelators (Siregar et al., 2017). According to Gusnidar et al. (2010), during the decomposition process, organic acids are produced, which then form Al complex compounds, reducing the Al-exch content and reducing P adsorption by Al while increasing P availability. Organic acids formed during organic material degradation can form chelate bonds with Al and Fe ions, lowering their solubility and increasing P availability. Organic acids produced by the breakdown of organic materials can also liberate adsorbed phosphorus and increase P availability (Bloom & Skyllberg, 2012). Ayodele & Shittu (2014) and Balík et al. (2019) reported that soil Al-exch decreased due to the application of, manure, compost and vermicompost.

Brady & Weil (2014) stated that P fertilization on acid soils needs to be accompanied by providing ameliorant materials, including organic matter. Previous research has shown that phosphate fertilizer combined with green manure (Rick et al., 2011), organic waste (Korzeniowska et al., 2013), or compost can increase available P. (Chien et al., 2011). Phosphorus solubility increases through microbial metabolism during the decomposition of organic materials, which release functional phosphate molecules for plants (Galvez-sola et al., 2010, Korzeniowska et al., 2013, Lu et al., 2014).

Adding organic matter increases microorganisms' activity and density, including phosphate solubilizing microbes (Agbede et al., 2017, Frimpong et al., 2017, Seshachala & Tallapragada, 2012). The relationship between the amount of Phosphate-solubilizing microbes and organic matter in the soil is that carbon compounds become the primary energy source for phosphate-solubilizing microbes (Alori et al., 2017). Various carbon sources influence the growth and activity of phosphate solu bilizing microbes. This carbon source has been reported to affect the production of enzymes to release organic P (Qureshi et al., 2010). Thus, Nur et al. (2019) have proven that giving compost about 20 t ha^{-1} increases the activity of phosphate solubilizing microbes.

Maize plant morpho-physiological character

The application of vermicompost significantly affected plant height, stem diameter, leaf area, leaf area index, and shoot dry weight of maize. The application of vermicompost up to a dose of 45 t ha^{-1} showed an increase in plant height, stem diameter, number of leaves, leaf area index, and shoot dry weight. 219%, 157%, 117%, 645%, and 1,263%, respectively. Vermicompost application of 45 t ha^{-1} resulted in a shorter appearance on male and female flowers of 30 dan 38 days earlier, respectively, compared to without vermicompost application (Table 3 and 4).

The efficiency of P uptake and P utilization increased by 100% and 106% compared to the dose of 15 t ha^{-1} with the application of vermicompost of 45 t ha^{-1}. The addition of vermicompost significantly increased the protein content of maize seeds. When vermicompost was applied at a rate of 45 t ha^{-1}, protein content of 9.1 percent was obtained, whereas a compost addition of 15 t ha^{-1} resulted in protein content of 6.0 percent (Table 6).

Table 3. The effect of different doses of vermicompost from the mushroom waste substrate on plant height, stem diameter, number of leaves per plant and leaf area index of maize

Vermicompost dosage	Plant height (cm)	Stem diameter (cm)	Number of leaves per plant	Leaf area index
0 t ha^{-1}	45.9 ± 3.3a	0.7 ± 0.05a	5.7 ± 0.6a	0.40 ± 0.16a
15 t ha^{-1}	107.6 ± 9.3b	1.2 ± 0.05b	11.0 ± 0.4b	2.03 ± 0.35b
30 t ha^{-1}	115.4 ± 6.5b	1.5 ± 0.03c	12.2 ± 0.1c	2.34 ± 0.20b
45 t ha^{-1}	146.5 ± 5.4c	1.8 ± 0.06d	12.4 ± 0.4c	2.98 ± 0.31c

Note: Value followed by the same letter in the same column showed no significant difference based on the Duncan Multiple Range Test with α = 0.05. DAP = Day After Planting.

Table 4. The effect of different doses of vermicompost from the mushroom waste substrate on shoot dry weight, time for male flowers to appear and time for female flowers to appear of maize

Vermicompost dosage	Shoot dry weight (g tan^{-1})	Time for male flowers to appear (DAP)	Time for female flowers to appear (DAP)
0 t ha^{-1}	7.3 ± 2.5a	83.3 ± 1.6c	92.9 ± 0.6d
15 t ha^{-1}	42.7 ± 2.7b	53.9 ± 0.7b	60.3 ± 0.6c
30 t ha^{-1}	59.6 ± 4.5c	51.1 ± 0.3a	56.3 ± 0.6b
45 t ha^{-1}	99.5 ± 11.d	50.3 ± 0.1a	54.7 ± 0.4a

Note: Value followed by the same letter in the same column showed no significant difference based on the Duncan Multiple Range Test with α = 0.05. DAP = Day After Planting.

According to Abdou et al. (2016), the improved growth of maize after receiving vermicompost is due to a mineralization process that occurs when compost is applied to the soil. The addition of compost in soil could increase the N, P, K and micronutrients content (Khan et al., 2017), increase the amount of soil organic carbon and soil pH (Agegnehu et al., 2016, Anhar et al., 2018, Karimuna et al., 2016, Zaman et al., 2010) and improve activity of microorganisms (Agbede et al., 2017, Frimpong et al., 2017). Other studies showed that the application of organic fertilizers on maize crop could increase plant height, the number of leaves, stem diameter and fresh weight at harvest (Okoroafor et al., 2013, Soro et al., 2015). Plant height also increased due to pig and chicken manure (Coulibaly et al., 2019). Meanwhile, Mahmood et al. (2017) stated that maize crop with applications of chemical fertilizers and poultry manure in dose of 7 t ha^{-1} resulted in the maximum Leaf Area Index.

When compared to unfertilized plots, the use of vermicompost increased plant height, which could be attributed to vermicompost's ability to improve photosynthesis rate, free radical scavenging, and soil enzymatic activity (Laugale et al., 2020). According to Kareem et al. (2017) an increase in plant height was caused by an increase in apical meristem activity, while an increase in stem diameter was caused by an increase in mitotic cell division and cell enlargement in the stem, as well as an increase in leaf area caused by an increase in cell division in the leaves.

Some previous studies have reported that an increase in plant dry weight was due to composts of cow dung, waste (Naderi & Ghadiri, 2010), cassava (Adejumo & Togun, 2014), and livestock manure with addition of phosphorus (Sharif et al., 2011). The increase in plant dry weight caused by composting is intimately connected to compost's function in improving soil fertility, both chemically and biologically, so that plants can grow better. According to Huang et al. (2010) and Zhang et al. (2016), composting increases soil fertility and nutrient uptake by plants, resulting in increased plant growth, yield, and yield components. Organic fertilizers improve soil fertility and microbial activity and increase the efficiency of chemical fertilizer use to improve crop production (Mahmood et al., 2017, Schoebitz & Vidal, 2016). The quickest time for male and female flowers to emerge was achieved using up to 45 t ha^{-1} of vermicompost. Imran & Khan (2015) believe that increasing the compost dosage can hasten the release of male and female maize flowers.

The appearance of flowers is a sign that the plant has entered the generative phase. In general, to enter the generative phase, plants need sufficient phosphorus. Phosphorus deficiency can cause delays in plants entering the generative phase. In this study, adding more vermicompost can significantly increase the availability of phosphorus (Table 2), so corn plants can enter the generative phase more quickly than those without vermicompost. According to Sabastian et al. (2018), phosphorus plays an important role in energy storage and transfer. An adequate supply of phosphorus in the early stages of plant life is critical for the reproductive phase of the plants. The optimal application of phosphatic fertilizers is required for rapid growth, early maturity, and improvement in the quality of vegetative growth, whereas its deficiency will slow overall growth (Ahmad et al., 2013).

Application of vermicompost increased the chlorophyll and proline content of maize leaves (Table 5). Naeem et al. (2017) reported that applying artificial fertilizers along with compost increased the chlorophyll content of leaves compared to applying synthetic fertilizers only. Chlorophyll content also increased in plants fed with organic fertilizers (Amujoyegbe et al., 2010), sawdust (Adekayode & Olojugba, 2010), urban waste compost (Pirdashti et al., 2010), and cow dung, poultry and rice straw (Siavoshi & Laware, 2013). According to Udom & Kamalu (2019), an increase in proline levels is caused by the rise in the three components of maize: leaf area index, stem diameter, and plant dry crown weight. As a result, with the same watering volume, the vermicompost-treated soil will quickly experience water shortages because water needs will increase with a larger canopy.

Table 5. The effect of different doses of vermicompost from the mushroom waste substrate on chlorophyll, proline at the end vegetative phase and proline in the seed filling phase of maize plants

Vermicompost dosage	Chlorophyll (mg g^{-1})	Proline at the end vegetative phase (µ mol g^{-1})	Proline in the seed filling phase (µ mol g^{-1})
0 t ha^{-1}	15.3 ± 2.0a	1.3 ± 0.1a	1.3 ± 0.1a
15 t ha^{-1}	24.7 ± 1.9b	2.7 ± 0.4b	2.8 ± 0.2b
30 t ha^{-1}	26.3 ± 1.9b	3.8 ± 0.4c	3.5 ± 0.4c
45 t ha^{-1}	29.1 ± 1.5c	6.0 ± 1.2d	4.6 ± 0.4d

Note: Value followed by the same letter in the same column showed no significant difference based on the Duncan Multiple Range Test with $\alpha = 0.05$.

Humic acid in vermicompost helps to increase the efficiency of P use. According to El-Etr et al. (2011), the presence of humic acid increases P use efficiency in maize sesame plants. The addition of compost (Majeed et al., 2018), manure (Ademba et al., 2015, Andriamananjara et al., 2019, El-Eyuoon & Amin, 2018), and Tithonia biomass was also reported to improve P uptake or use efficiency (Endris, 2019). Because the addition of vermicompost affects soil phosphorus levels, the protein content of maize seeds increases; according to Shahbazi & Nematollahi (2019), increasing the phosphorus application from 0 to 150 kg ha^{-1} increased the protein content significantly from 13.56

percent to 15.53 percent. The addition of phosphorus to the fertilization process can increase the protein content of maize kernels (Radulov et al., 2010), wheat (Rahim et al., 2010).

Table 6. The effect of different doses of vermicompost from the mushroom waste substrate on P absorption efficiency, efficiency of using P and seed protein of maize plants

Vermicompost Dosage	P absorption efficiency (dry seed weight / total P uptake) ($g\ g^{-1}$)	Efficiency of using P (dry plant weight / total P uptake) ($g\ g^{-1}$)	Seed protein (%)
0 t ha^{-1}	NA	NA	NA
15 t ha^{-1}	5.2 ± 0.4a	23.0 ± 1.3a	6.0 ± 1.4a
30 t ha^{-1}	7.7 ± 0.9b	30.6 ± 2.2b	6.8 ± 1.5b
45 t ha^{-1}	10.4 ± 1.2c	47.4 ± 4.6c	9.1 ± 1.1c

Note: Value followed by the same letter in the same column showed no significant difference based on the Duncan Multiple Range Test with α = 0.05. NA = Not Available.

Yield and yield components of maize

The application of vermicompost increased the length and diameter of the cobs significantly. With the addition of 15 t ha^{-1} of vermicompost, the size and diameter of the cobs increased by 137 percent and 517 percent, respectively. In comparison, a dose of 45 t ha^{-1} of vermicompost increased by 205 and 683 percent, respectively. The maximum yield index, seed weight per ear, number of seeds per ear, the weight of 100 grains, and highest yield index were all achieved with vermicompost up to 45 t ha^{-1} (Table 7 and 8).

Table 7. The effect of different doses of vermicompost from the mushroom waste substrate on cob lenght, cob diameter and seed weight per cob of maize

Vermicompost dosage	Cob length (cm)	Cob diameter (cm)	Seed weight per cob (g)
0 t ha^{-1}	5.7 ± 0.1a	0.6±0.05a	NA
15 t ha^{-1}	13.5 ± 0.7b	4.0 ± 0.08b	61.9 ± 7.2a
30 t ha^{-1}	15.5 ± 0.2c	4.3 ± 0.12c	94.0 ± 5.8 b
45 t ha^{-1}	17.4 ± 0.4d	4.7 ± 0.07d	130.1 ± 4.6 c

Note: Value followed by the same letter in the same column showed no significant difference based on the Duncan Multiple Range Test with α = 0.05. NA = Not Available.

Table 8. The effect of different doses of vermicompost from the mushroom waste substrate on weight 100 seeds, number of seeds per cob and harvest index of maize

Vermicompost dosage	Weight 100 seeds (g)	Number of seeds per cob	Harvest Index
0 t ha^{-1}	NA	NA	NA
15 t ha^{-1}	25.5 ± 1.9a	246.9 ± 24.3a	0.51 ± 0.02a
30 t ha^{-1}	28.3 ± 1.0b	333.2 ± 22.9b	0.59 ± 0.01b
45 t ha^{-1}	31.7 ± 1.4c	425.3 ± 8.55c	0.64 ± 0.01b

Note: Value followed by the same letter in the same column showed no significant difference based on the Duncan Multiple Range Test with α = 0.05. NA = Not Available.

The increased yield and yield components of maize due to vermicompost treatment were linked to increased soil fertility and plant development. Growing plants can supply photosynthate to storage organs or plant yields. Previous research found that using vermicompost (Jjagwe et al., 2019) or compost (Amanullah et al., 2015) increased the number of cobs per plant and seeds per row, the number of rows per cob, and the number of seeds per cob of maize. Ganjali et al. (2013), Glaser et al. (2014), and Doan et al. (2015) all reported increased maize yield and yield components with compost application. When organic fertilizers were used, the number of seeds per cob, the weight of 1,000 grains, and the weight of seeds increased (Achieng et al., 2010). Iqbal et al., 2015) reported increased yields and yield components of maize with organic matter. Bekele et al. (2019) found that combining nitrogen, phosphorus, and vermicompost application resulted in a 21.5 percent increase in groundnut pod harvest index over the control.

CONCLUSIONS

Vermicompost application of up to 45 t ha^{-1} can increase pH, C-organic, P-total, P-available, and phosphate solubilizing microbes while decreasing Al saturation. Plant height, stem diameter, the number of leaves, leaf area index, and dry crown weight increased by up to 45 t ha^{-1} with vermicompost. Male maize flowers appeared 30 days earlier when Ultisol was combined with 45 t ha^{-1} of vermicompost. The addition of 45 t ha^{-1} of vermicompost increased the levels of chlorophyll and proline. In the application of vermicompost up to 45 t ha^{-1}, the highest seed protein content, P uptake efficiency, and P use efficiency were achieved. The length of the ear, the diameter of the ear, weight of seeds per ear, the weight of 100 seeds, and the highest number of seeds were also achieved with vermicompost applications of up to 45 t ha^{-1}.

ACKNOWLEDGEMENTS. Thank you to the Chancellor of the Universitas Muhammadiyah Purwokerto for the permission and research funding assistance, the Chancellor of the Universitas Jenderal Soedirman for the support for research implementation facilities, and to all those who have helped carry out this research.

REFERENCES

Abdou, G., Ewusi-Mensah, N., Nouri, M., Tetteh, F.M., Safo, E.Y. & Abaidoo, R.C. 2016. Nutrient release patterns of compost and its implication on crop yield under Sahelian conditions of Niger. *Nutrient Cycling in Agroecosystems* **105**(2), 117–128.

Achieng, J.O., Ouma, G., Adhiambo, G. & Muyekho, F. 2010. Effect of farmyard manure and inorganic fertilizers on maize production on Alfisols and Ultisols in Kakamega, western Kenya. *Agriculture and Biology Journal of North America* **1**(4), 430–439.

Adejumo, S.A. & Togun, A.. 2014. Compost amendment, enhanced nutrient uptake and dry matter accumulation in heavy metal stressed maize crop. *Nigeria Agricultural Journal.* **45**(1), 65–79.

Adekayode, F.O. & Olojugba, M.R. 2010. The utilization of wood ash as manure to reduce the use of mineral fertilizer for improved performance of maize (Zea mays L.) as measured in the chlorophyll content and grain yield. *Journal of Soil Science and Environmental Management* **13**, 40–45.

Ademba, J.S., Kwach, J.K., Esilaba, A.O. & Ngari, S.M. 2015. The Effects of Phosphate Fertilizers and Manure on Maize Yields in South Western Kenya. *East Afrfican Agricultural and Forestry Journal* **81**(1), 1–11.

Adhikary, S. 2012. Vermicompost, The Story of Organic Gold: A Review. *Agricultural Sciences* **03**(07), 905–917.

Agbede, T.M., Adekiya, A.O. & Eifediyi, E.K. 2017. Impact of Poultry Manure and NPK Fertilizer on Soil Physical Properties and Growth and Yield of Carrot. *Journal of Horticultural Research* **25**(1), 81–88.
Agegnehu, G., Nelson, P.N. & Bird, M.I. 2016. Crop yield, plant nutrient uptake and soil physicochemical properties under organic soil amendments and nitrogen fertilization on Nitisols. *Soil & Tillage Research* **160**, 1–13.
Ahmad, M., Khan, M.J. & Muhamamd, D. 2013. Response of maize to different phosphorus levels under calcareous soil conditions. *Sarhad Journal of Agriculture* **29**(1), 43–48.
Alori, E.T., Glick, B.R. & Babalola, O.O. 2017. Microbial phosphorus solubilization and its potential for use in sustainable agriculture. *Front. Microbiology* **8**, 1–8.
Amanullah, Khan, I., Jan, A., Jan, M.T., Khalil, S.K., Shah, Z. & Afzal, M. 2015. Compost and Nitrogen management influence productivity of spring maize (Zea mays L.) under deep and conventional tillage systems in semi-arid regions. *Communications in Soil Science and Plant Analysis* **00**, 1–13.
Amujoyegbe, B.J., Opabode, J. & Olayinka, A. 2010. Effect of organic and inorganic fertilizer on yield and chlorophyll content of maize (Zea mays L.) and sorghum Sorghum bicolour (L.) Moench). *African Journal of Biotechnology* **6**(16), 1869–1873.
Andriamananjara, A., Rakotoson, T., Razafimbelo, T., Rabeharisoa, L., Razafimanantsoa, M. & Masse, D. 2019. Farmyard manure improves phosphorus use efficiency in weathered P deficient soil. *Nutrient Cycling in Agroecosystems*. Springer Netherlands. doi: 10.1007/s10705-019-10022-3
Anhar, A., Junialdi, R., Zein, A., Advinda, L. & Leilani, I. 2018. Growth and tomato nutrition content with bandotan (Ageratum Conyzoides L) bokashi Applied. *IOP Conference Series: Materials Science and Engineering* **335**.
AOAC. 1990. *Official Methods of Analysis of The Association of Official Analtytical Chemists*. (K. Helrich, Ed.), 15th ed., Vol. 1. Virginia, USA: Association of Official Analtytical Chemists, Inc.
Arnon, D.I. 1949. Copper Enzymes in Isolated Chloroplasts Polyphenoloxidase in Beta Vulgaris. *Plant Hhysiology* **24**(1), 1–15.
Aryani, N., Hendarto, K., Wiharso, D. & Niswati, A. 2019. Increased Production of Shallots and Some Chemical Properties of Ultisols Due to Application of Vermicompost and Complementary Fertilizers. *Journal of Tropical Upland Resources* **1**(1), 145–160 (in Indonesian).
Ayodele, O.J. & Shittu, O.S. 2014. Fertilizer, lime and manure amendments for ultisols formed on coastal plain sands of southern Nigeria. *Agriculture, Forestry and Fisheries* **3**(6), 481–488.
Balík, J., Kulhánek, M., Černý, J., Sedlář, O. & Suran, P. 2019. Impact of organic and mineral fertilising on aluminium mobility and extractability in two temperate Cambisols. *Plant, Soil and Environment* **65**(12), 581–587.
Bates, L.S. 1973. Rapid Determination of Free Proline for Water-Stress Studies. *Plant and Soil* **39**, 205–207.
Bekele, G., Dechassa, N., Tana, T. & Sharma, J.J. 2019. Effects of nitrogen, phosphorus and vermicompost on groundnut yield in Babile district, eastern Ethiopia. *Agronomy Research* **17**(4), 1532–1546.
Bellitürk, K., Çelik, A. & Baran, M.F. 2022. The Effect of vermicompost application on soil properties in olive (Olea europaea L. cv. Memecik) plant. *Erwerbs-Obstbau* **64**(1), 107–113.
Bintoro, M.H. 1989. *Corn Plant Tolerance to Salinity*. Graduate Faculty. Bogor Agricultural Institute, Bogor. Indonesia, 295 pp. (in Indonesian).
Bloom, P.R. & Skyllberg, U. 2012. Soil pH and pH Buffering. In: P.M. Huang, Y. Li & M.E. Sumner (eds) *Handbook of Soil Sciences Properties and Processes*. Boca Raton, New York, 1–14.
Brady, N.C. & Weil, R. 2014. *Elements of the Nature and Properties of Soils.* Third eds. Pearson Education Limited, England, 671 pp.

Butterly, C., Baldock, J. & Tang, C. 2010. Chemical mechanisms of soil pH change by agricultural residues. *19th World congress of soil science,* (August), 43–46.

Chien, S.H., Prochnow, L.I., Tu, S. & Snyder, C.S. 2011. Agronomic and environmental aspects of phosphate fertilizers varying in source and solubility : an update review. *Nutrient Cycling in Agroecosystems* **89**, 229–255.

Coulibaly, S.S., Kouassi, K.I., Koffi, K.K. & Zoro, B.I.A. 2019. Effect of compost from different animals manure on maize (Zea masys) growth. *Journal of Experimental Biology and Agricultural Sciences* **7**(2), 178–185.

Doan, T.T., Henry-des-tureaux, T., Rumpel, C., Janeau, J.-L. & Jouquet, P. 2015. Impact of compost, vermicompost and biochar on soil fertility, maize yield and soil erosion in Northern Vietnam: A three year mesocosm experiment. *Science of the Total Environment* **514**(2015), 147–154.

El-Etr, W.T., Osman, M.A. & Mahmoud, A.A. 2011. Improving Phosphorus Use Effeciency and Its Effect on The Productivitty of Some Crops. *J. Soil Sci. and Agric. Eng* **2**(9), 1019–1034.

El-Eyuoon, A. & Amin, A.Z. 2018. Improvement in phosphorus use efficiency of corn crop by amending the soil with sulfur and farmyard manure. *Soil Environment* **37**(1), 62–67.

Emalinda, O., Husin, E.F. & Rini, D.P. 2005. Changes in Nutrients and Microorganisms in Ultisols Due to Different Worms. *J. Solum* **2**(2), 55–61 (in Indonesian).

Endris, S. 2019. Combined Application of Phosphorus Fertilizer with Tithonia Biomass Improves Grain Yield and Agronomic Phosphorus Use Efficiency of Hybrid Maize. *International Journal of Agronomy* 1–9.

Fageria, N. & Baligar, V. 1997. Response of common bean, upland rice, corn, wheat, and soybean to soil fertility of an oxisol. *Journal of Plant Nutrition* **20**(10), 1279–1289.

Fernández-Gómez, M.J., Romero, E. & Nogales, R. 2010. Feasibility of vermicomposting for vegetable greenhouse waste recycling. *Bioresource Technology* **101**(24), 9654–9660.

Fitria, U., Zuraida & Ilyas. 2018. Effect of Vermicompost on Changes in Several Chemical Properties of Ultisol. *Unsyiah Agricultural Student Scientific Journal* **3**(4), 885–896 (in Indonesian).

Fitriatin, B.N., Yuniarti, A., Turmuktini, T. & Ruswandi, F.K. 2014. The effect of phosphate solubilizing microbe producing growth regulators on soil phosphate , growth and yield of maize and fertilizer efficiency on Ultisol. *Eurasian Journal of Soil Science* **3**, 101–107.

Frimpong, K.A., Asare-Bediako, E., Amissah, R. & Okae-Anti, D. 2017. Influence of compost on incidence and severity of okra mosaic disease and fruit yield and quality of two okra (Abelmoschus esculentus L. Moench) cultivars. *International Journal of Plant & Soil Science* **16**(1), 1–14.

Galvez-sola, L., Morales, J., Mayoral, A.M., Marhuenda-egea, F.C., Martinez-sabater, E., Perez-Murcia, M.D., Bustamante, M.A., Paredes, C. & Moral, R. 2010. Chemosphere Estimation of phosphorus content and dynamics during composting : Use of near infrared spectroscopy. *Chemosphere* **78**, 13–21.

Ganjali, H.R., Mobasser, H.R., Esmaielzehi, A. & Tavassoli, A. 2013. Effects of organic composts on yield and protein content of corn cultivars in Khash region. *Journal of Novel Applied Sciences* **2**(9), 369–374.

Glaser, B., Wiedner, K., Seelig, S., Schmidt, H.-P. & Gerber, H. 2014. Biochar organic fertilizers from natural resources as substitute for mineral fertilizers. *Agronomy for Sustainable Development*. doi: 10.1007/s13593-014-0251-4

Gomez, K.A. & Gomez, A.A. 1984. *Statistical procedures for agricultural research.* John Wiley and Sons, New York, 690 pp.

Gusnidar, Hakim, N. & Prasetyo, T.B. 2010. Incubation of Titonia in Rice Fields against Organic Acids. *Journal of Solum* **7**(1), 7–18 (in Indonesian).

Huang, S., Zhang, W., Yu, X. & Huang, Q. 2010. Effects of long-term fertilization on corn productivity and its sustainability in an Ultisol of southern China. *Agriculture, Ecosystems and Environment* **138**, 44–50.

Imran & Khan, A.Z. 2015. Influence of Compost Application and Seed Rates on Production Potential of Late Sown Maize on High Elevation in Swat -Pakistan. *Journal of Environment and Earth Science* **5**(5), 36–40.

Iqbal, A., Amanullah & Iqbal, M. 2015. Impact of potassium rates and their application time on dry matter partitioning, biomass and harvest index of maize (Zea mays) with and without cattle dung application. *Emirates Journal of Food and Agriculture* **27**(5), 447–453.

Jjagwe, J., Komakech, A.J., Karungi, J., Amann, A., Wanyama, J. & Lederer, J. 2019. Assessment of a Cattle Manure Vermicomposting System Using Material Flow Analysis : A Case Study from Uganda. *Sustainability* **11**.

Kareem, I., Jawando, O.B., Eifediyi, E.K., Bello, W.B. & Oladosu, Y. 2017. Improvement of growth and yield of maize (Zea mays) by poultry manure, maize varoety and plant population. *Cercetări Agronomice în Moldova* **4**(172), 51–64.

Karimuna, L., Rahni, N.M. & Boer, D. 2016. The Use of Bokashi to Enhance Agricultural Productivity of Marginal Soils in Southeast Sulawesi, Indonesia. *Journal of Tropical Crop Science* **3**(1), 1–6.

Khan, A.A., Bibi, H., Ali, S., Sharif, M., Shah, S.A., Ibadullah, H., Khan, K., Azeem, I. & Ali, S. 2017. Effect of compost and inorganic fertilizers on yield and quality of tomato. *Academia Journal of Agricultural Research* **5**(10), 287–293.

Korzeniowska, J., Stanislawska-Glubiak, E., Hoffmann, J., Górecka, H., Jozwiak, W. & Wisniewska, G. 2013. Improvement of the solubility of rock phosphate by co-composting it with organic components. *Polish Journal of Chemical Technology* **15**(4), 10–14.

Laugale, V., Dane, S., Strautiņa, S. & Kalniņa, I. 2020. Influence of vermicompost on strawberry plant growth and dehydrogenase activity in soil. *Agronomy Research* **18**(S4), 2742–2751.

Lu, D., Wang, L., Yan, B., Ou, Y., Guan, J., Bian, Y. & Zhang, Y. 2014. Speciation of Cu and Zn during composting of pig manure amended with rock phosphate. *Waste Management* **30**, 1–9.

Mahmood, F., Khan, I., Ashraf, U., Shahzad, T., Hussain, S., Shahid, M., Abid, M. & Ullah, S. 2017. Effects of organic and inorganic manures on maize and their residual impact on soil physico-chemical properties. *Journal of Soil Science and Plant Nutrition* **17**(1), 22–32.

Mahmud, M., Abdullah, R. & Yaacob, J.S. 2018. Effect of vermicompost amendment on nutritional status of sandy loam soil, growth performance, and yield of pineapple (Ananas comosus var. MD2) under field conditions. *Agronomy* **8**(9), 183. https://doi.org/10.3390/agronomy8090183

Majeed, A., Zehdi, S.M., Niaz, A., Mahmood, A., Ul-Haq, E., Ahmad, N., Javid, S. & Mehmood, A. 2018. Influence of P-enriched compost application on economics and P use efficiency of a maize – wheat rotation system. *The Crop Journal* **6**, 651–658.

Mekki, A., Aloui, F. & Sayadi, S. 2017. Influence of biowastes compost amendment on soil organic carbon storage under arid climate. *Journal of the Air & Waste Management Association* **0**(0).

Naderi, R. & Ghadiri, H. 2010. Urban waste compost, manure and nitrogen fertilizer effects on the initial growth of corn (Zea mays L.). *Desert* **15**, 159–165.

Naeem, M.A., Khalid, M., Aon, M., Abbas, G., Amjad, M., Murtaza, B., Khan, W.U.D. & Ahmad, N. 2017. Combined application of biochar with compost and fertilizer improves soil properties and grain yield of maize. *Journal of Plant Nutrition*. doi: 10.1080/01904167.2017.1381734

Nur, H., Sudiarso, Sugeng, P. & Nurul, A. 2019. The Effect of compost combined with phosphate solubilizing bacteria and nitrogen-fixing bacteria for increasing The growth and yield of chili plants. *Russian Journal of Agricultural and Socio-Economic Sciences* **8**(92), 287–292.

Okoroafor, I.B., Okelola, E.O., Edeh, O., Nemehetu, V.C., Onu, C.N., Nwaneri, T.C. & Chinaka, G.I. 2013. Effect of Organic Manure on the Growth and Yield Performance of Maize in Ishiagu, Ebonyi State, Nigeria. *IOSR Journal of Agriculture and Veterinary Science* **5**(4), 28–31.

Opala, P.A., Okalebo, J.R. & Othieno, C.O. 2012. Effects of organic and inorganic materials on soil acidity and phosphorus availability in a soil incubation study **2012**(July 2008).
Peiffer, J.A., Romay, M.C., Gore, M.A., Flint-Garcia, S.A., Zhang, Z., Millard, M.J., Gardner, C.A.C., McMullen, M.D., Holland, J.B., Bradbury, P.J. & Buckler, E.S. 2014. The genetic architecture of maize height. *Genetics* **196**(4), 1337–1356.
Pirdashti, H., Motaghian, A. & Bahmanyar, M.A. 2010. Effect of organic amendments application on grain yield, leaf chlorophyll content and some morphological characteristic in soybean cultivars. *Journal of Plant Nutrition* **33**, 485–495.
Purwanto, S., Gani, R.A. & Suryani, E. 2021. Characteristics of ultisols derived from basaltic andesite materials and their association with old volcanic landforms in Indonesia. *Sains Tanah* **17**(2), 135–143.
Qureshi, A.S., Dahot, M.U. & Panhwar, S.I. 2010. Biosysnthesis of Alkaline Phosphatase by Escherichia coli Efrl 13 in Submerged Fermentation. *World Applied Sciences Journal* **8**, 50–56.
Radulov, I., Sala, F., Alexa, E., Berbecea, A. & Crista, F. 2010. Foliar fertilization influence on maize grain protein content and amino acid composition. *Research Journal of Agricultural Science* **42**(3), 275–279.
Rahim, A., Ranjha, A.M., Rahamtullah & Waraich, E.A. 2010. Effect of phosphorus application and irrigation scheduling on wheat yield and phosphorus use efficiency. *Soil & Environment* **29**(1), 15–22.
Rakhmalia, R., Gema, R.R. & Yuniarti, A. 2015. C-Organic Content, N-Total Soil and Upland Rice Yield (Oryza sativa L.) Due to Organic Fertilizer Treatment on Ultisols from Kentrong Village, Banten Province. *Journal of Agriculture* **26**(2), 99–103 (in Indonesian).
Rick, T.L., Jones, C.A., Engel, R.E. & Miller, P.R. 2011. Green manure and phosphate rock effects on phosphorus availability in a northern Great Plains dryland organic cropping system. *Org. Agr* **1**, 81–90.
Sabastian, K.S., Mathukmi, K., Kuotsu, N.R., Thokchom, A. & Kayia Alice, A. 2018. Impact of nitrogen and phosphorus on cormel production in gladiolus grandiflorus L. cv. white prosperity. *International Journal of Current Microbiology and Applied Sciences* **7**(09), 226–233.
Saraswati, R., Husen, E. & Simanungkalit, R.D.M. 2007. *Soil Biological Analysis Methods.* Center for Research and Development of Agricultural Land Resources. Bogor. Indonesia, 279 pp. (in Indonesian).
Schoebitz, M. & Vidal, G. 2016. Microbial consortium and pig slurry to improve chemical properties of degraded soil and nutrient plant uptake. *Journal of Soil Science and Plant Nutrition* **16**(1), 226–236.
Seshachala, U. & Tallapragada, P. 2012. Phosphate solubilizers from the rhizosphere of Piper nigrum L. in Karnataka, India. *Chilean Journal of Agricultural Research* **72**(3), 397–403.
Setiawan, I.G.P., Niswati, A., Hendarto, K. & Yusnaini, S. 2015. Effect of Vermicompost Dosage on Pakcoy (Brassica rapa L.) Plant Growth and Changes in Some Chemical Properties of Ultisol Soil at Bogo Gardens. *Journal of Tropical Agrotech* **3**(1), 170-–173 (in Indonesian).
Shahbazi, F. & Nematollahi, A. 2019. Influences of phosphorus and foliar iron fertilization rate on the quality parameters of whole wheat grain. *Food Science & Nutrition* 1–7.
Sharif, M., Arif, M., Burni, T., Khan, F., Jan, B. & Khan, I. 2014. Growth and Phosphorus Uptake of Sorghum Plants in Salt Affected Soil as Affected by Organic materials Compsted With Rock Phosphate. *Pak. J. Bot.* **46**(1), 173–180.
Sharif, M., Shah, A.H. & Wahid, F. 2011. Response of fed dung composted with rock phosphate on yield and phosphorus and nitrogen uptake of maize crop **10**(59), 12595–12601.
Sianturi, S.M., Muktamar, Z. & Chozin, M. 2019. Enhancing Soil Chemical Properties and Sweet Corn Growth by Solid Organic Amendments in Ultisol. *Terra (Journal of Land Restoration)* **2**(2), 1–8.

Siavoshi, M. & Laware, S.L. 2013. Role of Organic Fertilizers on Chlorophyll COntent in RIce (Oryza sativa L.). *Trends in Life Sciences. Interntional Science Journal* **2**(3), 13–17.

Siregar, P., Fauzi & Supriadi. 2017. Effect of Giving Several Sources of Organic Matter and Incubation Period on Several Chemical Aspects of Ultisol Soil Fertility. *Journal of Agroecotechnology* **5**(2), 256–264. (in Indonesian).

Sitompul, S.M. & Guritno, B. 1995. *Plant Growth Analysis.* Gadjah Mada University Press. Yogyakarta, Indonesia, 412 pp. (in Indonesian).

Soro, D., Ayolié, K., Zro, F.G.B., Yéboua, F.Y., Kouadio, H.K., Bakayoko, S., Angui, P.T. & Kouadio, J.Y. 2015. Impact of Organic Fertilization on Maize (Zea mays L.) Production in A Ferralitic Soil of Centre-West Cote D'ivoire. *Journal of Experimental Biology and Agricultural Sciences* **3**(6), 556–565.

Subaedah, S., Edy, E. & Mariana, K. 2021. Growth, yield, and sugar content of different varieties of sweet corn and harvest time. *International Journal of Agronomy* **2021**. doi: 10.1155/2021/8882140

Sulaeman, Suparto & Eviati. 2005. *Technical instructions for chemical analysis of soil, plants, water and fertilizers.* Agricultural Research and Development Agency. Bogor. Indonesia, 143 pp. (in Indonesian).

Syahputra, E., Fauzi & Razali. 2015. Characteristics of Chemical Properties of Ultisol Soil Sub Groups in Several Regions of North Sumatra. *Journal of Agroecotechnology* **4**(1), 1796–1803 (in Indonesian).

Taisa, R., Maulida, D., Salam, A.K., Kamal, M. & Niswati, A. 2019. Improvement of soil chemical properties and growth of maize due to biochar application on ultisol. *Journal of Tropical Soils* **24**(3), 101.

Udom, B.E. & Kamalu, O.J. 2019. Crop water requirements during growth period of maize (Zea mays L.) in a moderate permeability soil on coastal plain sands. *International Journal of Plant Research* **9**(1), 1–7.

Utami, A., Hidayat, B. & Mukhlis. 2021. Study of some chemical properties of ultisol soil applied by biochar and compos from some biomasses and incubation time. *IOP Conference Series: Earth and Environmental Science* **782**(4).

Vicente-vicente, J.L., García-ruiz, R., Francaviglia, R., Aguilera, E. & Smith, P. 2016. Soil carbon sequestration rates under mediterranean woody crops using recommended management practices : A meta-analysis. *Agriculture, Ecosystems and Environment* **235**, 204–214.

Wahyudi, I. 2009. N Uptake of Corn Plants (Zea mays L.) Due to Guano Fertilizer and Lamtoro Green Manure on Ultisol Wanga. *Journal Agroland* **16**(4), 265–272 (in Indonesian).

Widiatmaka, Ambarwulan, W., Setiawan, Y. & Walter, C. 2016. Assessing the suitability and availability of land for agriculture in tuban regency, East Java, Indonesia. *Applied and Environmental Soil Science* **2016**.

Yuka, M.F., Niswati, A. & Hendarto, K. 2017. Effect of Vermicompost Dose on Production Growth and N&P Uptake of Cucumber (Cucumis sativus L.) on Media from Two Ultisol Soil Depths. *Journal of Applied Agricultural Research* **17**(2), 117–123 (in Indonesian).

Zaman, M., Ahmed, M. & Gogoi, P. 2010. Effect of Bokashi on plant growth, yield and essential oil quantity and quality in Patchouli (Pogostemon cablin Benth.). *Biosciences, Biotechnology Research Asia* **7**(1), 383–387.

Zhang, Y., Li, C., Wang, Y., Hu, Y., Christie, P., Zhang, J. & Li, X. 2016. Maize yield and soil fertility with combined use of compost and inorganic fertilizers on a calcareous soil on the North China Plain. *Soil & Tillage Research* **155**, 85–94.