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# Optimisasi Pemanfaatan Pupuk Vermikompos dalam Meningkatkan Pertumbuhan dan Hasil Tanaman Jagung di Tanah Entisol Pesisir Pantai

# (Optimizing The Use of Vermicompost Fertilizer to Increase Growth and Yield of Maize on Coastal Entisols)

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## ABSTRAK

**Entisol memiliki sifat fisik, kimia, dan biologi tanah yang miskin yang membatasi pertumbuhan dan hasil tanaman jagung. Hal ini dapat diatasi dengan penggunaan pupuk vermikompos yang tepat. Tujuan penelitian ini ialah untuk mendapatkan dosis vermikompos yang tepat guna meningkatkan pertumbuhan dan hasil jagung pada Entisol. Penelitian disusun menggunakan Rancangan Acak Kelompok, yang terdiri atas 7 dosis aplikasi pupuk vermikompos (0; 2,5; 5; 7,5; 10; 12,5; dan 15 Mg ha$^{-1}$) dengan ulangan 4 kali. Hasil penelitian menunjukkan bahwa dosis vermikompos berpengaruh nyata pada pertumbuhan dan hasil tanaman jagung di tanah Entisol pesisir pantai. Dosis vermikompos 10 Mg ha$^{-1}$ merupakan dosis terbaik untuk tinggi tanaman, jumlah daun, bobot segar tanaman, bobot kering tanaman, bobot segar tajuk, bobot segar akar, bobot kering tajuk dan akar. Sementara itu, dosis 12,5 Mg ha$^{-1}$ memberikan hasil terbaik untuk bobot basah tongkol berkelobot per tanaman, bobot basah tongkol tanpa kelobot per tanaman, dan bobot kering gabah per tanaman, yaitu masing-masing 322,75 g, 286,66, dan 173,4 g. Hasil terbaik bobot basah tongkol berkelobot per petak, variabel bobot basah tongkol tanpa kelobot per petak, dan bobot kering gabah per petak diperoleh dari dosis vermikompos 15 Mg ha$^{-1}$, masing-masing 11,28 kg, 9,72 kg, dan 5,94 kg.**

**Kata kunci: Entisol, jagung, pesisir pantai, vermikompos**

## ABSTRACT

**Entisol has poor physical, chemical, and biological properties that limit the growth and yield of maize. This study aimed to obtain the correct dose of vermicompost to increase the growth and yield of maize on Entisols. The research was arranged using Randomized Block Design, consisted of 7 treatment doses of vermicompost fertilizer (0; 2.5; 5; 7.5; 10; 12.5; and 15 Mg ha$^{-1}$ and 4 re;plications. The results showed that the dose of vermicompost significantly affected the growth and yield of maize in coastal entisol soils. The dose of 10 Mg ha$^{-1}$ was the best on plant height, leaf number, fresh weight, plant dry weight, shoot fresh weight, fresh root weight, and shoot and root dry weight. Meanwhile, the dose of 12.5 Mg ha$^{-1}$ produced the best maize yields for the fresh weight of husked ear per plant, fresh weight of unhusked ear per plant, and dry grain weight per plant, namely, 322.75 g, 286.66 g, and 173.4 g, respectively. The best results of fresh weight of husked ear per plot, fresh weight of unhusked ear per plot, and dry grain weight per plot were achieved by vermicomposting of 15 Mg ha$^{-1}$, which were 11.28 kg, 9.72 kg, and 5.94 kg, respectively.**

**Keywords: coastal, Entisol, maize, vermicompost, yield**

## INTRODUCTION

Vermicompost is commonly used as a source of plant nutrition in organic farming systems. This type of organic fertilizer has benefits for soil fertility and plant growth. The roles of vermicompost include: (a) improving the physical, chemical, and biological properties of the soil (Setiawati *et al*. 2017); (b) improving soil fertility, quality, and health; (c) increasing the availability of essential nutrients for plants (Masri *et al*. 2016; Allen 2016); (d) increasing soil moisture storage; (e) increasing healthy crop; (f) friendly to the environment; (g) free of toxic nutrients, pests, and plant diseases (Rahmawati & Herumurti 2016); and (h) odorless or smells like the smell of earth. The essential role of vermicompost in improving soil properties can be used to increase the potential of Entisol for maize cultivation. Entisol is classified as relatively young soil in its development, hence has very low nutrients available for the plant.

Entisols have poor soil physical properties, so it is easy to pass water and essential nutrients to the lower

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soil profile, so the soil lacks water and nutrients for plants. Entisols also have poor soil chemical properties (cation exchange capacity and nutrient binding capacity), so the availability of essential nutrients for plants is significantly reduced. Entisols also have low soil biological properties (organic C and nitrogen) for plants. In addition, to the low quality of soil fertility, Bengkulu coastal Entisol has enormous potential to be developed into corn cultivation because this province has the longest coastline, reaching ± 525 km (Pemerintah Provinsi Bengkulu 2015).

Maize is a plant that is very responsive to fertilization. Therefore, nutrient needs, especially N, are primary in corn cultivation. The deficiency of N elements can cause plant growth to be disrupted, plant stunting, yellowing leaves, and low yield; however, the soil's nutrient availability is quite mobile. Loss of N in the soil can reach 40% of the applied N if the technology applied needs to be corrected. In maintaining the presence of N in the soil, organic matter is needed so that water-soluble N can be maintained using organic matter to hold water and soil cations. The application of manure before planting resulted in significant stem elongation and higher wheat yields and reduced N loss than without the addition of manure (Meade *et al*. 2011).

Our previous experiment in a greenhouse in 2018 showed that the height of the corn plant was 160.7 cm, the weight of the dry stover was 27.56 Mg ha$^{-1}$, the dry stover weight was 5.68 Mg ha$^{-1}$, and the dry root weight of the corn plant. 1.16 Mg ha$^{-1}$ at a dose of 10 Mg ha$^{-1}$ vermicompost (Riwandi *et al*. 2019). The vermicompost dose of 10 Mg ha$^{-1}$ can be used in the field research in 2019. The results of the 2019 field study showed that the weight of corn cobs was 27.70 Mg ha$^{-1}$, the weight of corn cobs without cob 23.41 Mg ha$^{-1}$ at a vermicompost dose of 15 Mg ha$^{-1}$ (Riwandi *et al.* 2020). From these results, there was not sufficient evidence to recommend a dose of 15 Mg ha$^{-1}$ vermicompost, because the results have not shown the expected results. The expected result was that the maximum weight of dry shelled corn has not been determined at a vermicompost dose of 15 Mg ha$^{-1}$. Another reason is that the levels of plant leaf nutrients (N and P) tested in the 2019 study showed that the levels of N and P tended to increase with increasing doses of vermicompost. This also means that maize leaf's maximum N and P levels have not been determined. K content in the leaf was 2.12% (the highest) resulted from a dose of 25 Mg ha$^{-1}$ vermicomposts. This is an important reason why the vermicompost doses obtained were not optimal for N, P, and K in leaves. Soil nutrients (C, N, P, and K) have not reached the maximum soil nutrient levels.

The results of the 2018 and 2019 studies are (1) the optimum dose of vermicompost has not been achieved to increase the growth and yield of maize in coastal Entisols, (2) the levels of soil nutrients (C, N, P, K) and plants have not been achieved, and (3) maize's maximum dry shell weight has not been achieved. Information on optimizing the use of vermicompost fertilizer in increasing the growth and yield of maize in Entisol coastal Bengkulu has yet to be widely carried out. The main problem of Entisol is solved as follows. Entisol's main problem is the soil's physical, chemical, and biological properties, which do not support the growth and yield of maize. The problem could be overcome using the right vermicompost fertilizer (in the right way, in the correct dose, and at the right time). Therefore, this study aimed to obtain the correct dose of vermicompost to increase the growth and yield of maize in Entisols on the coast of Bengkulu.

## MATERIALS AND METHODS

This experiment was conducted in Kandang Mas Village, Kampung Melayu, Bengkulu City, S 03°52'42.4” E 102°19'10.1”, from 17 July 2021 to 6 November 2021. The experimental design arranged using a Completely Randomized Block Design consisted of 7 treatment doses of vermicompost fertilizer, which were 0, 2.5, 5, 7.5, 10, 12.5, and 15 Mg ha$^{-1}$ after being corrected for vermicompost moisture content of 21.71%, and 4 replications so that the number of plots was 28. The size of the experimental plot was 3 m × 2 m, and the distance between plants of 75 cm × 20 cm, so there were 40 plants in each plot. The distance between repetitions (blocks) was 1 m, and the distance between plots was 1 m, so the total land area was 450 m$^2$.

### Soil Sampling

The soil was classified into Entisol. Composite soil samples were randomly taken from 15 points of soil at a depth of 0–20 cm. All soil samples were mixed thoroughly in a bucket, and 2 kg was taken as a composite soil sample. The composite soil samples taken were brought to the Soil Science Laboratory for analysis of soil texture (sand, silt, clay) using the pipette method, pH ($H_2O$, 1:2.5 w/v), and pH (KCl, 1:2, five w/v) using a pH meter, C-organic by the Walkley and Black method, N-total by the Kjeldahl method, available P by the Bray-1 method, exchangeable Al was extracted using 1 N KCl and measured by titration.

Exchangeable bases (K, Ca, and Mg) were extracted using 1 N ammonium acetate and a spectrophotometer to measure the contents. Vermicompost was taken from Air Duku Village, Rejang Lebong, Bengkulu Province. Vermicompost was prepared using Peryonix excavations. The vermicompost samples were brought to the Soil Science Laboratory to be analyzed for pH (H2O, 1:2.5 w/v) using a pH meter; organic C, N-, P-, K-, Ca Mg-total were determined by the wet ashing method.

**Research Stages**

The Entisols were cleaned of weeds, plowed using a tractor, and plots were prepared with a distance between blocks of 1 m and a distance between plots of 1 m. The total land area required was 450 $m^2$ (15 m × 30 m). Each plot had 40 plant populations with a 75 cm × 20 cm spacing. Excellent dolomite lime (100 mesh) of 1.19 kg plot⁻1 (based on 1.5´ exchangeable-Al soil content) was spread evenly over each plot. Vermicompost was applied according to the treatment dose in each plot. The vermicompost was applied parallel to the left of the row of plants, then filled with soil. Two corn seeds of the BISI 18 variety, mixed with Furadan 3 G, were immersed in a planting hole of ± 2 cm depth. Urea, SP-36, and KCl basic fertilizers were given as follows: 175 kg $ha^{-1}$ (105 g $plot^{-1}$) urea, 100 kg $ha^{-1}$ (60 g $plot^{-1}$) SP36, and 50 kg $ha^{-1}$ (30 g $plot^{-1}$) KCl. The basic fertilizers were inserted into the soil hole, 2.5 cm away from the planting hole and parallel to the right with the row of plants. Watering was done every day when it did not rain. Weeding was done manually, and pests and diseases were sprayed using pesticides (Gramaxon and Emamectin 2mL $L^{-1}$ in clean water). Harvesting, twice, in the vegetative phase, was carried out 63 days after planting (seek for plant height, weight of stover, and weight of plant roots), and in the generative phase 112 days after planting (seek for weight of cob with cob, weight of cob without cob, and weight of dry shelled corn). Plant height was measured using a ruler every week, starting from the base of the stem to the top of the leaf. The weight of corn plants (burner, plant roots, cobs with husks, cobs without husks, and dry shells) was weighed using a 2-decimal balance.

**Statistical analysis**

Plant data were analyzed using the analysis of variance at a level of 5%. If there was a significant difference, the average value was further tested using Duncan's Multiple Range Test.

## RESULTS AND DISCUSSIONS

**Characteristics of Entisol and Vermicompost**

Before treatment, the Entisol had a pH $H_2O$ of 5 and a pH KCl of 4.38, or slightly acidic with a low exchangeable-Al of 1.08 cmol(+)$kg^{-1}$. The organic-C of 0,82% and the total N of 0.14%, fall in the low category. In addition, the levels of exchangeable K, Ca, and Mg were very low, namely 0.24 cmol(+)$kg^{-1}$, 0.54 cmol(+)$kg^{-1}$, and 0,22 cmol(+)$kg^{-1}$, respectively (Table 1).

In addition to soil analysis, the analysis in the laboratory showed that vermicompost had a pH $H_2O$ of 8.48, which could be classified as very high. The organic C content of 12.07% (very high), N-total of 0.53% (low), P-total of 0.50% (low), K-total of 2.14% (high), Ca-total of 0.68% (low), and Mg-total of 0.45% (low) (Table 2).

**Responses to the Applying Vermicompost**

The results showed that the application of various doses of vermicompost significantly affected almost all growth responses of maize. Table 3 shows that the dose of 10 Mg $ha^{-1}$ gave outstanding results for the plant height, fresh plant weight, dry plant weight, fresh shoot weight, fresh root weight, dry shoot weight, and dry root weight when compared with the other doses. The dose of 10 Mg $ha^{-1}$ was not significantly different from that of 12.5 Mg $ha^{-1}$, 219.11 cm, and 218.01 cm, respectively, on the plant height variable. The dose of vermicompost did not significantly differ in the number of leaves, but it was significantly different from the control (treatment without vermicompost).

On the dry plant weight variable, the dose of 5 Mg $ha^{-1}$ was not significantly different from that of 7.5 Mg $ha^{-1}$, 12.5 Mg $ha^{-1}$, and 15 Mg $ha^{-1}$, namely 146.12 g; 167.25 g; 153.87 g; and 163.37 g, respectively. Meanwhile, the dose of 5 Mg $ha^{-1}$ was not significantly different from the dose of 10 Mg $ha^{-1}$ and 12.5 Mg $ha^{-1}$ on the dry root weight, namely 53.25 g; 73.87 g; and 54.25 g, respectively, but significantly different with no dose of vermicompost, which was only 8.07 g.

The dose of vermicompost 10 Mg $ha^{-1}$ of 144.62 g and the control (46.25 g) indicated the highest shoot dry weight. However, the doses of 5 Mg $ha^{-1}$ and 12.5 Mg $ha^{-1}$ showed no significant difference, namely 92.87 g and 104.50 g on the dry shoot weight.

The results showed that the fresh weight of husked ear per plant and fresh weight of unhusked ear per plant

Tabel 1 Characteristics of Entisol before treatment

| Soil properties | Units | Value |
|---|---|---|
| pH ($H_2O$) | - | 5.00 |
| pH (KCl) | - | 4.38 |
| Exchangeable Al | cmol(+)$kg^{-1}$ | 1.08 |
| Organic C | % | 0.82 |
| Total N | % | 0.14 |
| Available P | ppm | 3.41 |
| Exchangeable K | cmol(+)$kg^{-1}$ | 0.24 |
| Exchangeable Ca | cmol(+)$kg^{-1}$ | 0.54 |
| Exchangeable Mg | cmol(+)$kg^{-1}$ | 0.22 |
| Texture | - | Sandy loam |

Table 2 Vermicompost analysis before experiment

| Vermicompost properties | Units | Value |
|---|---|---|
| pH ($H_2O$) | - | 8.48 |
| Organic C | % | 12.07 |
| N-total | % | 0.53 |
| P-total | % | 0.50 |
| K-total | % | 2.14 |
| Ca-total | % | 0.68 |
| Mg-total | % | 0.45 |

Table 3 Growth of maize plants after the vermicompost application at 7 weeks after planting (WAP)

| Dose (Mg ha$^{-1}$) | PH (cm) | LN (pieces) | FPW (g) | DPW (g) | FSW (g) | RFW (g) | DSW (g) | DRW (g) |
|---|---|---|---|---|---|---|---|---|
| 0 | 170.00$^{d}$ | 13.05$^{b}$ | 119.12$^{d}$ | 54.32$^{c}$ | 106.62$^{c}$ | 13.00$^{c}$ | 46.25$^{d}$ | 8.07$^{c}$ |
| 2.5 | 189.43$^{cd}$ | 14.55$^{a}$ | 286.87$^{c}$ | 93.12$^{c}$ | 255.62$^{b}$ | 31.25$^{c}$ | 71.50$^{cd}$ | 21.62$^{bc}$ |
| 5 | 195.85$^{bc}$ | 14.50$^{a}$ | 469.87$^{b}$ | 146.12$^{b}$ | 385.37$^{a}$ | 84.50$^{b}$ | 92.87$^{bc}$ | 53.25$^{a}$ |
| 7.5 | 194.62$^{bc}$ | 14.50$^{a}$ | 510.62$^{ab}$ | 167.25$^{b}$ | 420.75$^{a}$ | 89.87$^{b}$ | 120.50$^{ab}$ | 46.75$^{ab}$ |
| 10 | 219.11$^{a}$ | 15.20$^{a}$ | 603.75$^{a}$ | 218.50$^{a}$ | 462.12$^{a}$ | 141.62$^{a}$ | 144.62$^{a}$ | 73.87$^{a}$ |
| 12.5 | 218.01$^{a}$ | 14.90$^{a}$ | 453.50$^{b}$ | 153.87$^{b}$ | 370.62$^{a}$ | 82.87$^{b}$ | 104.50$^{bc}$ | 49.37$^{ab}$ |
| 15 | 212.90$^{ab}$ | 15.25$^{a}$ | 496.62$^{ab}$ | 163.37$^{b}$ | 404.50$^{a}$ | 92.12$^{b}$ | 109.12$^{abc}$ | 54.25$^{a}$ |

Description: The same letters in the same column indicated no significant difference at 5% significance level according to LSD. PH = plant height; LN = leaf number; FPW = fresh plant weight; DPW = dry plant weight; FSW = fresh shoot weight; DSW = dry shoot weight; FRW = fresh root weight; and DRW = dry root weight.

Table 4 Yield of maize plants after the application of vermicompost at harvest time

| Dose (Mg ha$^{-1}$) | FWHP (g plant$^{-1}$) | FWHPt (kg plot$^{-1}$) | FWUP (g plant$^{-1}$) | FWUPt (kg plot$^{-1}$) | DGP (g plant$^{-1}$) | DGPt (kg plot$^{-1}$) |
|---|---|---|---|---|---|---|
| 0 | 157.92$^{b}$ | 7.77$^{d}$ | 132.83$^{c}$ | 6.88$^{c}$ | 72.91$^{b}$ | 4.21$^{b}$ |
| 2.5 | 262.08$^{a}$ | 9.00$^{cd}$ | 232.24$^{b}$ | 7.93$^{bc}$ | 137.91$^{a}$ | 4.83$^{ab}$ |
| 5 | 263.58$^{a}$ | 9.31$^{bc}$ | 226.41$^{b}$ | 8.22$^{b}$ | 161.16$^{a}$ | 5.15$^{ab}$ |
| 7.5 | 283.58$^{a}$ | 10.25$^{abc}$ | 250.58$^{ab}$ | 8.99$^{ab}$ | 134.50$^{a}$ | 5.67$^{a}$ |
| 10 | 309.91$^{a}$ | 10.23$^{abc}$ | 273.58$^{ab}$ | 8.86$^{ab}$ | 160.49$^{a}$ | 5.63$^{a}$ |
| 12.5 | 322.75$^{a}$ | 10.57$^{ab}$ | 286.66$^{a}$ | 9.11$^{ab}$ | 173.41$^{a}$ | 5.64$^{a}$ |
| 15 | 319.41$^{a}$ | 11.28$^{a}$ | 278.08$^{ab}$ | 9.72$^{a}$ | 163.66$^{a}$ | 5.94$^{a}$ |

Description: The same letters in the same column indicated no significant difference at 5% significance level according to LSD. FWHP = Fresh weight of husked ear per plant; FWHPt = Fresh weight of husked ear per plot; FWUP= Fresh weight of unhusked ear per plant; FWUPt = Fresh weight of unhusked ear per plot; DGP = dry grain weight per plant; DGPt = dry grain weight per plot.

with the given dose of vermicompost were higher when compared to the control (Table 4). Dosage of 12.5 Mg ha$^{-1}$ of vermicompost showed the best results for the fresh weight of husked ear per plant and fresh weight of unhusked ear per plant, which were 322.75 g plant$^{-1}$ and 286.66 kg plot$^{-1}$, respectively. Meanwhile, for the best results, fresh weight of husked ear per plot and fresh weight of unhusked ear per plot was indicated by the application of 15.0 Mg ha$^{-1}$, namely 11.28 kg plot$^{-1}$ and 9.72 kg plot$^{-1}$. The dry weight of seeds per plot did not show a significant difference among doses of 7.5 Mg ha$^{-1}$, 10 Mg ha$^{-1}$, 12.5 Mg ha$^{-1}$, and 15 Mg ha$^{-1}$ doses of 5.67 g; 5.63 g; 5.64 g; and 5.94 g, respectively.

In addition, the dry weight of grain per plant showed higher yields with maize plants grown with vermicompost doses than the control. The dose of vermicompost increased the yield of maize fresh weight of unhusked ear per plant and fresh weight of unhusked ear per plot up to 21.5% and 14.1%, respectively.

## Discussion

Vermicompost application increased plant height, leaf number, fresh plant weight, plant dry weight, fresh weight of shoots and roots, and dry weight of shoots and roots of maize. This result is lower than that concluded by Akintoye and Olaniyan (2012), where shoot dry matter increases with the increase in the application rate of manure. A similar trend is also seen in vermicompost applications. This is in line with the reports of Kannan *et al*. (2013) and Manish *et al*. (2017), stating that the vermicompost application has a positive impact on corn plant height, where the highest plant height is obtained from a combination of vermicompost and manure fertilizer. Atazadeh *et al*. (2013) also added that the application of vermicompost with a high humic acid content could increase plant height growth.

However, Fahrurrozi *et al*. (2016) showed different results, where the combination of 15 Mg ha-1 vermicompost and liquid organic fertilizer had no significant effect on plant diameter, number of leaves, fresh root weight, fresh weight of crown on sweet corn plants but differed significantly on the plant height.

The application of vermicompost showed very different results on the responses of fresh weight of husked ear per plant, fresh weight of husked ear per plot, fresh weight of unhusked ear per plant, fresh weight of unhusked ear per plot, grain dry weight per plant, and dry grain weight per plot (Table 4). The dose of 12.5 Mg ha-1 showed the best results for the weight of the cob weight, and the weight of the cob without corn kernels per plant was up to 2 times higher when compared to without vermicompost. It is supported by Oluwatoyinbo (2005) work, which suggests that the application of vermicompost and lime can increase the weight of corn cobs. In addition, the vermicompost application can increase the availability of P and N levels in the soil, resulting in maize seeds' weight (Mihiteru 2014). Also stated by Reza *et al*. (2012) and Zaramanesh *et al*. (2017) about an increase in cob length, stem diameter, cob weight per plant, cob weight without grain per plant, dry seed weight per plant, and the number of seeds per cob in plants treated with vermicompost.

## CONCLUSIONS

The dose of vermicompost 10 Mg ha$^{-1}$ was the best dose of vermicompost on plant height, leaf number, plant fresh weight, plant dry weight, shoot fresh weight, root fresh weight, shoot and root dry weight. Meanwhile, the dose of 12.5 Mg ha$^{-1}$ showed the best maize yields for the fresh weight of husked ear per plant, fresh weight of unhusked ear per plant, and grain dry weight per plant, namely, 322.75 g plant$^{-1}$, 286,66 g plant$^{-1}$, and 173.4 g plant$^{-1}$, respectively. The best results in terms of fresh weight of husked earper plot, fresh weight of unhusked earper plot, and dry grain weight per plot are indicated by a dose of 15 Mg ha$^{-1}$, giving 11.28 kg plot$^{-1}$, 9.72 kg plot$^{-1}$, and 5.94 kg plot$^{-1}$, respectively. In general, the dose of vermicompost increased the yield of maize crop up to 14.1% for the fresh weight of unhusked ear per plot and 21.5% for the fresh weight of unhusked ear per plant.

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