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The Effects of Vermicompost on Carbon and Nitrogen Availability, C/N ratio and Corn Production Planted in Entisol Coastal Areas

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ABSTRACT

Entisols are soils that are widely used in Indonesia, both for irrigated and rainfed rice fields, for vegetable cultivation, and others. Vermicompost also contains many of the nutrients available to plants and increases soil porosity, soil aeration, and humidity, and controls soil erosion so that it can help in buffering toxins for plants and promoting plant growth. Corn is a cereal crop that is the second most important food crop in Indonesia besides rice. The volume of corn imports is higher than exports, this is due to the high demand for corn but domestic corn production has not been able to fulfill it. The experimental design used was a Randomized Completely Block Design (RCBD), seven levels of vermicompost doses, namely 0; 2.5; 5.0; 7.5; 10; 12.5; and 15 tons ha^{-1}) each repeated 4 times. This study aims to determine the dose of vermicompost fertilizer that can improve the properties of Entisols and yields of maize (Zea mays L.). The application of vermicompost fertilizer with seven dose levels had a significant effect on N nutrient levels in coastal Entisols. Doses of vermicompost were able to increase dry stover weight, cob weight with husk, and cob weight without husk of corn plants.

Keywords : Entisol, vermicompost, carbon, nitrogen, corn

INTRODUCTION

This research is related to the development of Entisols along the coastal area of Bengkulu City. The area of coastal area in Bengkulu reaches ± 14,452 ha (Badan Pusat Statistik, 2021). The condition of the coastal area in Bengkulu City is a very good potential to be developed in the agricultural sector.

Entisol soil is a soil that is widely used in Indonesia both for technically irrigated and rainfed rice fields, for vegetable cultivation, and others. Entisol soil that forms in coastal areas is called alluvial Mariene (Entisol). Entisol soils are formed due to the return of seawater after flooding or irrigation. This soil in Indonesia is problematic because apart from having poor physical and biological properties, it also has poor chemical properties. However, from the extent of this soil type has great potential for expanding agricultural land (Maroeto & Sasongko, 2004). Bengkulu coastal Entisol has enormous potential because Bengkulu has the longest coastline with a coastline reaching ± 525 km. However, this potential has not been utilized optimally because coastal land has many limiting factors and constraints to be developed into land for cultivating food crops such as corn. Entisol soil utilization can be maximized by adding organic matter. Utami & Handayani (2003) stated that organic matter can improve the physical and chemical properties of the soil to support better plant growth. This is also based on the results of several studies that have been conducted on organic farming systems that can improve the soil to ensure sustainability. One of the organic fertilizers that can be used is vermicompost.

Vermicompost has advantages compared to other composts such as compost made from coffee husks. The advantages of vermicompost include, (1) it can increase the absorption of nutrients (2) the ability to absorb and store water in the soil will increase (3) there are beneficial microorganisms in large quantities (4) it can improve soil structure (Sallaku, 2009).

Vermicompost also contains many nutrients available to plants and increases soil porosity, soil aeration, and moisture, and controls soil erosion so that it can help in buffering toxins for plants and increasing plant growth (Sheela & Khimiya, 2013). Organic corn cultivation needs to be done because organic cultivation for corn plant growth is more optimal than the results of cultivation using inorganic methods. Corn is a cereal crop that is the second most important food crop in Indonesia besides rice. The volume of corn imports is higher than exports, this is due to the high demand for corn but cannot be fulfilled by domestic corn production (Kementerian Pertanian, 2015). One of the limiting factors for maize development in Indonesia is the limited productive land due to land conversion and causing low soil fertility such as ultisols (Ayunda, 2014).

Corn plants require more essential nutrients such as N, P, and K, but these nutrients are very few in ultisols (Sirappa & Razak, 2007). Potassium is one of the essential nutrients needed by corn plants in large quantities, but the potassium nutrient in the soil is so small that it is unable to increase leaf K levels, and leaf K absorption so that corn plant growth is not optimal (Pradipta *et a*l., 2014).

MATERIALS AND METHODS

This research was carried out in July - December 2021 in Kandang Mas Village, Kampung Melayu, Bengkulu City. The research was conducted in the field and at the Laboratory of Soil Science, Faculty of Agriculture, Bengkulu University, and the Laboratory of Soil Science, Faculty of Agriculture, University of Lampung.

The materials used in this study were pH Universal 0-14, Paranet, meter, sacks, 5 kg plastic, scales, Bisi 18 corn seeds, dolomite, vermicompost, urea, SP36, KCl, natural pesticides, buckets, plastic, brown paper bags, bamboo, chemicals for soil analysis, plants, and fertilizers.

While the tools used in this study were a soil drill, GPS, tractor, fork, hoe, machete, hammer, hand sprayer, knife, ruler, logbook, mortar, oven, grinder machine, measuring device (pH meter, spectrophotometer, and photo light meter).

The experimental design used was a Randomized Completely Block Design (RCBD), 7 levels of vermicompost doses, namely 0; 2.5; 5.0; 7.5; 10; 12.5; 15 tonha^{-1} with 4 replicates. The number of experimental units is 28 plots. The plots are 2 m x 3 m in size with a spacing of 75 cm x 20 cm and there are 40 plants per plot. The total land area is 480 m2.

Land preparation begins with the selection of research land and a soil survey in the form of checking the location and then testing the pH on the land. The land chosen in the study was coastal entisols, then soil pH measurements and soil sampling were carried out to see the level of soil fertility. Furthermore, clearing the land of weeds aims to prevent pest attacks, diseases, and weed competition in absorbing soil nutrients, then making 28 plots. consisting of 4 repetitions. Each replicate consisted of 7 study plots with a size of 2 m x 3 m, the distance between plots was 1 m and the distance between replicates was 1 m. After the plots were completed, dolomite was added to each plot with the same number of sizes. Dolomite is applied by spreading it over the soil surface which is done at the time before planting.

The use of a dolomite dose of 1200 g plot^{-1}. Dolomite is used to increase soil pH and also to activate soil microorganisms. The processed land is then made into a hole using a drill made of wood with a pointed tip to make it easier to drill. The depth of the planting hole is ± 2 cm with a spacing of 75 cm x 20 cm. In each planting hole, 2 corn seeds were added at the same time and then the planting hole was closed again.

Vermicompost fertilizer was given in each plot according to the treatment that had been prepared. Urea, SP36, and KCl basic fertilizers were given half of the recommended dose from the previous study of 105 g, 60 g, and 30 g per plot, respectively. Basic fertilizer is put into the hole on the other side adjacent to the planting hole at the same distance of 2.5 cm. Fertilizer application is carried out at the same time as planting because when the plants grow and need nutrients, the availability of nutrients can be utilized by the plants as well because the vermicompost used is ripe.

Sample plants were selected from as many as 5 plants from each plant found in each plot. After that, it is marked using a label that has been coded according to the treatment of each plot. The purpose of labeling each sample plant is to avoid errors when observing and measuring the sample plants.

Plant maintenance includes several stages including watering, replanting, thinning, weeding, heaping, and pest and plant disease control.

Embroidery is done on seeds that do not grow. Thinning is done by cutting corn plants that grow more than one stalk per hole. Thinning is done by cutting the corn plants parallel to the soil surface when the plants are 2 weeks old. Weeding is the process of clearing land from weeds (weeds) that grow around plants/land that interfere with plants. Weeding is carried out every two weeks by pulling it out or cutting it and throwing it away. Watering is done in the afternoon at 04.00-05.30 pm. If it rains, watering is not carried out according to environmental conditions. Hoarding is done by digging the left and

right of the plants with a hoe, then the soil is piled up in rows of corn plants. Pest and plant disease control is carried out by spraying pesticides on plants according to the types of pests and diseases that attack the plants.

Harvesting is done 2 times, first in the late vegetative phase and second in the generative phase. Experimental data were taken from sample plants that had been randomly selected from as many as 5 samples, the main variables observed were: Total Soil N (%), Organic C (%), C/N Soil ratio, husted cob weight (g), unhusked cob weight (g), and dry flammed weight (g).

The collected data were analyzed statistically by Analysis of Variance (ANOVA) at a 5% level, and the relationship between independent variables and dependent variables was carried out by regression and correlation analysis.

RESULTS AND DISCUSSION

The research area is in the form of coastal Entisols which have a sandy loam texture with a percentage of sand of 76.98 (%) silt of 15.03 (%) and clay of 7.99 (%), C-organic content of 0.82 (%) which is very low, and total N-level of 0.14 (%) which is also relatively low and pH 5.00 which is classified as acidic. Vermicompost has an average C -organic content of 12.07% which is classified as very high and a total N-content of 0.53% which is also relatively high and a pH of 8.48 which is classified as alkaline. High C content is used by microorganisms to obtain energy sources so that the activity of microorganisms increases and can improve soil properties.

The pH value of coastal Entisols, namely 5.0, is classified as acidic, while the optimal soil acidity level (pH) for the growth and development of maize plants ranges from 5.6 to 6.2 (Riwandi *et al*., 2014).

Corn plants want open places and light. The altitude suitable for growing corn is 0-1300 m asl. The air temperature needed for the growth of corn plants is 23-27 ^{o}C. The ideal rainfall for corn plants is generally between 200-300 mm month^{-1} or 800-1200 mm year^{-1} (Riwandi *et al*., 2014). At the time of the study the corn plants grew well, it was seen from the first week that 95% of the plants had germinated. However, when the plants were 4 to 5 weeks old plants were attacked by armyworm pests which used up many plant leaves, the researchers immediately sprayed insecticides with the trademark Emacel 30 CE 500 mL with the active ingredient emamectin benzoate so that the plants could grow well again. 100% of crops can be harvested with good yields.

Data from the analysis of variance showed that there was a significant effect of vermicompost dosage on N-Total, dry cob weight, cob weight, and cob weight without husked. Whereas for C-Organic, C/N ratio, and dry shelled weight there was no significant effect of vermicompost dosage (Table 1).

Table 1. The analysis of variance on the effect of vermicompost doses on soil chemical properties, growth, and yield of maize

Variable	F-value
C-Org (%)	0.17ns
N-total (%)	3.57*
C/N ratio (%)	1.32ns
Dry stover weight	10.76*
Cob Weight with Husk	5.16*
Cob Weight without Husk	4.20*
Dry Seeds Weight	3.98*

Note : * = significant ; ns = non-significant

The dose of vermicompost shows a positive linear relationship to total N with a coefficient of determination (R^2) = 0.0681, the equation y = 0.1968 + 0.0021x, which means that each additional dose of vermicompost will increase the total N level by 0.0021 units (Figure 1). Vermicompost contains organic matter that is high enough for the growth of microorganisms in the soil, one of which is N-fixing microorganisms. Nitrogen is the most abundant element in the atmosphere, however, N is the nutrient most often deficient in agricultural soils. This paradox arises because N is the nutrient needed in the greatest amount for plant growth. The function of N nutrients is very important, especially in the formation of protein compounds in plants. Thus the dynamics of N nutrients are very important to study. Some of the causes of the nutrient deficiency by plants can be caused by: (1) intensive farming systems without the provision of sufficient fertilizers and organic matter, (2) the provision of nutrients in an unbalanced manner, (3) too high or low soil pH, (4) provision of certain micro-nutrients in excess which can cause other micro-elements to become depressed and (5) the soil is too wet or too dry so that it interferes with the absorption of nutrients (Sutanto, 2006).

The application of vermicompost fertilizer had a significant effect on the N-Total nutrient levels in the soil so that it was able to increase the N nutrient levels for Bisi-18 corn plants. The importance of

increasing N for plants is because N nutrients function to stimulate the vegetative growth of plants as a whole, especially the growth of roots, stems, and leaves (Pitaloka *et al*., 2022). In addition, N nutrients also play a role in the formation of leaf green matter (chlorophyll) which is very important for plants to carry out photosynthesis. Nitrogen is a nutrient needed by plants in large quantities, which is absorbed by plants in the form of ammonium (NH_4) and nitrate (NO_3). Nitrogen plays an important role in stimulating plant vegetative growth. Lack of N in plants results in stunted growth, stunted root growth, and pale yellow leaves (Zhai & Li, 2005).

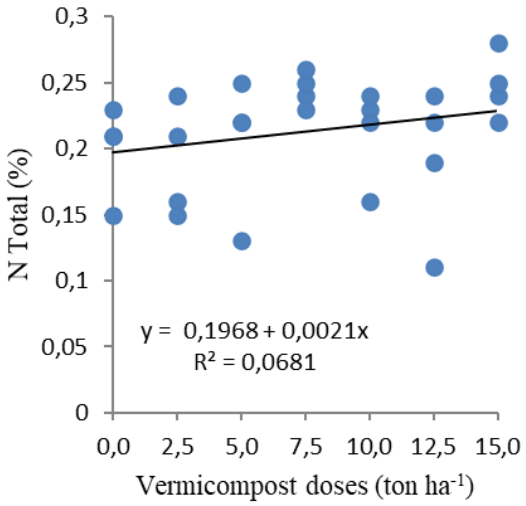

Figure 1. Relationship between vermicompost doses and soil N-total

The decrease in nitrate concentration due to the fast uptake of N-NO3- by corn plants or turning into N_2O and N_2 gases, can even be leached (Estiaty *et al*., 2004). Furthermore, Purwanto & Hairiah (2007) stated that an increase in soil NH^{4+} levels tends to increase soil potential nitrification, an increase in potential nitrification is closely related and significantly increases soil N03- concentration up to 3 times.

The C/N ratio is the ratio between organic C and total N in the soil. Decomposing organisms use carbon as an energy source and nitrogen as a protein source. The C/N ratio of good soil is 10-12. The C/N ratio will affect the availability of nutrients. The C/N ratio is inversely proportional to the availability of nutrients, meaning that when the C/N ratio is high, the nutrient content is little available for plants, whereas if the C/N ratio is low, the availability of nutrients is high and plants can meet their life needs (Riwandi *et al*., 2023).

The relationship between vermicompost dose and C/N ratio showed a positive linear relationship which was not statistically significant (Figure 2). The C/N ratio increased with the increasing dose of vermicompost. Provision of vermicompost mixed with tea compost can increase the availability of N, P, K and soil organic matter, in soil planted with shallots (El-Shaieny *et al*., 2022).

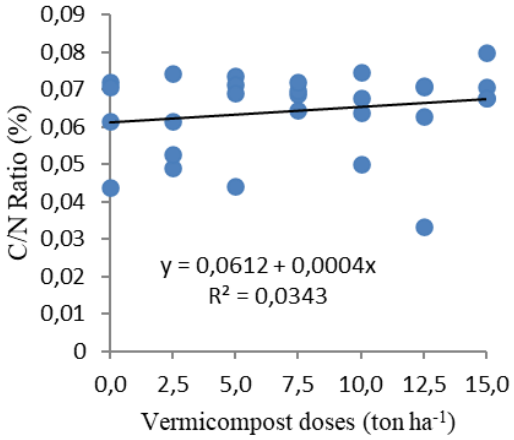

Figure 2. Relationship between vermicompost doses and C/N ratio

In this study, the dry stover weight after being analyzed by regression showed a significant relationship with the equation $y = 49.843 + 25.954x - 1.2464x^2$ with a coefficient of determination of (R^2) = 0.6657. The maximum dry stover weight yield was 178.344 g at the optimum dose of 11 tons ha^{-1}. Similar research conducted by Williams *et al*. (2012), showed that a dose of vermicompost fertilizers of 10 tonnes ha^{-1} produced an average dry stover weight of 64.6 g. Research by Herlina *et al*. (2016), also shows that a dose of Vermicompost 10 tons ha^{-1} produces a dry stover weight of 3.71 g. From the results of this study, it can be stated that the dose of vermicompost has a significant effect on dry stover weight (Sirappa & Razak, 2007). According to Jamin (2002), thin and long roots have a larger surface area when compared to thick and short roots, because they can explore the same amount of volume. In addition, it is possible for the accumulation of photosynthate to accumulate more in the canopy. This is by Salisbury & Ross (1992) that the larger canopy biomass compared to root biomass allows controlling the uptake of nutrients by the canopy. This is possible because the root is the last organ to get the assimilation formed in the leaves. This is what causes root growth not to coincide with plant vegetative growth (Gardner, 1991).

The results of the regression analysis showed that the higher the dose of vermicompost given, the higher the cob weight with a husk of each plant as seen from the equation y = 748.02 + 19.621x with a coefficient of determination (R^2) = 0.5377. This happens because vermicompost helps plants in providing the nutrients needed by plants during growth, both during the vegetative and generative periods.

According to Susilowati (2001), the yield of corn plants is determined by the fresh weight of the cobs per plant. The higher the cob weight per plant, the higher production will be obtained. Warisno (2004), also states that an adequate supply of nutrients at each growth phase is an absolute requirement to increase plant growth and production.

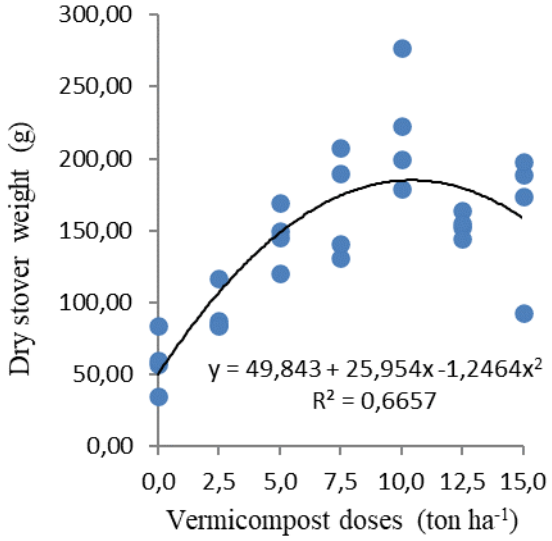

Figure 3. Relationship between vermicompost doses and dry stover weight

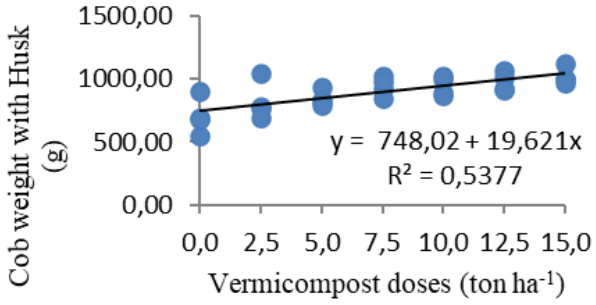

Figure 4. Relationship between vermicompost doses and cob weight with husk

Vermicompost dosage has a significant effect on the cob weight without husk of each plant. Cob weight without husk is determined by cleaning corn cobs from corn husk debris and then weighing them with a digital scale. The results of the regression analysis showed that the cob weight without husk increased with the increasing dose of vermicompost given (Figure 5). The relationship model between the two variables is shown by the equation y = 665.71 + 15.429x with a coefficient of determination of (R^2) = 0.4762.

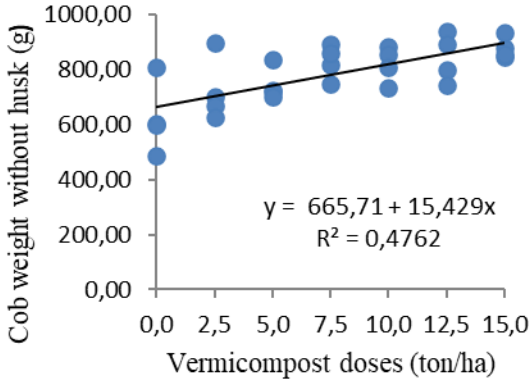

Figure 5. Relationship between vermicompost doses and cob weight without husk

The dose of vermicompost is significantly related to the dry seed weight of each plant, as stated by the model y = 4.2045 + 0.0889x with a coefficient of determination of (R^2) = 0.3197. The dry shell weight was calculated by weighing the corn husks which had been dried in the sun and separated from the cobs using an analytical balance. Drying the corn kernels aims to reduce the water content so that the corn kernels can be stored for a long time and avoid rotting.

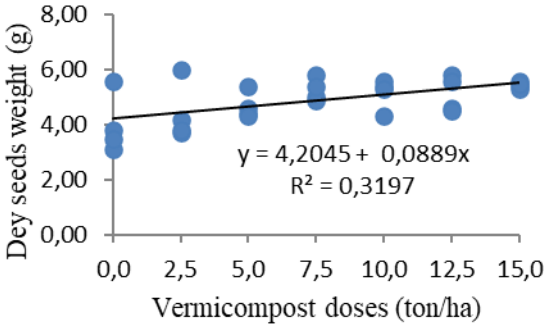

Figure 6. Relationship between vermicompost doses and dry seeds weight

CONCLUSION

The application of vermicompost fertilizer with seven dose levels had a significant effect on N nutrient levels in coastal Entisols. Doses of vermicompost were able to increase dry stover weight, cob weight with husk, and cob weight without husk of corn plants.

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