Compost and vermicompost engineering for the growth of BISI 18 variety of maize on coastal Entisols

Riwandi[1*], Hasanudin[1], Anandyawati[1], and *Kartika* Utami[1]

[1]Department of Soil Science, University of Bengkulu, Bengkulu, Indonesia

Abstract. The main issue of Entisols was the deficiency of macro-essential nutrients such as Carbon (C), Nitrogen (N), Potassium (K), Calcium (Ca), and Magnesium (Mg), causing maize to be dwarfed. This study aimed to increase the growth of maize, BISI 18 variety, mainly for height, leaf area, wet weight of maize stover, and dry weight of maize stover. This experiment used Completely Randomized Block Design (CRBD) with two factors: dosage levels as first factor and types of organic fertilizers (compost and vermicompost) as second factor, with three replications. Stages of organics were 0, 5, 10, 15, and 20-ton ha $^{-1}$ each other, whereas there were 30 experimental units. Dimensions of the experimental unit were 3m x 1m and length 75 cm x 20 cm with 20 plants per plot. Observations of soil and plant variables involved soil, compost, and vermicompost before experimentation and growth of maize (such as height, leaf area, wet weight stover, and dry weight stover of BISI 18 variety). The results showed optimum height (210.27 cm and 201.15 cm) on vermicompost with 15- and 20-ton ha $^{-1}$ dosages. Great leaf area (739 cm ^{2} and 812 cm ^{2}) on 20-ton ha $^{-1}$ of vermicompost and 5-ton ha $^{-1}$ of compost. The highest wet stover (710.5 g per plant) on 20-ton ha $^{-1}$ of vermicompost and dry stover (228.8 g per plant) on 5-ton ha $^{-1}$ of vermicompost and 20-ton ha $^{-1}$ of compost. This experiment concluded that vermicompost had a better impact than compost for supporting maize growth on coastal Entisols.

1 Introduction

The development of knowledge about compost and vermicompost over the last five years has been so fast that many farmers use it to increase plant growth and agricultural crop yields. Compost can come from various plant biomass (corn litter, hairpins, kipahit, rice straw, dry leaves, arasungsang, rice grain, etc.) and animal waste (cow, buffalo, horse, chicken, bird, etc.). Vermicompost comes from animal waste, especially cow dung fed with earthworms fermented over a certain period (1-3 months). Tindell [1] said that vermicompost is the final result of the decomposition of organic material by earthworms, which produces rich nutrients, organic fertilizer, and soil improvement. The advantages of compost and vermicompost are as follows: 1) Able to improve soil properties (physical, chemical, and biological); 2) Able

* Corresponding author: riwandi@unib.ac.id

to improve soil health and quality; 3) Able to provide nutrients in the soil so that the soil becomes fertile; 4) Environmental friendly; 5) Raw materials are abundantly available in nature; 6) Free of pests and diseases; 7) Easy to make. These were the opinions of researchers who said that vermicompost fertilizer contains available nutrients and can improve soil structure by increasing soil porosity, soil aeration, and soil moisture holding capacity, which ultimately results in increased plant growth [2-6]. Compost and vermicompost had N levels of 1.9 % and 1.4%, respectively, C/N ratios of 13.6 and 20.6, P 2% and 1.8%, K 0.8% and 1.8% [7]. According to Allen [8], the Ca and Mg nutrient levels were Ca 2.27 % and 4.40%, respectively, and Mg 0.57% and 0.46%. Compost and vermicompost have their respective advantages in providing nutrients for plant growth. Therefore, it is very urgent to research compost and vermicompost.

The issue of Entisol was poor fertility because it had a clayey sand texture, so it easily allowed water and nutrients to pass the soil and less available to be absorbed by plants. The number of living organisms is also less so that the soil's nutrient cycling process (C, N, P, K, Ca, Mg, and S) moves slowly. The growth of corn plants depends on the availability of soil nutrients. Therefore, to be able to provide soil nutrients, compost and vermicompost are used.

The research aims to increase the growth of corn plants of the BISI 18 variety, especially plant height, leaf area, dry weight of corn plants, and dry weight of corn plants by applying compost and vermicompost to Entisol.

The novelty of this research is reflected in the concept and technology of compost and vermicompost on Entisol soil, which is very rare, thus opening up opportunities for the use of these two fertilizers to be much more open.

2 Materials and methods

2.1 Location and time of research

This research was conducted in Beringin Raya Village, Pondok Kelapa District, Bengkulu City. The geographical coordinates are located at *Latitude* -3.757609, *Longitudinal* 102.261062. The research period starts from June 2023 to August 2023.

2.2 Research materials

The materials used mainly compost from the compost warehouse of the Faculty of Agriculture, University of Bengkulu and vermicompost from Slupu Rejang village, Curup city, Bengkulu, with the owner Zainal Muktamar. The essential fertilizers were Urea, SP-36, and KCl. The lime used Dolomite with a grain diameter of 100 mesh. The corn seeds used the BISI 18 variety. The pesticide used the active ingredients Emamectin Benzoate 30 EC and Carbofuran 3%.

2.3 Experimental design

This research used a Complete Randomized Block Design (CRBD) with two factors. These were 0, 5, 10, 15, and 20 $TonHa^{-1}$ fertilizer levels and type of fertilizer, namely compost and vermicompost, with three replications, so the number of experimental units was 30. Each experimental plot measures 3m x 1m, and the planting distance was 0.75m x 0.20m. The number of corn plants per plot was 20 plants. The distance between plots and replications was 1m, respectively.

2.4 Research stages

A soil survey was carried out to see the fertility level of Entisol and analyze the soil properties at the Soil Science Laboratory. Entisol was cleaned of weeds, plots were made, and compost and vermicompost were applied according to the treatment. Compost and vermicompost were mixed evenly in each plot. Two BISI 18 corn seeds mixed with Furadan 3 G with the active ingredient Carbofuran 3% were immersed in the planting hole ± 2 cm. Urea, SP36, and KCl essential fertilizers were given at 175 $KgHa^{-1}$, 100 $KgHa^{-1}$, and 50 $KgHa^{-1}$, respectively. The basic fertilizer was put into the hole adjacent to the planting hole 2.5 cm away. The use of dolomite lime $CaMg(CO_3)_2$ is based on 1.5 x soil Al-dd content (cmol(+)kg^{-1}). They were watering every day if it didn't rain. Weed control by weeding grass, pests, and diseases is sprayed with Emamectin Benzoate 30 EC solution. If there are plants infected with disease, they are immediately taken and destroyed by immersing them in the ground. Harvest in the vegetative phase by taking three corn plants as a sample. Observations of corn plant variables consisted of plant height observed every week for 6 weeks, and leaf area calculated every week for 6 weeks, wet plant stover weight, and dry weight of corn plants taken at the time of vegetative harvest. The weight of the wet and dry stover was weighed using a digital balance. The weight of the dry stover was obtained after drying it in an oven at a temperature of 80 ^{o} C for more than 4 hours or until the weight of the plant stover was constant.

2.5 Statistic test

The research data were statistically analyzed using the F test at α 5% and further tests using the DMRT test (*Duncan's Multiple Range Test*).

3 Results and discussion

Table 1 shows that the C-organic content is 4.40% high, N-total 0.24% (medium), P-Bray 1 6.17 ppm (low), K-dd 0.33 cmol(+)kg^{-1} (low), Ca-dd 0.39 cmol(+)kg^{-1} (low), Mg-dd 0.26 cmol(+)kg^{-1} (very low), Al-dd 1.48 cmol(+)kg^{-1} (very low), and pH (H_2O 1:2.5 w/v) 6.0 (slightly acidic) [9]. The chemical properties of Entisol, especially essential nutrients (P, K, Ca, and Mg), are classified as low to very low, with the soil acidity level slightly acidic.

Table 1. Chemical properties of soil.

Soil Example	C-organic	N-total	P-Bray 1	K-dd	Ca-dd	Mg-dd	Al-dd	pH (H20)
	%		ppm	cmol(+)kg^{-1}				1:2.5b/v
Entisol	4.40	0.24	6.17	0.33	0.39	0.26	1.48	6.0

Note: dd = exchangeable, b = weight of soil , v = volume of distilled water

When comparing the chemical properties of soil in Table 1 with the chemical properties of soil from Kandang Mas village and other Bengkulu Coastal areas, it is almost the same, especially C-organic 3.34%, N-total 0.27%, P-Bray 1 6.6 ppm, K-dd 0.15 cmol(+)kg^{-1}, pH (H_2O) 5.03 [10]. The quality of soil from the results of this research is low.

Table 2. Soil particle size distribution and texture class.

Soil Example	Soil Particle Size Distribution			Texture Class
	Sand (%)	Dust (%)	Clay (%)	USDA
Entisol	81.56	10.21	8.23	Clay Sand

Description: Clayy sand = Loamy sand

Table 2. shows that Entisol is dominated by 81.56% sand with a clayey soil texture class. The USDA triangle defines entisol soil texture classes. The clayey sandy soil texture means Entisol quickly passes nutrients and water from the soil layer to the bottom.

Table 3. Chemical properties of vermicompost and compost fertilizer.

Organic fertilizer	pH (H_2O)	C-organic	N-total	C/N Ratio	P-total	K-total	Ca-total	Mg-total
	(%)				(%)			
Vermicompost	7.50	21.59	2.65	8	1.34	0.94	1.36	0.28
Compost	7.20	17.33	2.35	7	1.17	0.36	1.66	0.54

Note: b = weight of soil, v = volume of distilled water

Table 3. shows that the pH (H_2O) and C-organic of vermicompost and compost have met the technical requirements for organic fertilizer with a pH of 4-8 and C-organic of at least 15% [9]. According to [10], vermicompost has an N-total of 1.41%, P-total of 0.77%, and K-total of 2.14%. The N, P, and K analyses of vermicompost (Table 3) are superior to those of [10] unless K is lower. According to Isroi [11], compost has met the quality standards for compost fertilizer, namely pH (H_2O) 6-7.49, C-organic 9.80-32%, N-total 0.40%, P 0.10%, K 0.20%, Ca 25.50% (maximum), and Mg 0.60% (maximum). [12] said that quality compost fertilizer has a C/N ratio of 6.75, C-organic 18.21%, nitrogen (N) 2.08%, phosphorus (P) 0.31%, potassium (K) 1, 14%, Ca 0.29%, Mg 0.26% [12]. When comparing the results of the analysis of the chemical properties of compost fertilizer (table 3) with those stated by Riwandi [12], compost is superior, except for the lower K content.

Table 4. Plant height (TT), leaf area (LD), wet stover weight (BBB) and dry stover weight (BBK) of corn plants.

Treatment	TT (cm)	LD (cm2)	BBB (gplant $^{-1}$)	BBK (gplant $^{-1}$)
P_1D_0	194.6 ^{ab}	698.3 ^{ab}	366.8 ^{c}	136.0 ^{b}
P_1D_1	204.6 ^{ab}	726.6 ^{ab}	626.5 ^{ab}	228.8 ^{a}
P_1D_2	194.2 ^{ab}	743.3 ^{ab}	624.3 ^{ab}	228.8 ^{a}
P_1D_3	210.2 ^{a}	775.0 ^{ab}	615.5 ^{ab}	194.0 ^{ab}
P_1D_4	211.5 ^{a}	739.0 ^{a}	710.5 ^{a}	214.8 ^{a}
P_2D_0	206.8 ^{ab}	738.3 ^{ab}	331.6 ^{c}	130.3 ^{b}
P_2D_1	206.8 ^{ab}	812.0 ^{a}	506.8 ^{b}	190.3 ^{ab}
P_2D_2	166.0 ^{b}	555.6 ^{b}	546.5 ^{b}	195.8 ^{ab}
P_2D_3	189.5 ^{ab}	739.0 ^{ab}	598.6 ^{ab}	192.0 ^{ab}
P_2D_4	199.5 ^{ab}	709.0 ^{ab}	635.0 ^{ab}	214.0 ^{a}

Note: P_1D_0 = Vermicompost 0 TonHa $^{-1}$; P_1D_1 = Vermicompost 5 TonHa $^{-1}$; P_1D_2 = Vermicompost 10 TonHa $^{-1}$; P_1D_3 = Vermicompost 15 TonHa $^{-1}$; P_1D_4 = Vermicompost 20 TonHa $^{-1}$; P_2D_0 = Compost 0 TonHa $^{-1}$; P_2D_1 = Compost 5 TonHa $^{-1}$; P_2D_2 = Compost 10 TonHa $^{-1}$; P_2D_3 = Compost 15 TonHa $^{-1}$; P_2D_4 = Compost 20 TonHa $^{-1}$

3.1 Corn plant height

The interaction between vermicompost fertilizer (P_1) and vermicompost dose gave the highest plant height at a vermicompost dose of 20 TonHa $^{-1}$, namely 211.5 cm. According to

Nurlaila [13], the highest corn plant height of 195.5 cm was obtained at a vermicompost dose of 13.5 TonHa $^{-1}$. [14] obtained the highest corn plant height of 160.7 cm at a vermicompost dose of 9.59 TonHa $^{-1}$. Compost fertilizer (P_2) at a dose of 10 tonHa $^{-1}$ provides the highest corn plant height (100.50 cm) [15]. When comparing vermicompost fertilizer (P_1) and compost (P_2) at various fertilizer doses, it was found that vermicompost fertilizer (P_1) was better than compost fertilizer (P_2) in increasing the highest plant height.

3.2 Leaf area

The interaction between vermicompost fertilizer (P1) and vermicompost dose gave the highest leaf area at a vermicompost dose of 20 TonHa $^{-1}$, namely 739.0 cm ^{2}. The interaction of compost fertilizer (P_2) and compost dose gave the highest leaf area at a compost dose of 5 TonHa $^{-1}$, namely 812.0 cm^2. Observing the growth of corn plants at the age of 52 days after planting (DAT) provides an opportunity for the availability of nutrients in the soil through the decomposition of vermicompost and compost so that the corn plants absorb these nutrients optimally [16]. The greater leaf area gives corn plants more significant opportunities for photosynthesis so that the plants have a higher chance of producing higher yields.

3.3 Wet stove weight

The interaction between vermicompost fertilizer (P_1) and vermicompost dose gave the highest wet stover weight at a dose of 20 TonHa $^{-1}$, namely 710.5 gplant $^{-1}$ or 47,367 KgHa $^{-1}$. [14] said that the highest wet stover weight was 27,561 KgHa $^{-1}$ at a vermicompost fertilizer dose of 10.2 TonHa $^{-1}$. When compared between the two, the highest corn plant height from this study is better than the corn plant height obtained by Nurjanah et al. [14].

3.4 Dry stove weight

The interaction between vermicompost fertilizer (P_1) and vermicompost dosage gave the highest dry stover weight at vermicompost dosages of 5 TonHa $^{-1}$, 10 TonHa $^{-1}$, and 20 TonHa $^{-1}$, namely respectively 228.8 g plant $^{-1}$ (15,253 KgHa $^{-1}$), 228.8 g plant $^{-1}$ (15,253 KgHa $^{-1}$), and 214.8 g crop $^{-1}$ (14,320 KgHa $^{-1}$). The interaction between compost fertilizer (P2) and compost dose gave the highest dry stover weight of 214.0 g plant -1 (14,267 KgHa $^{-1}$) at a compost dose of 20 TonHa $^{-1}$. Nurjanah et al. [14] obtained The highest weight of dry corn stover was 5,675.5 KgHa $^{-1}$ with a vermicompost dosage of 9.9 TonHa $^{-1}$. Thus, when compared, the dry stover weight of corn plants from this study is 2-3 times higher than the dry stover weight of corn plants from the research results of Nurjanah et al. [14].

4 Conclusion

Based on the results and discussion, it can be concluded that 1) Entisol soil is poor in nutrients and has a clayey sand texture, 2) Vermicompost has better advantages than compost fertilizer in increasing the growth of corn plants, 3) The highest corn plant height (211.5 cm) obtained from vermicompost at a dose of 20 TonHa $^{-1}$. 4) The highest leaf area of corn plants (812 cm^2) was obtained with 5 tonHa^{-1} compost and 739 cm^2 with 20 TonHa $^{-1}$ vermicompost. 5) The highest wet stover weight of corn plants (710.5 g plant $^{-1}$ or 47,367 KgHa $^{-1}$) was obtained from 20 TonHa^{-1} vermicompost. 6) The highest dry stover weight of corn plants (228.8 g plant^{-1} or 15,253 KgHa^{-1}) was obtained at 5 tonHa^{-1} vermicompost and 214.0 g plant $^{-1}$ or 14,267 KgHa $^{-1}$ at 20 tonHa^{-1} compost.

The author would like to express his sincere thanks to the Head of the Institute for Research and Community Service (LPPM) at the University of Bengkulu for providing funding for Higher Education Excellence Research from the University of Bengkulu PNBP (Non-Tax State Revenue) for the 2023 Fiscal Year.

References

1. J. P. Tindell, Dep. Park. Recreat. Sacramento, CA (2010)
2. M. Tejada, I. Gómez, T. Hernández, and C. García, Soil Sci. Soc. Am. J. **74**, 525 (2010)
3. K. Hashemimajd, M. Kalbasi, A. Golchin, and H. Shariatmadari, J. Plant Nutr. **27**, 1107 (2004)
4. R. M. Atiyeh, J. Domínguez, S. Subler, and C. A. Edwards, Pedobiologia (Jena). **44**, 709 (2000)
5. R. D. Kale, B. C. Mallesh, B. Kubra, and D. J. Bagyaraj, Soil Biol. Biochem. **24**, 1317 (1992)
6. K. A. Handreck, (1986)
7. Naturland, *Vermicompost High-Grade Fertilizer for Improved Soil Fertility* (2018)
8. G. W. Dickerson, Coll. Agric. Home Econ. New Mex. State Univ. (2001)
9. Balittaland, *Technical Instructions for Soil, Water, Fertilizer and Plant Analysis* (Soil and Agroclimate Research and Development, Bogor, 2005)
10. Riwandi, Hasanudin, G. Herry, and Anandyawati, (2020)
11. Isroi, *Compost* (BPBPI Bogor, Bogor, 2008)
12. M. Handajaningsih, in *IOP Conf. Ser. Earth Environ. Sci.* (IOP Publishing, 2018), p. 12030
13. N. Nurlailah and H. B. Setyawan, J. Bioind. (JOURNAL Bioind. **2**, 374 (2019)
14. N. Nurjanah, R. Riwandi, and H. Hasanudin, TERRA J. L. Restor. **3**, 45 (2020)
15. M. Handajaningsih and A. Munawar, J. Trop. Soils **20**, 11 (2016)
16. W. I. Sari, S. Fajriani, and S. Sudiarso, J. Produksi Tanam. **4**, (2016)