Potential of Vermicompost as Soil Improvement Material in Inceptisol

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Abstract. The aim of this study was to investigate the extent to which vermicompost can be used as a soil conditioner on Inceptisols. The study was conducted in the greenhouse of the Faculty of Agriculture, University of Sriwijaya. The material used in this investigation is Inceptisol, vermicompost made from goat, cow and chicken manure, water and material analysis of soil chemical properties. A completely randomised factorial design with two factors was used in this study. The first factor is the type of material treatment vermicompost (P) is P1 = vermicompost from goat manure, P2 = vermicompost from cow manure, and P3 = vermicompost from chicken manure. The second factor is the dose of vermicompost treatment (D): D0 = 0% vermicompost, D1 = 2.5% vermicompost, D2 = 5% vermicompost, and D3 = 7.5%. Based on the research results on the changes of some soil chemical properties after the application of vermicompost on Inceptisols, it can be concluded that the application of vermicompost on Inceptisols had a significant effect on the changes of pH, C-organic content, available P and K-dd in the soil, but no significant effect on the changes of total N content in the soil.

Keyword: Potential, Vermicompost, Soil Improvement Material, Inceptisol

1. Introduction

Inceptisols are the most important agricultural soils in Indonesia because they are widely distributed. Inceptisols are the largest soil type in Indonesia, accounting for about 70.52 million ha or 37.5% of the total land area of Indonesia. Inceptisols can be considered as soils that have great potential to support agricultural production in Indonesia. The main problem of these inceptisols is that they are poor in K and the pH of the soil is usually very acidic to slightly acidic. Management of this soil is more about enriching K and neutralizing the pH. Adding organic matter is also strongly recommended to improve soil fertility. Generally, the soil is found in marshy swamps and tidal marshes, whose cultivation techniques are largely determined by the management of micro-water and appropriate means of production [1]. According to [2], the degree of fertility of a soil or the ability of the soil to supply nutrients to a plant is very important, especially for inceptisols. One of the problems of soil fertility is the availability of nutrients, which is often a limitation of agricultural yields. Therefore, fertilization plays an important role in providing nutrients present in inceptisols. The use of chemical fertilizers can have a negative impact on the environment. The production of chemical fertilizers can not only pollute the environment, but also consume non-renewable natural resources such as phosphate rock.

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Organic fertilizers are very useful in increasing agricultural production on suboptimal soils, both qualitatively and quantitatively, and in reducing pollution. In the long run, the use of organic fertilizers can increase soil productivity and prevent soil degradation. Due to the wide variation in physical properties and nutrient contents, the effects of organic fertilizer use on soils and plants may vary [3]. To reduce the effects of environmental degradation, organic fertilizers must be used to increase soil fertility. One of the organic fertilizers that can be used is vermicompost or worm compost. Vermicompost is an organic fertilizer that is environmentally friendly and has its own advantages compared to other composts that we have known for a long time [4]. Vermicompost contains complete nutrients, both macro and micro elements, which are useful for plant growth [5]. According to [6], the application of vermicompost can increase soil pH or decrease soil acidity. Soil acidity decreased by 0.006 pH units per ton of vermicompost applied. In addition, application of vermicompost can neutralize aluminum and iron in the soil, reducing P fixation in the soil and increasing P availability in the soil. Each ton of vermicompost can increase the available P content of the soil by 1,035 ppm.

2. Materials and Methode

This study was conducted in the greenhouse of the Faculty of Agriculture, Sriwijaya University, and the analysis of the chemical properties of the soil was carried out in the Laboratory of Chemistry, Biology and Soil Fertility of the Department of Soil of the Faculty of Agriculture, Sriwijaya University, Indralaya. The equipment used in this study were a 5-mm sieve, a hoe, a balance, a hand sprayer, a polybag, and equipment for chemical analysis of soil. The materials used in this study were inceptisol, vermicompost, water, and soil chemical property analysis materials. This study was conducted using a factorial, completely randomised experimental design (RALF) with 2 factors: The first factor is the type of vermicompost material (P), namely P1 = vermicompost from goat manure, P2 = vermicompost from cow manure, and P3 = vermicompost from chicken manure. The second factor is the vermicompost dose based on soil weight (D), namely D0 = 0% vermicompost, D1 = 2.5% vermicompost, D2 = 5% vermicompost, and D3 = 7.5% vermicompost. Each treatment was repeated three times, making the total number of treatments 36. The soil was freed from roots, dried by the wind-drying method, and sieved with a 2-mm sieve. The soil is then weighed up to 5 kg and placed in polybags without holes. Vermicompost is evenly mixed into the soil, based on the condition of the field capacity. The soil was incubated in a greenhouse for about 2 months. The variables observed in this study were different soil chemical properties consisting of pH, organic carbon, total N, available phosphorus and K-dd, which were observed at the beginning and at the end of the study. The data obtained were statistically evaluated using the analysis of the pressures of the variety. If the factors are significantly different, another test is performed to determine the comparison between treatments using the BNT test (least significant difference) at the 5% level.

3. Results and Discussion

3.1 Characteristics of inceptisol.

The soil used in this study is an Inceptisol soil type from a swamp area in Talang Bubuh, Talang Kelapa district, Banyuasin regency, South Sumatra. The results of the analysis showed that the soil used for the study has a very acidic soil reaction with a pHof 3.36. This soil has a

very low availability of P, namely 1.35 mg/kg, while the content of organic C is high at 3.56% and the content of total N and K-dd is considered moderate at 0.27% and 0.38 cmol/kg, respectively. The limiting factors used in this study were soil pH, available P, Na, Ca and Mg.

3.2 Vermicompost Nutrient Content

The results of the analysis of the nutrient content of the worm compost used in the study are that chicken manure had the highest nutrient content with total N-0.59%, total P-0.45%, organic C-11.38%, and a C/N ratio of 19%. While the highest total K content was the type of vermicompost from goat manure, which was 0.18%, vermicompost from chicken manure had a low total K content of 0.05%.

3.2.1 Soil pH

The results of the analysis of variance show that the application of vermicompost on inceptisols had a very significant effect on the change in soil pH. The effect of vermicompost dosage factor on Inceptisols showed a very significant effect on the changes in soil pH.

Table 1 shows that the highest pH was obtained when treated with 5% vermicompost from cow manure (D2P2) with a deviated pH of 3.56, while treatment with 7.5% vermicompost from chicken manure (D3P3) with a pH of 3.49 was not significant. The best treatment dose was 5% vermicompost (D2) with a pH of 3.53, which was not significantly different from the treatment with 7.5% vermicompost (D3) with a pH of 3.50. The type of vermicompost material showed no significant difference.

Table 1. The Results Of The Analysis Of pH (H_20) Inceptisol Soil After Being Given Vermicompost and Incubating For 2 Months

Vermicompost Dose (%)	Type Of Vermicompost Material			Average
	Goat Manure (P_1)	Cow Manure (P_2)	Chicken Manure (P_3)	
0 (D_0)	$3,37^{a}$	$3,39^{a}$	$3,39^{a}$	$3,38^{a}$
2,5 (D_1)	$3,43^{ab}$	$3,51^{cd}$	$3,48^{bc}$	$3,48^{b}$
5 (D_2)	$3,51^{cd}$	$3,56^{d}$	$3,52^{cd}$	$3,53^{c}$
7,5 (D_3)	$3,51^{cd}$	$3,51^{cd}$	$3,49^{bcd}$	$3,50^{bc}$
Average	$3,46^{a}$	$3,49^{a}$	$3,47^{a}$	
BNT $_{0,05}$	0,069			

Note: Numbers followed by the same letter in the same column mean that they are not significantly different based on the BNT test at the 5% level

According to [6], worm compost added to the soil undergoes another decomposition process that produces organic acids such as humic acid and fulvic acid. These organic acids react with the aluminum in the soil to form chelates and precipitate the aluminum.

3.2.2 C-organic soil

From the results of the analysis of variance (Appendix 4), it is evident that the application of vermicompost on inceptisols had a very significant effect on the changes in soil organic C. The effect of vermicompost dosage factor on Inceptisols showed a very significant effect on the changes of organic C in soil. Based on Table 2. it can be seen that the highest soil organic C content was obtained in the treatment with 7.5% vermicompost from chicken

manure (D3P3) with soil organic C content of 60.75 g/kg, which was not significantly different from the treatment with 5% vermicompost from goat manure (D2P1) with soil organic C content of 57.66 g/kg. The best treatment dose was the treatment of 7.5% vermicompost (D3) with C organic soil 58.86 g/kg, which was significantly different from the treatment of 5% vermicompost (D2) with C organic soil 55.86 g/kg. However, the type of vermicompost material was not significantly different from the others.

Table 2. The Results of The Analysis C-Organic Content in Inceptisol After Being Given Vermicompost and Incubating For 2 Months (g/kg)

Vermicompost Dose (%)	Type Of Vermicompost Material			Average
	Goat Manure (P_1)	Cow Manure (P_2)	Chicken Manure (P_3)	
0 (D_0)	37,58^{a}	35,27^{a}	34,75^{a}	35,87^{a}
2,5 (D_1)	42,22^{ab}	44,79^{bc}	44,28^{bc}	43,76^{b}
5 (D_2)	57,66^{de}	55,35^{d}	54,57^{d}	55,86^{c}
7,5 (D_3)	57,66^{de}	58,18^{de}	60,75^{e}	58,86^{d}
Average	48,78^{a}	48,70^{a}	48,59^{a}	
BNT $_{0,05}$	4,845			

Note: Numbers followed by the same letter in the same column mean that they are not significantly different based on the BNT test at the 5% level

It was found that the administration of vermicompost to Inceptisol with increasing dosage increased the organic C content very well. This is consistent with the results of the study of [7], according to which the application of compost and manure can increase the organic C content of the soil. The more organic manure is added to the soil, the more the soil organic C content increases. This is because the organic C content in each dose of vermicompost is certainly different. The higher the dose, the higher the C organic content of the soil.

3.2.3 N-total

The results of the analysis of variance showed that the application of vermicompost on inceptisols had no significant effect on the changes in total soil N content.

Table 3. The Results of The Analysis N-total Content in Inceptisol After Being Given Vermicompost and Incubating For 2 Months (g/kg)

Vermicompost Dose (%)	Type Of Vermicompost Material			Average
	Goat Manure (P_1)	Cow Manure (P_2)	Chicken Manure (P_3)	
0 (D_0)	2,77^{ab}	2,60^{ab}	2,78^{ab}	2,72^{a}
2,5 (D_1)	2,58^{ab}	3,03^{b}	2,76^{ab}	2,79^{a}
5 (D_2)	2,82^{ab}	3,01^{b}	3,22^{b}	3,02^{a}
7,5 (D_3)	3,06^{b}	2,15^{a}	2,78^{ab}	2,66^{a}
Average	2,81^{a}	2,70^{a}	2,89^{a}	
BNT $_{0,05}$	0,812			

Note: Numbers followed by the same letter in the same column mean that they are not significantly different based on the BNT test at the 5% level

Based on Table 3. it can be seen that the highest total N treatment was 5% vermicompost from chicken manure (D2P3) with a total soil N of 3.22 g/kg, which was not significantly different from the treatment with 2.5% vermicompost from goat manure (D1P1) with a soil organic C of 2.58 g/kg.

The best treatment dose was 5% vermicompost (D2) with a total soil N content of 3.02 g/kg, which was not significantly different from the other doses. However, the different types of vermicompost were not significantly different from each other. It is assumed that this insignificant change in total N content is due to the quality of the vermicompost or the content

of N compounds in the vermicompost. According to [8], the quality of vermicompost depends on the type of litter material, the food provided, the type of earthworm, and the age of the vermicompost. Other possible influences affect the total N content in the soil, which is used as a food source by soil microorganisms.

3.2.4 P-available

The results of the analysis of variance show that the application of vermicompost on inceptisols has a very significant effect on the change of P availability in the soil. The effect of vermicompost dosage factor and type of vermicompost material on Inceptisols showed a very significant effect on the changes of P availability in soil. The interaction between the dose treatment and the type of vermicompost material had a significant effect on the changes in soil P availability.

Table 4. The Results of The Analysis P-available Content in Inceptisol After Being Given Vermicompost and Incubating For 2 Months (mg/kg)

Vermicompost Dose (%)	Type Of Vermicompost Material			Average
	Goat Manure (P_1)	Cow Manure (P_2)	Chicken Manure (P_3)	
0 (D_0)	$4,13^{a}$	$6,00^{ab}$	$9,50^{e}$	$6,54^{a}$
2,5 (D_1)	$6,35^{bc}$	$7,15^{bcd}$	$14,45^{f}$	$9,32^{b}$
5 (D_2)	$7,00^{bcd}$	$8,20^{cde}$	$15,70^{f}$	$10,30^{b}$
7,5 (D_3)	$14,73^{f}$	$8,75^{de}$	$15,75^{f}$	$13,08^{c}$
Average	$8,05^{a}$	$7,53^{a}$	$13,85^{b}$	
BNT $_{0,05}$	1,972			

Note: Numbers followed by the same letter in the same column mean that they are not significantly different based on the BNT test at the 5% level

Based on Table 4. it can be seen that the highest available P was the 7.5% vermicompost treatment from chicken manure (D3P3) with a soil available P of 15.75 mg/kg, which was not significantly different from the 2.5% vermicompost treatment from goat manure (D1P3) with a soil available P of 14.45 mg/kg. The best treatment dose was the 7.5% vermicompost (D3) treatment with soil P availability of 13.08 mg/kg, which was significantly different from the 5% vermicompost (D2) treatment with P availability of 10.30 mg/kg. The best type of vermicompost material is vermicompost from chicken manure (P3) with available P of 13.85 mg/kg, which was significantly different from vermicompost from goat manure (P1) with available P of 8.05 mg/kg

This increase in P availability is due to the presence of organic acids produced after the decomposition process of vermicompost. According to [9], inceptisols have low available P due to the very high solubility of the elements Al, Fe and Mn in acidic soils, so they tend to bind phosphate ions to insoluble phosphate and are not available to plants.

3.2.5 K-dd

The results of the analysis of variance showed that the application of vermicompost on inceptisols had a very significant effect on the changes in soil K-dd content. The effect of vermicompost dose factor and type of vermicompost material on Inceptisols showed a very significant effect on the changes of K-dd content in soil. The interaction between dose treatment and type of vermicompost material had a significant effect on the changes of K-dd value in soil.

Table 5. The Results of The Analysis K-dd Content in Inceptisol After Being Given Vermicompost and Incubating For 2 Months (cmol/kg)

Vermicompost Dose (%)	Type Of Vermicompost Material			Average
	Goat Manure (P_1)	Cow Manure (P_2)	Chicken Manure (P_3)	
0 (D_0)	0,55^{c}	0,33^{abc}	0,28^{a}	0,39^{a}
2,5 (D_1)	0,94^{d}	0,39^{abc}	0,39^{abc}	0,57^{b}
5 (D_2)	1,02^{de}	0,48^{bc}	0,44^{abc}	0,65^{bc}
7,5 (D_3)	1,19^{e}	0,53^{c}	0,46^{abc}	0,73^{c}
Average	0,93^{b}	0,43^{a}	0,39a	
BNT $_{0,05}$	0,195			

Note: Numbers followed by the same letter in the same column mean that they are not significantly different based on the BNT test at the 5% level

Based on Table 5, it can be seen that the highest K-dd treatment was 7.5% vermicompost from goat manure (D3P1) with soil K-dd of 1.19 cmol/kg, which was not significantly different from the 5% vermicompost treatment from goat manure (D2P3) with soil P availability of 1.02 cmol/kg. The best treatment dose was the 7.5% vermicompost (D3) treatment with soil K availability of 0.73 cmol/kg, which was not significantly different from the 5% vermicompost (D2) treatment with soil K availability of 0.65 cmol/kg. The best type of vermicompost material is vermicompost from goat manure (P1) with a K-dd of 0.93 mg/kg, which is significantly different from vermicompost from cow manure (P2) with a K-dd of 0.43 cmol/kg.

The K-dd content tends to increase with increasing vermicompost dose. Vermicompost from goat manure is very different from vermicompost from cow and chicken manure. This is believed to be due to the high potassium content in vermicompost derived from goat manure. It is believed that the increase in K-dd is influenced by the increase in CEC in the soil. According to [10], an increase in soil CEC increases the ability of the soil to bind K so that K is not leached.

4. Conclusion

Based on the research results on the changes of some soil chemical properties after the application of vermicompost on Inceptisols, it can be concluded that the application of vermicompost on Inceptisols had a significant effect on the changes of pH, C-organic content, available P and K-dd in the soil, but no significant effect on the changes of total N content in the soil. The interaction between the material type treatment and the vermicompost dose showed a very significant effect on the changes in soil P availability and a significant effect on the changes in soil K-dd, but no significant effect on the changes in soil pH, soil C organic content, and total soil N content.

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