Effect doses level of vermigot fertilizer on the chemical and biological characteristics of Inceptisol and Maize (*Zea mays* L.) production

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Abstract. Vermigot is an organic fertilizer produced from a combination of vermicompost and BSF compost. By applying Vermigot fertilizer to maize on Inceptisol, it's hoped that it can help increase maize production and improve the chemical-biological characteristics of Inceptisol. This research aims to determine the effect of various doses of Vermigot fertilizer on the chemical and biological properties of Inceptisol soil and maize production This study used a Non Factorial Randomized Complete Block Design (RCBD), including: V_0 = 0 gram, V_1 = 100 gram, V_2 = 200 gram and V_3 = 300 gram with 6 replications to obtain 24 treatments. Parameters observed included maize production: shoot dry weight (g), root dry weight (g), corncob weight (g), final plant height of the vegetative phase (cm) and stem diameter at the end of the vegetative phase (mm). Inceptisol soil chemical-biological properties: pH soil, C-Organic (%), N-Total (%), Available-P (ppm) and microbial population (CFU/g). The maize variety used was Pioneer 35. The results showed that the application of various doses of Vermigot had a significant effect on the chemical of the Inceptisol, pH soil with the highest treatment at the V_3 (300 g) of 6.80 (neutral) and the available-P of the soil with the best treatment V_3 (300 g) of 31.90 ppm. Microbial population had no significant effect and maize production (*Zea mays* L.) had a significant effect, the weight of corn cobs with the best treatment V_3 (300 g) of 250.56 gram.

1 Introduction

Inceptisols are young soils and are starting to develop. The profile has a horizon that forms rather slowly as a result of alteration of the parent material. The horizons do not show the results of intensive weathering. A clear accumulation horizon of clay and iron and aluminium oxides is absent in these soils. The characteristic of Inceptisol soil is that it has a fairly thick solubility, about 1-2 meters. Black or gray to dark brown in color, with soil texture consisting of dust, humus and alluvium, loose soil structure, loose consistency, pH 5.0 - 7.0.

The problem with Inceptisol soil is the relatively acidic soil acidity, the content of exchange bases such as Ca^{2+}, Mg^{2+}, K^+ and low base saturation, besides the low content of

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available phosphorus. One way to improve the fertility level of Inceptisol is by adding soil organic matter. Research by [1] revealed that the soil fertility status of oil palm land with a planting age of 5 years on Inceptisol soil if averaged, has CEC, C-organic, base saturation, P-total, and K-total values which are classified as fertility status. very low. The low status of soil fertility is due to the very low content of CEC, base saturation, total P, and total K and low C-organic content.

The addition of organic matter is one of the activities undertaken to improve soil fertility and crop production. In most soils, the percentage of organic matter is relatively low, but its effect on soil function is significant. This ever-changing soil composition has a great influence on many physical, chemical and biological properties of the soil as well as the functions of the soil ecosystem, such as improving soil agglomeration, enhancing soil exchange. and nutrients, retain soil moisture, reduce soil compaction and hardness, and by increasing soil moisture, water seeps into the soil [2].

The addition of inputs in the form of organic fertilizers has also been widely practiced, especially in maize. However, no innovation has yet been found when combining the use of earthworms and black fly larvae, also known as biotransformation. Ichwan et al [3] stated that vermicompost (the result of decomposition of earthworms) is able to increase the growth and yield of melon plants by increasing stem diameter, leaf area, fruit diameter and fruit weight. The vermicompost dosage of 25 ton ha^{-1} is the dosage that provides the best melon growth and yield, with a weight per fruit of 1.8 kg. Fauzi et al [4] stated that kasgot (the result of maggot decomposition) on the growth of mustard greens showed that there was significance in the height and fresh weight of mustard plants, but the number and area of mustard leaves showed no significant difference. The kasgot treatment of 100 gr/3 kg soil showed the highest mustard plant height (38.03 cm), the largest leaf area (36 cm2) and the largest wet weight (220 gr). Compost is produced from a combination of biological treatment of waste using two decomposing agents, earthworms and Black Soldier Fly larvae, which are vermicompost.

A study on fertilizer Vermigot by [5] stated that vermigot fertilizer at a dose of 200 g/pot was able to produce pakchoy vegetables with a fresh weight of 57 grams and was able to add nutrients to Ultisol soil at a higher dose, namely 300 g/pot. Therefore, research with Vermigot fertilizer on maize plants on Inceptisol soil needs to be further investigated to determine the effect of various doses of Vermigot fertilizer on the chemical and biological properties of Inceptisol soil and maize production.

2 Materials and methods

This research was carried out from September 2021 to December 2021 in Medan Baru District, North Sumatra with an altitude of ±25 m above sea level. The materials used were vermigot compost, maize kernels of the Pioneer 35 variety, fertilizers (Urea, Triple Super Phosphate and Potassium chloride), Inceptisol soil, water and chemicals for analysis purposes. The tools used are polybags, scales, labels, plastic, rulers, and stationery.

This study used the Non-Factorial Randomized Complete Block Design (RCBD) which included: V_0 = 0 grams; V_1 = 100 grams; V_2 = 200 grams; and V_3 = 300 grams with 6 replications to get 24 treatments. Data were statistically analyzed using a two-way Analysis of Variance (ANOVA), and Tukey's HSD 5%.

The implementation of the research began with the production of Vermigot fertilizer. Vermigot fertilizer used as a treatment is the result of decomposition by two decomposer agents, namely earthworms and BSF larvae with a composition of cow dung, quail dung, and crushed straw (3:2:1). Next, an initial analysis of Vermigot fertilizer was carried out which included pH, water content (%), C-Organic (%), N-Total (%), P_2O_5 (%) and C/N Ratio.

Soil samples were taken from several sampling points at random at a depth of 0-20 cm from the soil surface, then composited, air-dried, sifted with a soil sieve, and placed in a polybag equivalent to 10 kg of oven-dry soil weight. Next, an initial analysis of the Inceptisol soil was carried out which included pH, C-Organic (%), N-Total (%), and available P (ppm). The basic fertilizer application of Urea 250 ppm N was divided into 3 times at planting, 30 days after planting (DAP) and 45 DAP, Potassium chloride 100 ppm K was divided into 2 times at planting and 45 DAP and Triple Super Phosphate (TSP) was given 10 days before planting. Application of Vermigot fertilizer treatment was given according to the dose when the maize seeds were a week and applied every two weeks until the vegetative period ended. Harvesting was carried out in two stages, namely at the end of the vegetative crop (8 weeks after planting) and at the end of the generative plant (14 weeks after planting).

Parameters were observed which included shoot dry weight (g), root dry weight (g), corn cob weight (g), plant height at the end of the vegetative phase (cm), and stem diameter at the end of the vegetative phase (mm). Chemical and biological characteristics of Inceptisol soil: soil pH H_2O (electrometric method), C-Organic (%) Walkley and Black method, N-Total (%) Kjeldhal method, P-Available (ppm) Bray II method, microbial population (CFU/ g).

3 Results and discussion

3.1 Measurement of initial soil chemical characteristics

The soil that will be given treatment is first analyzed for the chemical properties of the initial soil, to determine the fertility of the soil. The results of the analysis of the initial soil chemical properties can be seen in Table 1.

Table 1. The results of preliminary analysis of Inceptisol soil.

Soil Chemical Properties	Value	Criteria
pH H_2O	6.00	Neutral
C-Organic (%)	1.05	Low
N-Total (%)	0.09	Very Low
P-available (ppm)	5.65	Low
K-exch (me/100 g)	0.23	Low
CEC (me/100 g)	18.6	Low
Base saturation (%)	16.70	Very Low

Inceptisol soil is low in fertility but it can still be improved because of its neutral pH. Improved soil fertility can be achieved by adding organic matter. However, donated compost must first have its nutrient content analyzed and have a C/N ratio value of <20.

Table 2. The results of preliminary analysis of Vermigot fertilizer.

Chemical-Biological Characteristics	Value
pH H_2O	6.85
Water content (%)	71.0
C-Organic (%)	39.65
N-Total (%)	2.00
P_2O_5 (%)	2.37
K_2O (%)	1.25
C/N Ratio	19.82
Microbe Population (CFU/ml)	233 x 10^8

Based on the organic fertilizer quality standards, the value of Vermigot fertilizer to be applied has met the standards set by SNI 19-7030-2004 so that it is suitable for application to plants.

3.2 Effect of Vermigot on the Chemical characteristics of Inceptisol

The results of the analysis of the chemical properties of the treated Inceptisol soil can be seen in Table 3.

Table 3. The average Inceptisol soil chemical characteristics against Vermigot fertilizer doses.

Treatments	Parameter				
	pH	C-Organic (%)	N-Total (%)	P-Available (ppm)	K-exch (me/100g)
V_0 (control)	6.00 ^{b}	1.40	0.15	26.50 ^{c}	0.25
V_1 (100 g)	6.50 ^{b}	1.47	0.45	28.63 ^{c}	0.59
V_2 (200 g)	6.70 ^{a}	1.50	0.54	30.15 ^{b}	0.80
V_3 (300 g)	6.80 ^{a}	1.45	0.55	31.90 ^{a}	0.81

Note: *significant p ≤0.05 means in a column followed by a common letter are not significantly different at the 0.05 lavel by Tukey.

The average results of Inceptisol soil chemical properties after applying Vermigot fertilizer in several doses. Based on the results of variance analysis, the effect of pH is very real after applying Vermigot fertilizer. The pH with the highest value was in treatment V3 (Vermigot 300 g), namely 6.80. This occurs due to appropriate treatment, apart from that the added organic material undergoes a decomposition process with the help of bacteria in Vermigot fertilizer which has a high microbial population, so that it can increase the soil pH due to the release of organic acids contained in the compost. Anwar et al [6] states that compost that undergoes a decomposition process in the soil will release organic acids so that soil pH can increase. The compost added must also be seen from the nature of the compost.

Apart from that, the Vermigot fertilizer applied is classified as perfectly mature with a C/N ratio of 19.82, because the maturity of the compost greatly influences its performance when applied to the soil. If the added compost is not perfectly ripe, the soil pH will experience a slow increase. The beneficial effects of using manure on agricultural land are generally based on the ability to change soil properties beneficially, such as the availability of nutrients for plants, soil pH, cation exchange capacity, and air retention capacity [7].

C-organic is the carbon content contained in soil organic matter. Based on the results of the analysis showed that the application of organic matter had no significant effect on soil C-organic. This can be caused by microbes using organic C as an energy source, thereby causing a decrease in organic C in the soil. As stated, [8] the compost added to the soil contains C-organic, and the C-organic contained in the compost is utilized by soil microbes, after the organic matter is decomposed the microbes reuse the organic matter as a food source so that it is suspected to cause C-organic sinking into the ground. In a study of Min et al [9], CO_2 emissions decreased with different compost substitution rates and the relative abundance of Bacillus increased after compost replacement. This leads to carbon sequestration in the soil, resulting in less microbial breakdown of organic matter and less metabolism of mineral nutrients. Different rates of compost substitution lead to differences in the amount of organic carbon fixed in the soil.

N-total is the most important essential nutrient needed by plants. Based on the results of the analysis of variance, N-total had no significant effect after adding organic matter but had high criteria. High N in the soil can be caused by the presence of microbes that are able to fix N in the air, which causes N in the soil to increase. This is in line with Ma'Munir [10] which states that one of the bacteria in compost is *Azotobacter sp*. and *Azoospirilium sp*. which is able to fix N from the atmosphere and can be absorbed by plants and soil.

Phosphorus is an element needed by plants in large quantities. Not all of the phosphorus contained in the soil is available to plants, especially as the phosphorus contained in Inceptisol soil is very low. Based on the ANOVA test, administration of Vermigot had a significant effect on changes in available P-pm (ppm). The highest amount of available phosphor was in treatment V3 (Vermigot 300 g), namely 31.90 ppm. With this dose, one of the problems with Inceptisol soil, namely low available P, can be overcome by using Vermigot fertilizer. In the initial analysis of inceptisol soil, results were obtained of 5.65 ppm which was classified as low class. In the final results after application, the P-available treatment in the soil increased the availability of P nutrients and was classified as a very high P-available criterion. This increase in P-available has increased two to three times. It is suspected that the P- available in Inceptisol soil binds to Al, Fe, and Ca and binds to clay to form an insoluble clay phosphate complex. Compost contains different organic materials with different concentrations of the P form. In the study of Lanno et al [11], 7.75 g P/kg in fish waste compost and more than 50% of P in all fertilizers were present in an unstable and potentially bioavailable form.

Potassium is a nutrient that is very active in carrying out exchanges in the soil. Table 3 shows that the application of organic matter has no significant effect on soil K-exch. This is presumably because plants need potassium for growth.

3.3 Effect of Vermigot on the Biological characteristics of Inceptisol

The results of the analysis of the chemical properties of the treated Inceptisol soil can be seen in Table 4. The highest microbial population in Inceptisol soil planted with corn and Vermigot fertilizer was found on average in the fourth week after planting at all doses. Vermigot fertilizer dose treatment of 300 grams showed the largest population in the fourth week among all treatments, 254.33 $\times 10^6$ CFU/g.

Table 4. The average Inceptisol soil biological characteristics against Vermigot fertilizer doses.

Microbe Population (...x106CFU/g)				
Time (Weeks After Planting)	Treatments			
	V0 (Control)	V1 (100 g)	V2 (200 g)	V3 (300 g)
0	36.78 ± 16.6 c	36.35 ± 20.0 c	41.90 ± 23.8 c	35.80 ± 29.0 c
2	38.65 ± 19.5 c	114.01 ± 35.6 b	180.76 ± 16.0 a	230.35 ± 70.5 a
4	49.05 ± 29.3 c	178.65 ± 39.0 b	195.80 ± 72.4 a	254.33 ± 48.6 a
6	38.50 ± 16.0 c	138.50 ± 16.0 b	181.05 ± 16.0 a	220.40 ± 50.3 a
8	40.59 ± 26.8 c	110.59 ± 26.8 b	167.45 ± 45.6 b	190.80 ± 45.0 a
10	38.34 ± 19.5 c	98.34 ± 17.6 c	150.00 ± 19.5 b	187.05 ± 35.6 a
12	34.30 ± 20.3 c	54.30 ± 29.3 c	135.55 ± 45.8 b	175.50 ± 74.5 a
14	30.13 ± 20.0 c	50.37 ± 20.0 c	120.67 ± 18.7 b	169.14 ± 45.7 b

Note: *significant p ≤0.05 means in a column followed by a common letter are not significantly different at the 0.05 lavel by Tukey.

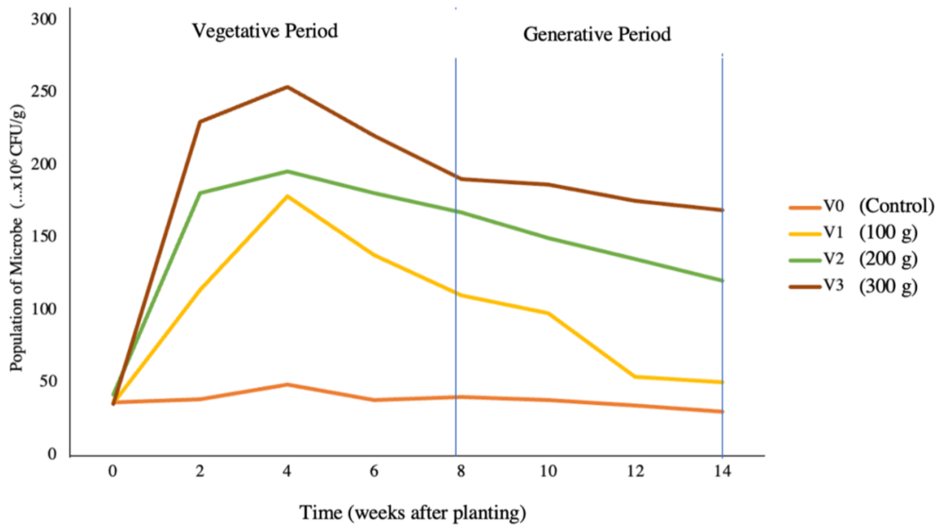

Fig. 1. Microbial population in maize plants applied with several doses of Vermigot fertilizer in Inceptisol soil.

The microbial population continued to increase starting from the second week after planting until the fourth week after planting, but slowly began to decrease in the sixth week after planting until the end of the generative period (14th week after planting) (see figure 1). This shows that the microbes found in Vermigot fertilizer have decreased in population every week due to decreased food or energy sources. During the vegetative period, microbial populations tend to be high and can carry out activities in the soil that can affect soil characteristics, such as soil pH, and help provide the nutrients needed by maize.

Studies [12] stated that in the composting process, the population of microorganisms, especially bacteria, increases with increasing water content because water is a soluble nutrient medium required for microbial metabolism and physiological activity. Based on the results of the initial analysis of Vermigot fertilizer, the water content has a fairly high value, namely 71%, while the initial analysis of the microbial population reaches 233 x 10^8 CFU/ml. Soil fungi play a fundamental role in agricultural ecosystems, with a wide range of ecosystem functions and several taxonomic groups. Although there is little recent research on the impact of compost on fungal communities, it is important to highlight the important role compost plays in soil fertility, with symbionts and saprophytes involved in soil organic matter and nutrient cycling.

Using Vermigot fertilizer at the highest dose in the treatment, namely 300 g, is the best treatment for increasing the microbial population in the soil. In accordance with the study [12] shows that optimal ecological agricultural techniques such as the application of manure, organic farming, biochar modification, tillage management, and increasing the soil carbon-nitrogen ratio encourage bacterial growth and activity, thereby increasing the efficiency of nutrient use by plants.

3.4 Maize growth and production

The results of the test of variance based on growth and production of corn plants are presented in Table 5.

Table 5. The average growth and production maize against Vermigot fertilizer doses.

Treatments	Parameter				
	Plant Height (cm)	Stem Diameter (mm)	Head Dry Weight (g)	Root Dry Weight (g)	Corn Cob Weight (g)
V_0 (control)	190.72	15.68	75.60	12.11	194.20 ^{b}
V_1 (100 g)	220.95	17.50	85.95	12.43	203.40 ^{b}
V_2 (200 g)	221.70	18.54	104.70	13.14	204.60 ^{b}
V_3 (300 g)	223.10	19.12	105.68	13.50	250.56 ^{a}

Note: *significant $p \leq 0.05$ means in a column followed by a common letter are not significantly different at the 0.05 lavel by Tukey.

The plant height parameter had no significant effect on the application of various doses of Vermigot fertilizer to Inceptisol soil. The highest plant height obtained in treatment V_3 (300 g) was 223.10 cm and the lowest plant height in treatment V_0 (control) was 190.72 cm. Although based on ANOVA the results did not have a significant effect, when compared with the control treatment, the application of Vermigot fertilizer to corn still resulted in higher plant height. In the stem diameter parameter (mm), the highest diameter was obtained in the V_3 treatment (300 g), namely 19.12 mm and the lowest stem diameter in the V_0 (control) treatment was 15.68 mm. In this case, Vermigot fertilizer plays a very important role in the growth of corn plants. This is because Vermigot manure contains many nutrients, especially 2.00% Nitrogen, which is used by microorganisms for energy and the resulting decomposition produces inorganic compounds in the form of ammonium and nitrate that plant roots can be used for the metabolism of maize.

In the parameters of shoot dry weight and root dry weight, the results showed that the application of Vermigot fertilizer in several doses had no significant effect on the shoot and root dry weight of corn plants (g) and kernel weight based on the variance test. The results of Table 4 show that the highest shoot dry weight was found in treatment V_3 (300 g), namely 105.68 g, while the root dry weight was 13.50 g. This proves that the higher the dose of Vermigot fertilizer, the greater the effect on the growth of maize plants.

On the cob weight parameter, the results showed that the application of Vermigot fertilizer in several doses had a real effect. The highest cob weight obtained was in treatment V_3 (300 g), namely 250.56 g, while the lowest cob weight was in treatment V_0 (control) at 194.20 g. This also proves that the higher the dose of Vermigot fertilizer, the greater the effect on the growth of maize plants.

4 Conclusions

The application of various doses of Vermigot fertilizer had a significant effect on the chemical properties of Inceptisol soil, namely the pH of the soil with the highest treatment at the V_3 dose (300 g) was 6.80 (neutral) and the available P of the soil with the best treatment V_3 (300 g) was 31.90 ppm. Soil biological characteristics of Inceptisols, namely microbial population had no significant effect and maize production (*Zea mays* L.) had a significant effect, namely the weight of corn cobs with the best treatment V_3 (300 g) of 250.56 grams.

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