Effectiveness of compost and vermicompost from market organic waste to improve soil chemical properties

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Abstract. The purpose of this study is to evaluate the results of compost and vermicompost derived from market organic waste and its ability to improve soil chemical properties. Seven treatments consisted of treatments without organic matter (control), compost consisted of three treatments (2.5, 5, and 10 tons/ha), and vermicompost consisted of three treatments (2.5, 5, and 10 tons/ha). The treatments were arranged using a Completely Randomized Design with three replications. Each treatment was mixed with soil and incubated for eight weeks. After eight weeks the parameters observed consisted of total N, total P, available P, total K, Organic-C, and pH. The results showed a change in soil chemical content. The highest increase in soil chemical content was shown in the treatment of vermicompost. Application vermicompost 10 tons/ha had a significant influence on changes in soil pH, organic C, total P, available P, total K, and Compost 10 tons/ha increased total N. Vermicompost application of 10 tons/ha could increase total P (215.99%), available P (465.34%), total K (37.78%), pH (12.38%) and organic-C (40.34%). Compost 10 tons/ha increases total N by (54%). Market organic waste effectively used as vermicompost and compost that could improve the soil's chemical properties.

1. Introduction
The availability of nutrients in the soil is a critical factor in agricultural cultivation. Land degradation due to improper land management today has decreased soil properties that support plant growth [1]. This is also exacerbated by the excessive application of inorganic fertilizers resulting in reduced living things or microorganisms that exist in the soil, such as fungi, bacteria, earthworms, and others [2]. If this is not overcome by changing agricultural practices in the field over time, it will decrease the productivity of agricultural products because the soil is no longer able to provide suitable conditions for plants to grow well [3]. One way to increase soil fertility is by adding organic material. The application of organic matter to the soil is one of the methods used to improve soil quality to enhance the soil’s physical, chemical, and biological properties [4]. In the cultivation of organic agriculture, organic material is used as the main essential ingredient to provide soil nutrition, not to feed plants. For this reason, the success of crop cultivation is primarily determined by the type of organic material supplied to realize sustainable agriculture [5].

One source of organic matter that can be utilized is organic matter from market waste [6]. In general, waste is one of the problems that exist in each region, and its quantity always increases from time to time. Proper waste management is one way to maintain sustainability not to be polluted and
create a healthy environment [7]. Waste management that is generally done today has not solved the problem of waste as a whole, and even it has resulted in water, air, and soil pollution, especially at the final waste disposal site. For this reason, efforts are needed so that the waste can be reused for the benefit of humans, especially in agriculture.

The use of market waste as an alternative source of organic material has great potential. Organic matter availability from market waste can be converted as soil ameliorant always increase from time to time, and the source of organic matter available at any time. The method of converting organic matter is essential to producing good quality organic matter for applied to the soil [8]. The method that can be used is composting and vermicomposting methods [9]. Both of these methods have their respective advantages to produce organic matter that can improve soil conditions.

Compost and vermicompost’s direct effect has been well known for its positive impact on increasing chemical, physical, biological soil content, and enhancing plant growth [10]. Vermicompost and compost have some differences in the content of specific ingredients. The process of phosphatase and β-glucosidase vermicomposting are higher than the composting process. Based on the high levels of phosphatase, this is why vermicompost becomes one of the potential organic materials to be able to increase the presence of P content in the soil [11].

The process of composting municipal waste using earthworms showed higher values of the elements N, P, K, Ca, Mg, and Na compared to composting without worms. Increased nutrient content that is higher comes from the enzymatic activity in the earthworm's body so that it affects the process of mobilization, and mineralization of these elements is higher when compared to the treatment without worms [12]. Vermicompost application also shows an increase in the number of growth hormones present in the ground, such as gibberellin, cytokinins, auxins, and humic acids, increasing plant growth [13]. This study aims to determine the effect of compost and vermicompost organic market waste on improving soil chemical properties.

2. Materials and methods

2.1. Soil, compost and vermicompost product materials

The soil used in this was taken from agricultural land in Telaga Waru Village, Labuapi District, West Lombok, West Nusa Tenggara (8°37'32.6"S, 116°07'04.9"E). Soil characteristics topsoil (0-20 cm) used include clay texture class (Sand 42%, Clay 14%, slit 44%), moisture content 46.75%, pH (H2O) 5.68, organic C 1.17%, Total N 0.15%, Total P 23.74 mg/100g, Available P 2.03 ppm, Total K 19.67 mg/100g, exchangeable cation of K, Na, Ca, Mg respectively 1.14, 0.63, 3.83 and 1.82 cmol/kg, CEC 15.45 cmol/kg and base saturation of 58.03%. The vermicompost’s chemical composition was as follows: total N 1.77%, total P 0.43%, total K 2.20%, pH 7.30, and organic-C 19.38%. The compost’s chemical composition was as follows: total N 1.95%, total P 0.29%, total K 4.96%, pH 7.6, and organic C 25.69%.

2.2. Experimental incubation design

The incubation experiment in the laboratory was following the methods used by [14]. The experimental treatment was combinations of three doses of vermicompost (2.5, 5, 10 tons/ha), three doses of compost (2.5, 5, 10 tons/ha), and a control (0 ton/ha). Seven treatments were arranged in a completely randomized design with three replication. Each treatment combination of vermicompost and compost was mixed with 300 g of soil (diameter < 2 mm, dried oven), and water added to 80% of field capacity. Each treatment is covered with aluminum and given a hole to reduce the evaporation process. All incubation pots were placed at room temperature and periodically weighed. In the eighth week, all vermicompost and compost treatment were analyzed for the soil’s chemical properties. At eight weeks, the observation was made for total N (Kjeldahl), total P (HCl 25%), available P (Bray I), total K (HCl 25%), pH (H2O) and organic C (Walkley-Black). Methods of analysis, according to [15]. Data were subjected for analysis of variance (ANOVA) for total N, total P, available P, total K, pH, and organic C, followed by DMRT (Duncan’s Multiple Range Test). The probability levels used for
statistical significance were $P < 0.05$ for the tests. Statistical analysis of the data was carried out with SPSS 18.0 software program.

3. Result and discussion

3.1. Total nitrate content (N)

Applications compost and vermicompost increased the total N content of the soil. The highest increase in total N was the addition of 10 tons/ha of compost (figure 1). The increase in total N content from 0.13% to 0.20% or increased by 54% of the initial soil content. The increase in total N content was due to the rise in nitrogen mineralization, and the total N of compost was higher than vermicompost.

Several studies have shown mixed results related to the N mineralization process in soils. Research shows that compost has an average N value of total soil of 221.2 mg/kg higher than vermicompost of 196 mg/kg [16]. While another research shows the opposite, the total N soil in vermicompost application has a higher value of 138 mg/kg compared with compost application of 134 mg/kg [17]. The difference in soil nitrogen content is due to differences in material composition due to the treatment given, affecting the final result of the incubation process [18].

**Figure 1.** The effect of giving vermicompost and compost on the total soil N content (%).

**Figure 2.** The effect of giving vermicompost and compost on the soil pH content.
3.2. pH

The application of compost and vermicompost increased soil pH compared to initial soil (figure 2). The increase in pH was directly proportional to the amount of organic matter added. Vermicompost 10 tons/ha gave the highest pH increase from 5.60 to 6.29 or an increase of 12.38%.

Some research showed that giving vermicompost has been able to improve soil pH conditions towards neutral. pH changes that occur due to the decomposition of organic matter to produce organic acids such as humic acid and phosphoric acid derived from earthworm decomposition to reduce the concentration of hydrogen ions (H+). Which causes the soil to become more acidic and increase hydrogen ions (OH-) [19].

3.3. Total and available phosphorus content (P)

The application of compost and vermicompost significantly influenced the total content of P and available P soils. Application 10 ton/ha vermicompost provided the highest total and P available than compost and other doses (figure 3 and figure 4). The vermicompost application could increase the initial P content from 19.67 ppm to 58.33 or increase of 215.99%, and available P content had increased from 2.60 ppm to 13.96 ppm increased by 465.34%.

![Figure 3](image-url)  
**Figure 3.** The effect of giving vermicompost and compost on the soil total phosphorus content (mg/100g).

![Figure 4](image-url)  
**Figure 4.** The effect of giving vermicompost and compost on the available phosphorus content (ppm).
The increase in the total P content and available P is due to the decomposition process and mineralization of organic matter that produces organic acids that help release P, so the availability of soil P is increasing [20]. The increase in soil P content is also due to the P assimilation mediated by microorganisms derived from the digestion of earthworms, increasing the presence of soil P content [21].

Some research reports the application of vermicompost has increased the value of available soil P content by 15.45 ppm higher than compost by 13.82 ppm and application of vermicompost is able to increase the presence of available P from 38 ppm to 81 ppm for dose 10 tons/ha [22]. Another study using vermicompost doses of 20, 30, and 40 tons/ha can increase the available P, 81, 90, and 109 ppm, respectively, from the initial soil sample. Based on this, vermicompost is a technology that can provide more P elements compared to other organic materials to improve soil properties [23][11].

3. 4. Total potassium content (K)
Application of compost and vermicompost increased total K content compared to original K soil content. The highest increase of total K (91.41%) occurred in vermicompost treatment, from 17.67 to 37.00 (figure 5). The increase in soil K content that occurred was in line with the dose of organic matter used.

![Figure 5](image_url)

Figure 5. The effect of giving vermicompost and compost on the potassium (K) content (mg/100g).

An increase in the total K element in the soil is caused by changes in potassium distribution between the forms that can be exchanged and cannot be exchanged in the soil [24]. This change in total K content is due to the digestive system of earthworms can process organic waste material [25]. Besides that, it produces high levels of interchangeable potassium concentrations because earthworms microbial activity can increase organic matter degradation and release K to enhance K in the soil. [26]

3. 5. Organic C
Based on the analysis result, the application of vermicompost and compost had a significant effect on the increase in soil organic-C compared to initial soil organic C (control) (figure 6). The increase in soil organic C that occurred was in line with the dose of organic matter used. In the vermicompost application, 10 tons/ha gave the highest value compared to other treatments. The vermicompost dose of 10 tons/ha increased the organic C content by 40.34%, while the compost application increased the organic C content by 27.84%.

A similar research report vermicompost application has increased the organic C content from 0.95% to 1.30% or increased to 36.84%, while compost can increase organic C by 1.27 or increase by 33.88%. The increase in soil organic C from vermicompost applications, because of the mineralization process to the soil assisted by microorganisms from earthworm that ingested organic matter [27].
Figure 6. The effect of giving vermicompost and compost on the soil organic-C content (%).

4. Conclusion
Application vermicompost 10 tons/ha had a significant influence on changes in total-P, available-P, total-K pH, C-organic, and Compost 10 tons/ha increases total-N. Vermicompost application of 10 tons/ha could increase total P (215.99%), available P (465.34%), total K (91.41%), pH (12.38%) and organic C (40.34 %). Compost 10 tons/ha increased total N by (54%). Therefore, the application of vermicompost and compost could improve the soil chemical properties and be applied.

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