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VERMICOMPOSTING OF MUNICIPAL SOLID WASTE MIXED WITH POULTRY LITTER AND FARMYARD MANURE TO IMPROVE COMPOST QUALITY

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A B S T R A C T

Persistent increases in population and urbanization have led to an increase in municipal solid waste (MSW) production. Solid wastes pose a great threat to the environment. The vermicomposting technique is use full for the degradation and reduction of solid waste, recovery of nutrients and returning them to the environment to feed the globe by increasing agricultural productivity and generating the least amount of damage possible to the environment. The aim of this study is utilizing municipal solid waste in combination with poultry litter and farmyard manure to enhance the quality of final product vermicompost used. Also to increase the impact of vermicompost on crops. The treatments involved in the study was include municipal solid waste (control treatment), municipal solid waste and poultry litter (1:1), municipal solid waste and farmyard manure (1:1). In second stage vermicompost were used for growing maize in pots. Soil and plant analysis were carried out before and after experiment. Plant growth parameters i.e, plant height, fresh biomass weight was also being recorded. The rationale of this study is to utilize vermicomposting for the degradation of municipal solid waste. Moreover, to check the efficacy of vermicompost for agricultural development and study its potential for future perspective by using various parameters of soil and analysis of plant growth.

Keywords: Vermicompost; Organic Waste; Vermicomposting; Municipal Solid Waste

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INTRODUCTION

Vermicomposting is the practice of using earthworms to break down organic waste, creating an excellent final product also known as vermicast. Due to its high nutritional content and soil-conditioning properties, vermicompost is regarded as an important organic fertilizer. Vermicomposts contains water-soluble nutrients and improves the soil's drainage and other physical characteristics. Earthworms consume organic wastes such as leftover food, beverage residues, scarp papers, farmyard manure, crop residues and yard trimmings. They then turn these wastes into useful products including worm meal, vermicast tea, and worm casting, among others. Vermicompost also functions as a biological control agent and organic fertilizer, eradicating a variety of plant illnesses brought on by pests and soil-borne plant pathogens. Vermicompost can be used to improve soil nutrient status (Adhikari et al., 2008). Vermicomposting is "bioxidation and stabilization of organic waste" carried out by earthworms and mesophilic bacteria. Earthworms consume agricultural waste and lower the volume by 42 to 62% when under specific environmental conditions. Vermicompost contains a wealth of macro and micronutrients, vitamins, growth hormones, enzymes including lipase, cellulase, and chitinase, as well as immobilized microflora (Aldieri and Vinci, 2020).

Vermicompost application can promote the growth of beneficial microbes, boosting crop yields, enhance soil structure, and increasing plant secretion. In case of plants with longer growing seasons, further fertilizing with bio-humus is sufficient and the use of inorganic fertilizers in this situation is not essential. Vermicompost is 100% natural and suitable for use in organic farming (Al-Wabel et al., 2013).The managing of waste has always been a crucial component of a sustainable society, but the amount and density of waste generated by the contemporary market are growing, and this is generating serious issues around the globe since it threatens ecosystems and public health (Mujtaba et al., 2021). Vermicomposting is widely utilized throughout the world to break down various organic resources into environmentally beneficial products due to its eco-friendly character. The kind of earthworms used in a particular application, the composition of the substrate, the ambient conditions, and the aeration system used in the assessment are just a few of the variables that affect how effective vermicomposting would be (Lim and Wu, 2016).

Existing literature has primarily focused on the effects of different types of feedstock on nutrients contents during composting processes (Kaudal and Weatherley, 2018), with a specific emphasis on reducing nutrient losses, particularly N and improving compost quality (Li et al., 2014). However, there is a scarcity of studies on the vermicomposting technique. A detailed investigation of different organic waste and their by-productsis necessary. The overall hypothesis of this research stated that vermicompost with different wastes generates an organic amendment that enhances nutrient retention, water storage, soil health and crop productivity.

MATERIALS AND METHODS

Experimental Setup

The experiment was conducted at PMAS-Arid Agriculture University Rawalpindi, utilizing the Biogas Unit on campus to carry out the experiment. The experimental setup was located in a storage room within the biogas unit, which provided an ideal environment for vermicomposting. The conditions in terms of temperature and ventilation were optimal for raising earthworms. The experiment involved the use of three plastic baskets, each equipped with a small hole at the bottom for water drainage, and with a capacity to hold 5 kg of organic waste. The study included three different treatments, each replicated three times. After 15-20 days of pre-decomposition, a mixture of organic materials (1:1) was layered in the plastic buckets according to the specified treatments, following the method described by (Agegnehu et al., 2015). After the vermicompost preparation phase, water sprinkling was stopped approximately a week ago, and the compost was arranged into a heap to enhance earthworm performance. The earthworms responded by moving downwards and congregated at the bottom of the heap. The fully matured vermicompost was collected from the top layer (Awasthi et al., 2020).

Collection of Earthworms

The specific species of earthworms used for the vermicomposting process was *Eisenia fetida*, commonly known as red wigglers or composting worms. These worms were collected from the Attock region, where a local village farm is located. Interestingly, the earthworm species employed in the vermicomposting process at this farm were originally imported from Australia.

Collection of Organic Wastes

Three different types of organic wastes were used for this research purpose, these includes municipal solid waste, farmyard manure and poultry litter. Various sources of municipal solid waste were gathered from different locations, including vegetable and fruit shops, household kitchen waste bins, and the university garden. The collected waste consisted of a variety of organic materials such as vegetable scraps (tomatoes, cucumber, potatoes, brinjal, mint, coriander, okra, etc.), fruit peels and leftovers (melons, bananas, watermelons, mangoes, peaches, apples, plums, etc.), and green manure like grass clippings. Once all the organic materials were collected, they were crushed into small pieces in preparation for the vermicomposting process.

The farmyard manure used in the experiment was obtained from the university farm, which is located within the campus premises. However, the fresh farmyard manure was found to be detrimental to the earthworms. To make it suitable for vermicomposting, the farmyard manure was spread out for air drying for a period of 15-20 days. This process helped in removing harmful gases and reducing excessive heat. After the drying phase, the farmyard manure was manually crushed into fine particles, creating an ideal feed for the earthworms.

The poultry litter used in this study was obtained from a poultry farm located opposite the university campus. To ensure consistency, the litter was sun-dried for four days until it reached a moisture content of 40%. Before starting the vermicomposting process, the litter underwent a pre-composting phase using the windrow method, which lasted for 15 days. Essentially, three distinct treatments were employed to prepare vermicompost using three different organic materials. Municipal Solid Waste served as the common component in all three treatments, while farmyard manure and poultry litter were added as supplementary sources to enhance the decomposition process of the municipal solid waste. Each treatment incorporated a mixture of organic materials in a 1:1 ratio, comprising 50% municipal solid waste and 50% other waste materials, tailored to each specific treatment, T1 Municipal Solid Waste (Control), T2 Municipal Solid Waste + Poultry Litter (1:1), Municipal Solid Waste + Farmyard Manure (1:1).

Greenhouse Experiment

A greenhouse pot experiment was conducted at PMAS-Arid Agriculture University, Rawalpindi campus, spanning 60 days. The primary objective was to assess the impact of vermicompost-amended soil on plant micronutrient uptake and concentrations. Soil samples were collected from the university grounds, sieved to a particle size of 2mm, and then filled into individual pots at a quantity of 5kg per pot. This setup allowed for the evaluation of seven different treatments, T1 (Control), T2 (N, P, K (Recommended Dose), T3 (MSW @ 25g / pot), T4 (MSW + PL @ 25g / pot), T5 (MSW + FYM @ 25g / pot), T6 MSW + ½ NPK @ 25g / pot), T7 (MSW + PL + ½ NPK @ 25g / pot), T8 (MSW + FYM + ½ NPK @ 25g / pot) each replicated three times to ensure reliable results.

Chemical Analysis

The pH was determined by pH meter method by Prado et al. (1991). EC was done by EC meter method by (Prado Leite & Freeman, 1991).

Statistical Analysis

The data collected from the different parameters were statistically evaluated using Completely Randomized Design (CRD). Statistics 8.1 software was used to examine the data obtained for the various parameters. LSD (Least Significant Difference) values were determined at a probability level < 0.05 (Steel et al., 1997).

RESULTS AND DISCUSSION

The analysis shows that the pH high in (control) treatment and low in (MSW+PL) treatment respectively. In end products of vermicomposting all raw materials attained lower pH, which falls in optimum range for plant growth. The lower pH might be due to production of carbon dioxide and organic acids by microbial metabolism during decomposition of organic materials. Krishan et al. (2014) reported similar results on pH of vermicomposting materials of cow dung and garden litter in ratio 1:3, in the mixture of different feeds. The decreasing trend of pH might be due to more mineralization of nitrogen into nitrates and phosphorus into orthophosphates (Garg et al., 2006). The highest EC (3.7 dSm^{-1}) of mature vermicompost was found in T1 (Control) followed by T2 (3.5 dSm^{-1}) and T3 (2.57 dSm^{-1}). It indicated that vermicompost having good quality. Similar results were found by (Bernal et al., 2017). The highest level of nitrogen is (3.16%) is observed in (MSW+PL) followed by MSW+FYM (2.7%) (Figure 1).

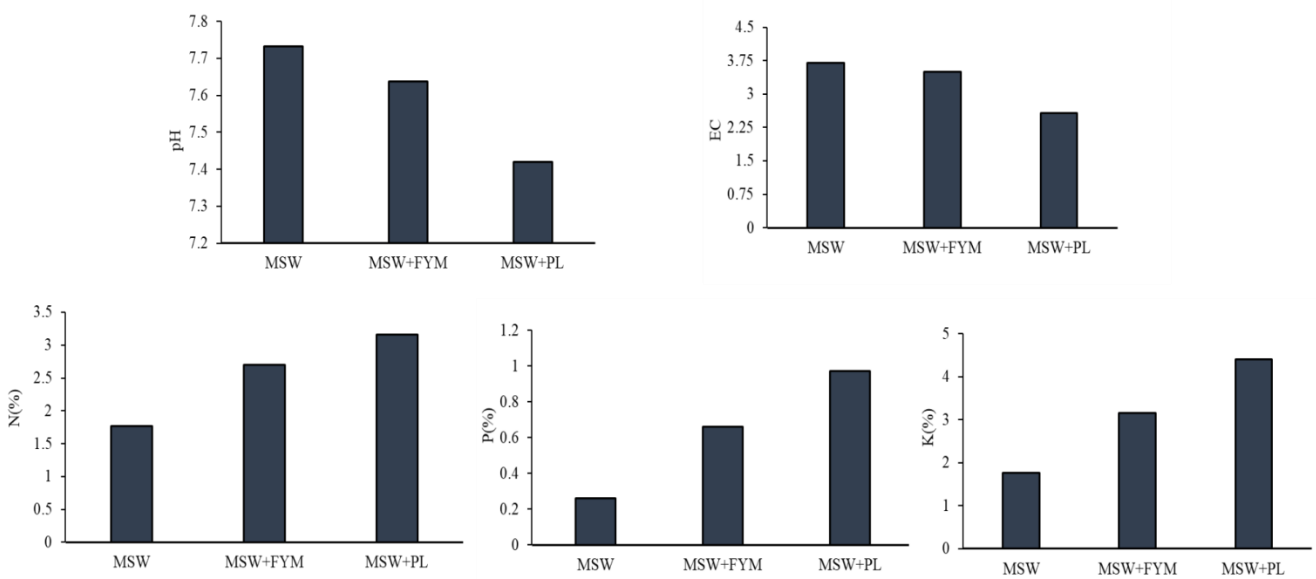

Figure 1. Physico-chemical properties of different types of vermicomposts.

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The lowest nitrogen percentage (1.7%) was noted in MSW. The reduction in organic carbon mass in the form of CO_2 results due to utilization of substrates by activity of microorganisms and earthworms, along with loss of water by evaporation during mineralization of organic contents (Hayat et al., 2013) might these lead to reduction of relative increase of nitrogen content. The highest value of phosphorus (0.97%) was found in MSW+PL followed by MSW+FYM 0.66%. Whereas the lowest phosphorus percentage (0.26%) found in MSW. During vermicomposting increase in total phosphorus results was most probably due to mobilization and mineralization of phosphorus by bacteria and phosphate activity of earthworms (Ramdzan et al., 2018). The highest potassium (4.4%) of compost found in MSW+PL followed by MSW+FYM (3.15%). The lowest potassium (1.7%) noted in MSW. The enhanced number of microorganisms during vermicomposting present in the gut of *Eisenia fetida* worms might played an important role in increasing potassium content (Kaviraj & Sharma, 2003).

Greenhouse Experiment

In plants, the nitrogen content varies within the range of 0.52% to 1.64%. Among these variations, the highest nitrogen content, reaching 1.66%, was observed in the treatment involving MSW+FYM+1/2NPK @ 25g/pot. Conversely, the lowest recorded value of 0.52% was associated with the control. Microbial activity plays a pivotal role in making carbon, nitrogen, and phosphorus within microbial biomass accessible to plants (Malik, Marschner, & Khan, 2012). Within the realm of plant composition, the phosphorus content spans a range of 0.28% to 0.69%. The highest phosphorus content, registering at 0.69%, was documented in the treatment involving MSW+PL+1/2NPK @ 25g/pot. A phosphorus content of 0.68% was observed in the MSW+PL @ 25g/pot treatment, while the lowest value of 0.28% was attributed to the control. Research by Khan et al, (2022) put forth that vermicomposting procedures contributed to an increase in soil organic matter content, consequently leading to higher concentrations of phosphorus, calcium, magnesium, and potassium. The potassium content varies within a range of 0.41% to 0.96%. The highest phosphorus content, reaching 0.96%, was documented in the treatment involving MSW+PL+1/2NPK @ 25g/pot (Figure 2).

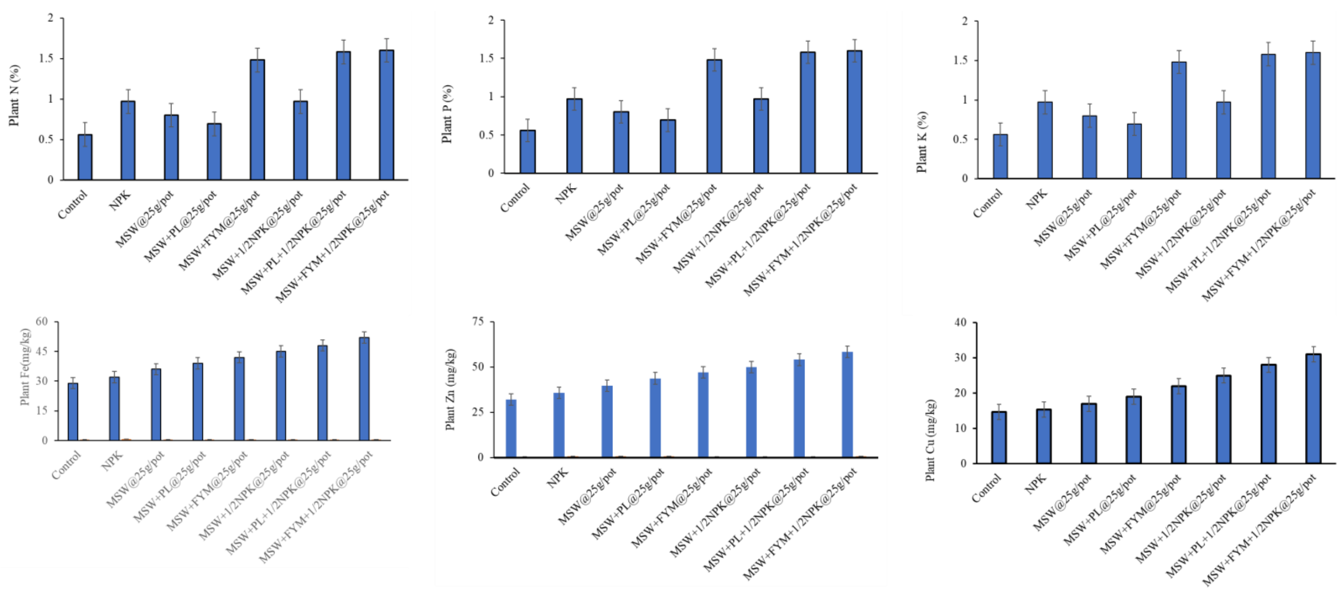

Figure 2. Effect of vermicomposts on soil marco and micro nutrients during greenhouse experiment.

In a closely trailing sequence, a phosphorus content of 0.74% was observed in the MSW+PL @ 25g/pot treatment, while the lowest recorded value of 0.41% was attributed to the control. Research by (Azeem et al., 2019) posited that vermicomposting processes contributed to heightened soil organic matter content, subsequently leading to increased concentrations of phosphorus, calcium, magnesium, and potassium. The iron content varies within a span of 29mg/kg to 52mg/kg. The highest iron content, reaching 80.2mg/kg, was documented in the treatment involving SF+MM+1/2NPK. Iron content of 64.5mg/kg was observed in the MM+1/2NPK treatment, while the lowest measured iron content of 41.16mg/kg was attributed to the control. In the realm of plants, the zinc content exhibits a range spanning from 32mg/kg to 58.3mg/kg. The highest zinc content, reaching 58.3mg/kg, was observed in the treatment involving MSW+FYM+1/2NPK @ 25g/pot. The zinc content of 58.3mg/kg was recorded in the MSW+PL+1/2NPK @ 25g/pot treatment, while the lowest measured zinc content of 32mg/kg was attributed to the control. The copper content spans a range extending from 14.4mg/kg to 31mg/kg. The highest recorded copper content of 31mg/kg was found in the MSW+FYM+1/2NPK @ 25g/pot treatment. Subsequently, a copper content of 28mg/kg was observed in the MSW+PL+1/2NPK @ 25g/pot treatment. On the opposite end of the spectrum, the lowest measured copper content of 14.4mg/kg was identified in the control. Both of these values were found to be statistically significant in relation to each other and significantly different from all other treatment groups. The manganese content exhibits a span from 26.7mg/kg to 56.7mg/kg. The highest manganese content of 31mg/kg was documented in the MSW+FYM+1/2NPK @ 25g/pot treatment. In succession, a manganese content of 50.5mg/kg was observed in the MSW+PL+1/2NPK @ 25g/pot treatment. On the lower side of the range, the minimum recorded manganese content of 26.7mg/kg was noted in the control. These two values exhibited a significant correlation with each other and were notably distinct from all other treatment groups (Hayat et al., 2014).

CONCLUSIONS

Vermicomposting process resulted in notable improvements in the properties of compost, leading to reduced nutrient losses. Throughout the co-composting period, *Eisenia fetida* played a key role in enhancing moisture content, increasing it from an initial stage, which is highly advantageous for the composting process. Additionally, *Eisenia fetida* effectively improved the nutrient status of the mixture, promoting nutrient retention. This indicates enhanced decomposition and mineralization of OC during the co-composting process. Regarding N content, in composting mixture exhibited an increase in TN and TDN contents over the during composting period. This indicates a progressive enrichment of N, which is essential for plant growth and productivity. Furthermore, our findings demonstrated an upward trend in P and K content in both MSW+FYM and MSW+PL compost, with the exception of K. This indicates the effective retention and availability of these essential nutrients in the co-composted materials. Such nutrient enrichment can significantly contribute to improving soil fertility and crop productivity. Based on these compelling results, we confidently conclude that the vermicomposting with the MSW+FYM and MSW+PL composting mixture is an environmentally friendly, safe and highly effective approach for producing high-quality compost. The application of vermicomposting materials can contribute to the establishment of resilient agricultural systems, ensuring both environmental sustainability and improved agricultural productivity.

CONFLICT OF INTEREST

The authors declare that there is no conflict in the publication of this article.

AUTHOR’S CONTRIBUTION

All the authors contributed equally in the manuscript.

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