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Effect of NPS and Vermicompost on the Physico-Chemical Properties of the Soil at the Bako Agricultural Research Center in Western Oromia, Ethiopia

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Abstract

The main chemical, physical, and biological limitations on soil production in western Ethiopia include low soil fertility and nutrient unavailability. Therefore, the purpose of the study was to evaluate how specific physico-chemical properties of soil were influenced by the combined application of vermicompost and NPS fertilizer rates at Bako Agricultural Research Center. Four vermicompost levels (0, 2.32, 3.48, and 4.64 tons ha-1) and four NPS fertilizer levels (0, 50, 75, and 100 kg ha-1) are combined in a factorial manner were laid out in Randomized Complete Block Design (RCBD) with three replications. The study's findings demonstrated that while bulk density decreased below the control due to different levels of organic fertilizer application, all treatments applied increased soil moisture and in general porosity relative to the control or NPS fertilizer alone. The results showed that the combination of vermicompost and NPS fertilizer rates significantly affected organic carbon, organic matter, total nitrogen, basic cations (Ca^{2+}, Mg^{2+}, K^{+}), and available phosphorous. Nevertheless, the experiment indicated the integration of organic and inorganic fertilizers to enhance nutrient availability by maintaining soil fertility and health because the pH of the soil was significantly influenced by the primary effects of vermicompost levels ($P \leq 0.01$).

Keywords: Fertility; Depletion; NPS; Vermicompost; Improvement

Introduction

Nutrient depletion in Ethiopia has been accelerated by improper management of soil fertility and land use shifts, primarily from natural vegetation to cultivated areas. A reduction of the physical, chemical, and biological characteristics of the soil was the outcome of intensive and continuous farming of land with inadequate soil fertility management techniques. The country's declining agricultural output and food scarcity are made worse by these changes in the soil's properties [1]. According to this perspective, the main causes of the nation's declining soil fertility include nutrient input levels or absence, crop residue management issues, continuous cultivation, nutrient removal through erosion, and a lack of crop rotation programs [2]. Thus, the sustainability of agricultural productivity is impacted by inadequate management of soil fertility.

The fertility and productivity of soils are crucial factors in guaranteeing food security for the growing global population [3]. To maintain the productivity of the soil and balance the nutrient outflow from agricultural land, it is, therefore, necessary to improve soil fertility by adding nutrients in the form of fertilizer and managing it properly. Hence, soil fertility and plant nutrition are two closely related topics that focus on the types and availability of nutrients in soils, as well as their mobility, uptake by plants, and utilization by plants.

Among the main obstacles to crop development in Ethiopia are low soil fertility, acidity-induced nutrient unavailability, and high amounts of agricultural inputs [4]. Acid soil production is restricted by the toxic levels of manganese (Mn) and aluminum (Al), as well as by the lack of nutrients like phosphorus (P), calcium (Ca), magnesium (Mg), and molybdenum (Mo) [5]. Due to its high exchangeable aluminum content, Al lowers P uptake by fixing P [6]. Applying organic fertilizer can improve soil aeration, reduce acidity, promote greater microbial activity, increase soil organic matter, CEC, and P availability, and significantly raise crop yields [11]. Maintaining increased soil production has become more successful recently when organic and mineral fertilizers are used in combination.

Methodology

Experimental materials

The NPS fertilizer containing (19% N, 38% P_2O_5, and 7% S) was used as sources of nitrogen, phosphorus, and sulfur. Vermicompost prepared from soybean residue and farmyard manure at Bako Agricultural Research Center was used for this study. The soya bean straw and cow dung were mixed 1:2 ratio respectively. The Vermicompost had been prepared from soya bean straw and cattle manure at Bako Agricultural Research Center, using red earthworms (Eisenia fetida). The vermicompost used in the experiment was selected based on its nutrient content information obtained from the laboratory analytical results.

Treatments and experimental design

Vermicompost rates (0, 50, 75, and 100%) and NPS (0, 50, 75, and 100 kg NPS ha-1) were the treatment levels. The experiment contained 16 treatments [7].

Soil sampling and sample preparation

Using the given auger, samples were collected across the diagonal of each block from the top soil surface (0–30 cm deep). The fifteen samples were completely mixed in the field right away following sampling, and

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then a 1 kg composite and the homogenized sample were taken and placed in the plastic bag along with the label.

Following harvesting, soil samples were taken from every experimental field plot. Samples were obtained from the middle three rows of the plots where vermicompost and fertilizer were applied. Following collection, the samples were well combined in the field, and one kilogram of homogenized material was removed from each of the 48 plots and placed in a plastic bag with a label. After that, the sample's physico-chemical characteristics were examined.

With the help of the room's airflow, the soil samples were spread out over a sample bag and dried. To analyze the chosen soil parameters, the air-dried soil samples were first ground with a mortar and pestle and then sieved through a 2 mm diameter sieve. Soil samples were screened through a 0.5 mm sieve for measurement of total nitrogen and organic carbon content.

Analysis of selected soil physical and chemical properties

At Bako Agricultural Research Center, soil samples taken from the study area were examined. After following the procedure, the Bouyoucos hydrometer method was used to examine the texture (size distribution) of soil particles. Using the soil textural triangle, soil textural classes were determined by comparing the percentages of sand, silt, and clay separations as described by [8]. The undisturbed soil samples that the core sampler took were used to calculate the bulk density of the soil using the methodology. Based on the bulk density and particle density measurements, total porosity was determined using the technique described.

Results

Being the primary soil variable, pH represents the general chemical status of the soil and affects a wide variety of chemical, physical, and biological activities in the soil [9]. The soil has a pH of 5.13, which is very acidic. A pH range of 6.0 to 7.5 is preferred by the majority of plants and soil organisms [10].

Soil organic carbon is an essential indicator of soil fertility status. According to the soil organic carbon rating by the organic carbon in the soil of the experimental site was 1.23%, which is in the moderate range. Furthermore, the total nitrogen in the soil of the study area was 0.13%, which was low.

As indicated by Bray II, the experimental site's soil had 5.02 ppm of extractable available phosphorus, which is slightly below the required amount of 8 ppm for the majority of Ethiopian soils and in the low range as per rating by for available soil Phosphorus. The available sulfur content of the soil (0.38 ppm) is in the low range. Similarly, the cation exchange capacity of the soil of the experimental site (14.8 cmol(+)kg^{-1}) was rated as moderate according to the rating by. Overall, the soil analysis results indicate that the experimental site's soil had a low level of fertility. The low amounts of total nitrogen, available phosphorus, and available sulfur that were observed may have resulted from continuous crop production with little in the way of inorganic fertilizer input, as well as from a lack of application of organic matter or soil incorporation of crop residue. The low contents of total N, available S, and available P observed in the soil of the study area are in agreement with the results reported.

Discussion

The analysis of variance showed that the interaction effects of vermicompost and NPS were significant on the bulk density of the soil ($P \leq 0.05$). The lowest bulk density value (1.28 $g.cm^{-3}$) was recorded for the soil of plots treated with 100% of the recommended rate (4.64t VC ha^{-1}) and 75 kg NPS ha^{-1}. However, the control treatment had the highest bulk density value (1. 45$g.cm^{-3}$). (Table 13) indicates a significant negative relationship ($r = -0.67^{**}$) between soil organic matter and bulk density, which suggests that the influence of vermicompost on bulk density may be the reason for the lowest bulk density values among the other treatments when compared to the control Agreeing with this reported lower bulk density values when organic matter was applied to the soil. Similarly, also reported the inverse relationship between soil bulk density and organic matter content.

The analysis of variance showed that the interaction effects of vermicompost and NPS were statistically highly significant on the total porosity of the soil ($P \leq 0.01$)

The soil of the plots treated with 100% of the prescribed rate (4.64 t ha^{-1}) and 75 kg NPS ha^{-1} showed the maximum total porosity value (51.46%), whereas the control plots had the lowest value (42.79%). The maximum total porosity values observed for 4.64 t VC ha^{-1} and 75 kg NPS ha^{-1} corresponded with increased levels of organic matter content and decreased bulk density values. This suggests that increasing rates of vermicompost application reduced soil bulk density and subsequently increased total porosity. In line with this, reported that low organic matter content and high bulk density as causes of the low total porosity of soil. Increasing soil organic matter due to the application of organic fertilizer, which led to a decrease in bulk density and, ultimately, an increase in soil porosity.

Conclusion

poor soil fertility is the key chemical constriction on soil that limits productivity in the western part of Oromia. The use of integrated vermicompost and NPS inorganic fertilizer is necessary to improve the soil's fertility status, which can raise production and revenue. Raising the soil's potential is essential for raising the yield and productivity of the crop. By using both organic and inorganic fertilizers, which were employed to achieve the major goals of soil fertility and crop production, the production per unit area will increase as the fertility of the soil is raised.

The studies were set up using a randomized complete block design (RCBD) with three replications, four levels of vermicompost rates (0, 2.32, 3.48, and 4.64-ton ha^{-1}), and four levels of NPS (0, 50, 75, and 100 kg ha^{-1}). The findings revealed a slight increment in pH, total nitrogen, and available phosphorus. The amount of exchangeable calcium, exchangeable magnesium, cation exchange capacity, and organic carbon results in some reduction of soil acidity and some improvement of soil fertility. If organic and inorganic fertilizers are applied together in a sustainable manner, such as with vermicompost and NPS, the soil's fertility is increased.

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