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Vermiculture Technology Promotion Through on Farm Validation of Vermicompost in Asossa Zone of Western Ethiopia

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Abstract:
A field experiment was conducted for two consecutive cropping seasons (2020- 2021) on farmers' fields in the Asossa zone of Benishangul Gumuz Regional State. The objective of this study was to promote vermicompost or vermiculture technology on the farmer's field. The treatments included three selected combinations of organic and inorganic nutrient sources, including NPS, NPS plus 100% N from vermicompost, and NPS plus 100% N from Urea. The design was replicated over the farmer's field. Results showed that from 2020 to 2021, the vermicompost technology was demonstrated on 15 farmers' fields with plot size 10mx10m planted with hot pepper, maize and sorghum crops. The results indicated that all crops treated with recommended NPS plus 100% N from vermicompost performed better than NPS alone and NPS plus N from Urea. The application of recommended NPS plus 100% of N from vermicompost based on N equivalency was higher in grain yield of maize by 80.2% and 51.7% compared to the control N and application of recommended NPS plus 100% of N from inorganic fertilizers, respectively. Additionally, the application of recommended NPS plus 100% of N from vermicompost based on N equivalency was higher in grain yield of sorghum by 44.8% and 16.2% compared to the control N and application of recommended phosphorous plus 100% of N from inorganic fertilizers, respectively. Therefore, it is better to scale out the vermicompost/vermiculture technology on wider areas of the same agroecologies of Benishangul Gumuz Regional State.

Keywords: vermicompost, vermiculture, based on equivalency, grain yield, promotion, technology

INTRODUCTION

Low soil fertility is one of the bottlenecks to sustain agricultural production and productivity in Ethiopia. Continuous nutrient depletion and low soil fertility have not only led to the development of integrated soil fertility management technologies that offer the potential for improving soil fertility in Africa (Tilahun, 2003), but almost simultaneously caused extensive studies on nutrient balance in various African farming systems. The application of balanced fertilizers is the basis to produce more crop output from existing land under cultivation and the nutrient needs of crops are according to their physiological requirements and expected yields (Ryan, 2008). The application of inorganic fertilizer is to increase crop yield, but it becomes a chronic problem due to its cost and deterioration in soil physical, chemical, and biological properties of the soil. And also, it cannot full fill long-term productivity on many soils since they are not effective in maintaining soil fertility. The application of bio-fertilizers such as vermicomposts has been recognized as an effective means for improving soil aggregation, structure and fertility, increasing microbial diversity and populations, improving the moisture-holding capacity of soils, increasing the soil Cation Exchange Capacity (CEC) and increasing crop yields (Hargreaves *et al*., 2008).

Vermicomposting has been considered a suitable technology for developing countries, especially at the household and community level as it is a simple and natural technology that does not require sophisticated machinery, high capital investment, and frequent process monitoring (Lim *et al*., 2016). Zucco *et al*. (2015), reported that vermicompost is often used in sustainable farming systems to improve soil physical properties, provide plant nutrients, and recycle organic wastes and has been shown to increase plant growth and crop yields. The solely recommended inorganic fertilizer has not further improved crop production and it aggravates for soil acidity problem of Western Ethiopia. Therefore, to increase crop production in this area, there was a need to integrated soil fertility management through verm-culture/earthworm technology promotion in the Region. This study was conducted to promote vermiculture technology through on farm Validation of Vermicompost, at Mao-komo and Asossa Zone, Western Ethiopia

MATERIAL AND METHODS

Description of the Study Sites

The experiment was conducted in Benishangul Gumuz Regional State, at Asossa Agricultural Research Center (AARC) research farm in the 2016/17 main cropping season under rain-fed field conditions. Benishangul Gumuz Regional State is geographically located at $9^{O}30'$ to $11^{O}39''$ N latitude and 34^{O} 20' to 36^{O} 30''E longitude covering a total land area of 50,000 square kilometers. The study site is located at 10^{O} 02' 05'' N latitude and 34^{O} 34' 09'' E longitudes. The study area is situated east of Asossa town and West of Addis Ababa about 4 km and 660 km distance, respectively. Asossa has an unimodal rainfall pattern, which starts at the end of April and extends to mid-November, with maximum rainfall received in June, to October. The total annual average rainfall of Asossa is 1275 mm.The minimum and maximum temperatures are 16.75°C and 27.92°C, respectively. The dominant soil type of the Asossa area is Nitosols with the soil pH ranging from 5.0 to 6.0.

Site and Beneficiary Selection

The participating farmers were selected by the Office of Agriculture and rural development respective woredas of Asossa and Bambasi). Beneficiary farmers were selected based on the criteria and objectives of the operational research for the technology dissemination project and the interest of farmers to participate in the demonstration trials. In addition, the safety net beneficiaries and disadvantaged households (youths and women-headed households) were the main focus of the activity.

Materials and Agronomic Management

The earthworms were demonstrated and popularized in two selected districts (Asossa and Bambasi) on. Three treatments with three tests (T1=Recommended inorganic nitrogen (Urea) plus Recommended NPS, T2=100% of vermicompost based N equivalence plus Recommended NPS and T3=Negative control of nitrogen fertilizer Recommended NPS) were replicated across the five farmer's field for each testing crop of the respective weredas according to research procedure or phase. Popularization of small-scale vermiculture/earthworm technology demonstration in farmers was implemented on selected farmers Crops were planted as demo plots across the farmer's field of the respective weredas. All plots uniformly received NPS as basal application during planting for each test crops. The experiment was replicated across farmers field with three treatments. The blocks were separated by a 1.5 m wide open space where as the plots within a block were separated by a 0.75 m wide space. Soil bunds were constructed around each plot and around the entire experimental field to minimize nutrient, water movement, and cross contamination from plot to plot. Weed control was achieved manual by hand picking. Crop growth was then monitored until harvest.

Training and Awareness Creation

Farmers were trained before how they can multiply earthworms. The bin is constructed from locally available materials. A total of 110 male and 72 female beneficiary farmers were participated on training and the earth worm technology was delivered for those tried farmers. As part of the intervention activities, training on verm-compost and earthworm was given to farmers, DAs and experts. During the training, we discussed with farmers to give the earthworm for other farmers, so redistribute to other new beneficiaries in the next production season and it will be continued in the form of a revolving fund.

Field Day

In the field day and experience sharing farmers, development agents (DAs), experts, heads of agricultural and rural development office and researchers were participated. Finally, to evaluate the performance and final outputs of the vermicompost and share the lessons with different stakeholders' field days were organized in the fields of beneficiary farmers. On the field days farmers, development agents (DAs), experts, heads of the agricultural and rural development office, woreda administrators, researchers from Asossa Agricultural Research Center and other stakeholders from Bambasi.

Data Collection

Grain yield and yield components of sorghum, maize and hot pepper, farmers feedbacks were collected. The grain and yield components data were collected using data collection sheets and only the grain yield for maize and sorghum, and fresh red fruit weight and dry fruit weight based its economic importance. The feedbacks were collected using checklist by conducting group discussions and key informant interviews.

Yield advantage was calculated by:

$$\text{Yield advantage \%} = \frac{\text{Yield advantage of vermicompost} - \text{Negative control of N}}{\text{Negative control of N}} \times 100$$

Yield advantage of the demonstrated varieties was calculated using

Data Analysis

The collected agronomic data was analyzed using descriptive statistics and excel. The grain yield and fruit weight data were analyzed using excel and presented using figures.

RESULT AND DISCUSSION

Current Status of Vermiculture for Vermicompost Production Under Small-Scale Farmers in Assosa Zone

The demonstration and popularization of earthworm technology for vermicompost production was undertaken by Asossa Agricultural Research Center in collaboration with NGOs, SLM PProject 2 and the Asossa Environmental Protection, Association. Pre-scaling up of small-scale vermiculture technology demonstration in farmers were implemented on selected farmers. Consequently, the Asossa Environment Protection Association (Local NGO) and SLM project promoted and demonstrated the advantage of vermiculture with the collaboration of the Asossa

Agricultural Research Center through the distribution of three earthworm species that have been known in the region. Overall vermiculture focused training was delivered to farmers across the Weradas of the region by the Asossa Agricultural Research Center. Vermiculture unit constructed from locally available materials (Bamboo trees) including bin. About 200 kg of worms were multiplied and distributed to more than 1500 farmers (0.5 kg/bin). A total of 110 male and 72 female beneficiary farmers participated in verm-compost technology. In the first year, vermicompost was produced using the selected local worm and *E. fetida* (standard check) from the already recommended source and proportion in the Asossa Agricultural research center. The 50 - 70 farmers per kebeles can be engaged during field demonstrations. In addition, these members subsequently trained other farmers and gave their earthworms to other farmers to distribute to other group members. The mini field day was organized across the Weredas for the vermiculture/earthworm technology promotion.

Pictures 1: Earthworm multiplication with locally available feeding materials

Pitures 2: Practical and theoretical training of farmers on bin construction from locally available materials

The trained farmers have started to construct the bins for earth worm/vermicompost technology use. The small-scale farmers have been starting to use vermicompost as source of Urea fertilizer and planted maize, hot pepper and sorghum.

Pictures 3: Field performance of the crops under field condition

Farmers field day

As part of the intervention activities, training on verm-compost and earth worm was given to farmers, DAs and experts. Finally, in order to evaluate the performance, share the lesson with different stakeholders' field day and experience sharing were organized in the fields of beneficiary farmers. In the field day and experience sharing famers, development agents (DAs), experts, heads of agricultural and rural development office, researchers were participated. The vermicompost demonstrated were compared based on farmers preferences and the field data recorded and analyzed by descriptive statics. The participant farmers preferred vermin compost plus NPS fertilizer during the field day and their first choice.

List of participants on the day of field day								
Farmers			Researchers			Expert and development agents		
male	women	total	male	Women	total	Male	women	Total
30	15	45	5	2	7	3	1	4

Pictures 4. During farmers field day conducted under field condition

The Effect of Vermicompost on Hot Pepper at Bambasi and Asossa Destricts

The highest red fresh fruit weight (2155.8 kg/ha) and red dry weight fruit weight (1585.9 kg/ha) were obtained under the application of 100% based N equivalence of vermicompost (7.5-ton ha^{-1} vermicompost), while the lowest red fresh fruit weight (1296.5) and red dry fruit weight (977.7 kg/ha) were recorded under the negative control of N. Comparing the red fresh fruit weight showed that 100% based N equivalence of vermicompost application resulted in 66.3% and 50.6% more red fresh fruit weight as compared to the control treatment and recommended inorganic N respectively (Figure 1). On the other hand, application of vermicompost T3 increases the red dry fruit weight by 62.2% over the negative control plot. As compared to the recommended inorganic N, the mean value of the weight of red dry fruit of hot pepper increased by 43.9% for T3 at Asossa and Bambasi Destricts. These results are similar to previous findings of Pavan AS (2013), who reported that chili yield and fruit weight increased with increasing quantity of vermicompost. The reason might be that vermicompost which is a rich source of macro and micro nutrients, enzyme and growth hormones that promoted growth of plant as well as fruit yield. These results are similar with that of (Arancon *et al*., 2004) who found that pepper produced greater fruit yield with the application of vermicompost.

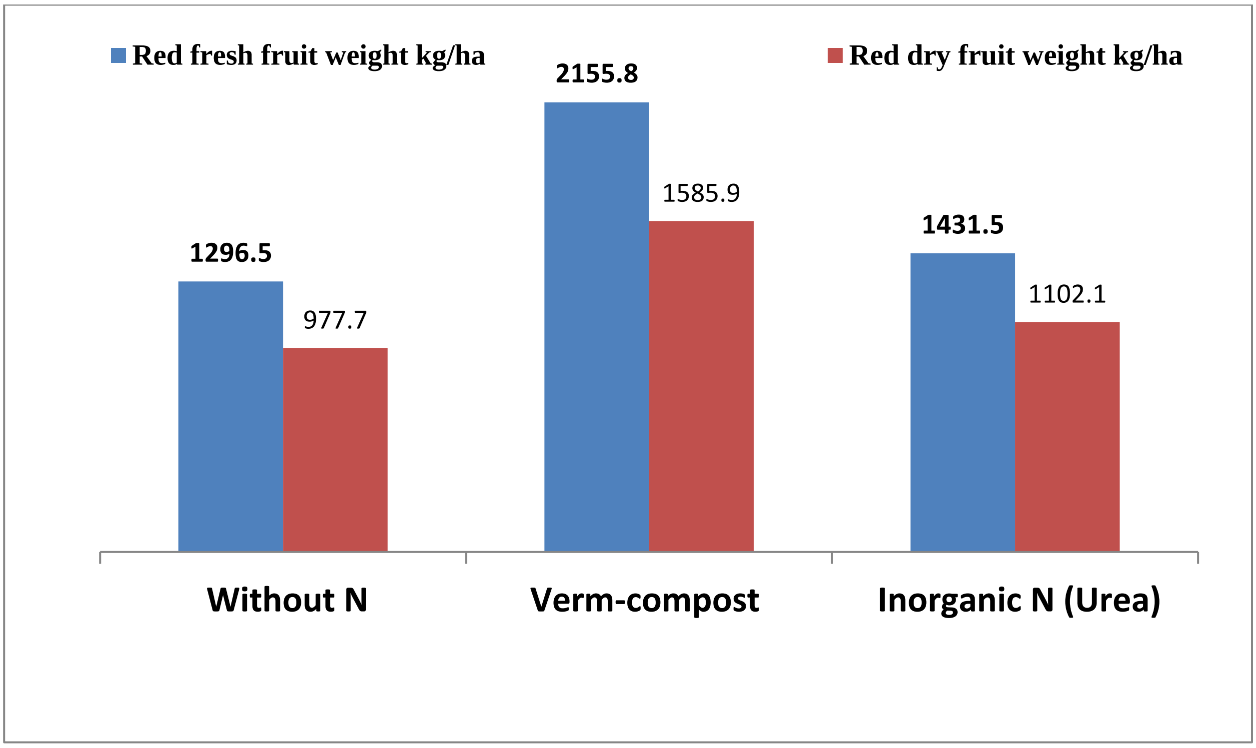

Figure 1. Effect of vermicompost and inorganic N on fresh fruit weight and dry fruit weight of hot pepper

The highest red fresh fruit weight and red dry weight fruit observed under vermicompost fertilizer could be due to vermicompost has capacity to supply both macro and micronutrients in the soil for optimum plant growth which might have enhanced growth and development of crop as compared to the recommended N and P and control or without fertilizer (Harris *et al.*, 1990). These plant nutrients are adsorbed on the humic acid molecules and are released slowly and gradually into the soil solution and made available for plant growth and development processes (Guiterrez 2007).

The Effect of Vermicompost on Maize at Bambasi and Asossa Destricts

The application of recommended NPS plus 100% of N from vermicompost based on N equivalency (5-ton ha^{-1} vermicompost) was higher in grain yield of maize by 80.2% and 51.7% compared to the control N and application of recommended NPS plus 100% of N from inorganic fertilizers, respectively. The same founding was reported by Abdissa *et al*. (2018), who reported the found interaction effect of lime, vermicompost and mineral P fertilizer had a highly significant effect on the 1000-seed weight of maize with higher mean 1000-seed weight was obtained with the application of 2.5 t vermicompost ha^{-1} and 40 kg P ha^{-1} and lime, which might be due to the synergistic effects of the combined effects of vermicompost and lime in improving growth and grain filling of maize, the physicochemical and biological soil properties. The yield advantage relative to the control (unfertilized) of N treatment was 80.2% (Figure 2) indicating the depletion of the soil and its strong response to fertilizer application. This is an indication that the integrated use of organic and inorganic nutrient sources of fertilizers was advantageous over the use of inorganic fertilizer alone and also result in synergy and improved synchronization of nutrient release and uptake by the crop. Combined application of both organic and inorganic sources to take care of maize nutrition more effectively leads to better productivity (Yadav *et al*., 2016).

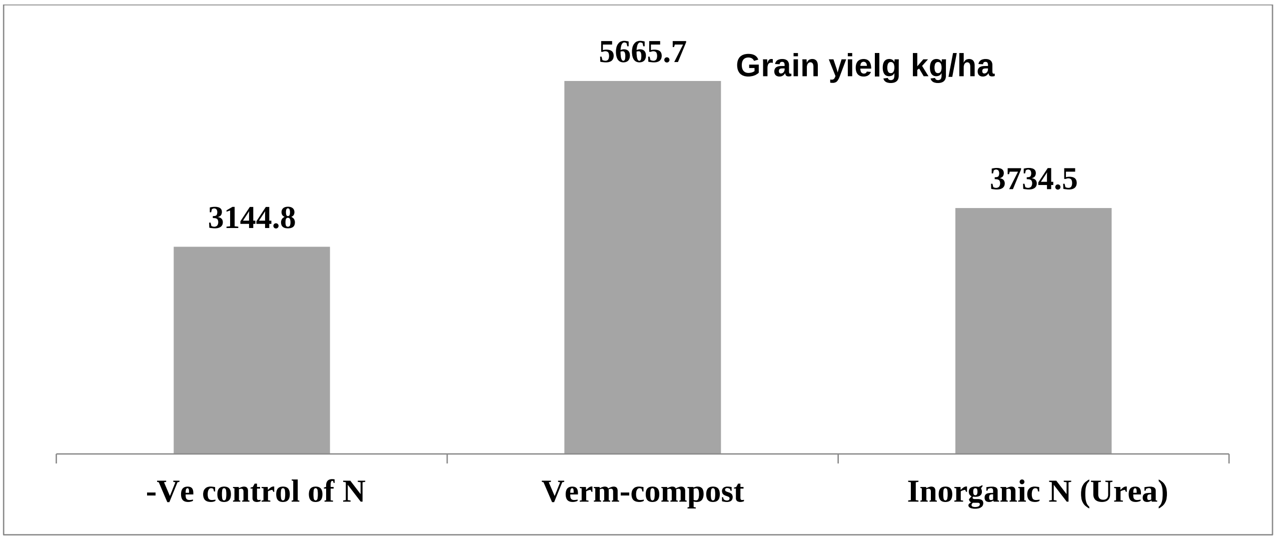

Figure 2 Effect of vermicompost and inorganic N on grain yield of maize at Asossa and Bambasi Districts

The Effect of Vermicompost on Sorghum at Bambasi and Asossa Destricts

The application of recommended NPS plus 100% of N from vermicompost based on N equivalency (3-ton ha^{-1} vermicompost) was higher in grain yield of sorghum by 44.8% and 16.2% compared to the control N and application of recommended phosphorous plus 100% of N from inorganic fertilizers, respectively. Similar finds were reported by Cavagnaro (2014), who reported that organic amendments have improved soil physical, chemical, and biological properties, providing essential plant nutrients to stimulate plant growth and yield. Similar funds by Makinde and Ayoola (2010) concluded that high and sustainable crop yields are only possible with the integrated use of mineral fertilizers and organic matter. According to a study by Dawar *et al*. 2022 observed that the height of the maize plant treated with vermicompost plus NPK was greater than that of the vermicompost or minerally fertilized plot. According to Chimdessa and Sori (2020), the addition of 3 t·ha^{-1} of vermicompost increased grain production by approximately 66.88% compared to the treatment using 100 kg·ha^{-1} of the locally advised NPS rate. Additionally, past research indicated that higher vermicompost quality and vermicompost levels boosted grain Dawar *et al*. 2022. Similarly, Sigaye *et al*. (2020) found that grain yield responded well when organic fertilizer and mineral fertilizer were applied together.

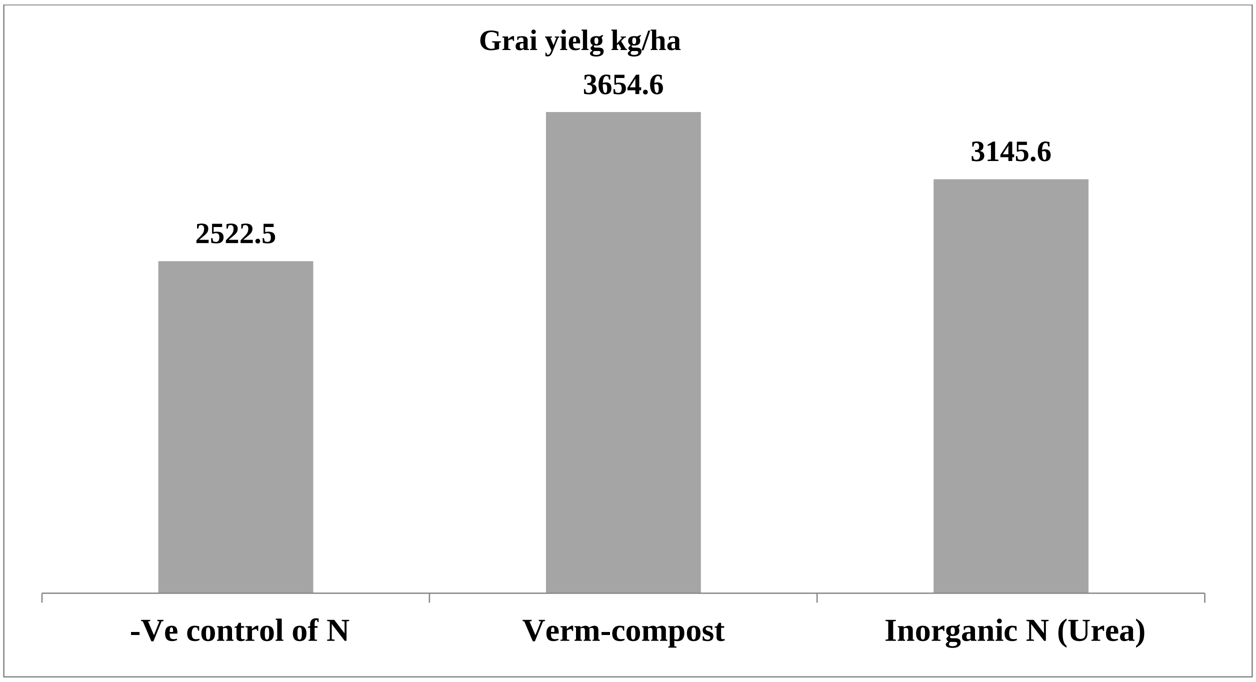

Figure 3 Effect of vermicompost and inorganic N on grain yield of sorghum at Asossa District

CONCLUSION AND RECOMMENDATION

Vermicompost improved the red fresh weight, red dry weight of hot pepper, grain yield of maize and grain yield of sorghum, while increasing soil pH and reducing exchangeable acidity resulting in high grain yield of hot pepper, maize and sorghum. The application recommended NPS plus 100% of N from vermicompost based on N equivalency revealed superior fruit weight of hot pepper, and grain yield of maize and sorghum as compared with the application of recommended NPS plus recommended inorganic N. Thus, for the sustainability of crop production in western Ethiopia, rather than using inorganic fertilizer, the combination of organic sources with inorganic ones would be beneficial in terms of crop and soil productivity. Popularization and on-farm validation of vermicompost technology were essential components of disseminating the best technologies to farmers to boost the production and productivity of small-scale farmers per unit area in the study sites. The obtained yield advantage of vermicompost was significantly better than the inorganic N. Moreover, farmers who participated in the vermicompost technology have gotten higher income per production season from the sale of green hot pepper and dry red-hot pepper. From the results of it can be concluded that application recommended NPS plus 100% of N from vermicompost based was superior for increased productiviety and sustabability of crop production. Thefore application recommended NPS plus 100% of N from vermicompost can be recomendede for scale up study area and similar its agro-ecological areas.

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