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Evaluation of Different Level of Vermicompost on Yield and Yield Components of Wheat at Vertisols of L/Machew District

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was carried out to evaluate different rates of vermicompost, and inorganic NPS(Nitrogen-Phosphate Fertilizer With Sulphur) fertilizers for wheat production in 2015-2017 main cropping seasons at L/machew district of the Tigray Regional State. There were five systematically combined rates of vermicompost and one rate of NPS treatments during the study. The experimental design was randomized complete block with three replications. Surface soil samples were collected before planting to analyze selected soil properties. The textural class of the soil was clay. The pH of the soil was rated under moderately acidic. Available P was rated under medium in most of the experimental sites while total N was low in all experimental sites. The treatments significantly affected crop phenology, yield and yield components of wheat. Thus tallest plant height was found from treatments that received 100kg/ha NPS, followed by 8.75t/ha vermicompost which resulted in (73.25cm) while the shortest plant (62.73cm) was obtained from control plots, respectively. Highest mean wheat grain yield (2642.8kg/ha) was obtained in response to 100kg NPS from inorganic fertilizer application followed by the second highest dose of vermicompost (7t/ha) with

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grain yield of 2620 kg/ha. At the wheat plants grown in plot received vermicompost compost at 7t/ha of vermicompost increased the grain yield by 67.78% over the control. Though highest grain yield was obtained from highest dose of vermicompost the partial budget analysis shows that the highest marginal rate of return (456) was obtained from 3.5t/ha VC ha^{-1} plus 100kg/ha urea at the study area.

Keywords: Vermicompost; NPS fertilizers; grain yield.

1. INTRODUCTION

Besides the deficiency of nitrogen (N) and phosphorous (P), multiples nutrients deficiency in most of Ethiopian soil, including soils in Tigray region has been recently reported [1]. In addition, due to the high price of chemical fertilizer that could not affordable by resource-poor smallholder farmers, the soil fertility constraints has been aggravated by the use of sub-optimal and imbalanced plant nutrients [2]. As a result, the productivity of annual crops in the study areas such as Tigray region has been declining [3]. The current fertilizer application types and rates in many parts of Tigray is not improved the productivity of crop productivity including wheat, indicating the presence of less-response of soil to NP fertilizer in the study site. Recently, application of manures and other nutrients such as (Ca, Mg, S, Zn and B) further improved the productivity of the test crop, maize, on top of NP effect, in east African countries where the deficiency of other macronutrients besides some micronutrients constraints has been reported [4]. Recently, there has been serious concern about the long-term adverse effect of continuous and blanket use of agrochemicals, particularly fertilizers on degradation of soil health and environment [5]. Use of organic manure not only reduces the requirement of chemical fertilizers but also supplements important all essential nutrients to the plants besides improving the soil properties and processes [6]. Application of organic manures may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers [7]. Among different sources of organic manures, vermicompost is most important source and used since long as a nutrients supplement to crop production [8]. [9]Reported that vermicompost is potential sources of nutrients for field crops if applied integrated with synthetic fertilizers. The earlier workers have reported a positive effect of vermicompost application on growth and productivity of cereals and legumes [10] Maximum plant height was recorded with the application of 100% NPK but could not differ significantly in most cases from the treatments where 2 ton of vermicompost was applied 75% N and 100% PK. Grain yield recorded under 100% NPK differ significantly from other treatments while all the treatments consisting application of 4 ton vermicompost and 50% N and 100% PK were significantly greater than application of 100% NPK fertilizers from inorganic fertilizers [11].

In the study location, low quality organic input such as conventional compost and farmyard manure (FYM) has been commonly used as sources of nutrients for crop production beside inorganic NP fertilizer. The yield increase due to such nutrient management is unsatisfactory. Hence, the use of high quality organic input like vermicompost (VC) has recently introduced into the locality, although comparative advantage with other currently utilized other organic inputs and its exact rate required for wheat in the study site is generally unknown. Hence, the objective of this study was initiated to evaluate the effect of different rates of vermicompost, and inorganic NPS application on yield and yield components of wheat.

2. MATERIALS AND METHODS

A field experiment was conducted at Laelay Maichew district six farmers' site for three year on wheat. The districts locate on 38°46'7.294"E 14°7'25.954"N. The District altitude varies between 1842 and 2200 meter above sea level. Vertisols are the dominant soil types in the area. The area has crop-dominated mixed crop-livestock farming system.

The experimental design was a randomized complete block design (RCBD) with six treatments (Control, rec. NPS, 1.75t/ha of vermicompost, 3.5t/ha of vermicompost, 7.0t/ha of vermicompost and 8.75t/ha of vermicompost. Plot size was 4m*3m and spacing between blocks, plots and rows

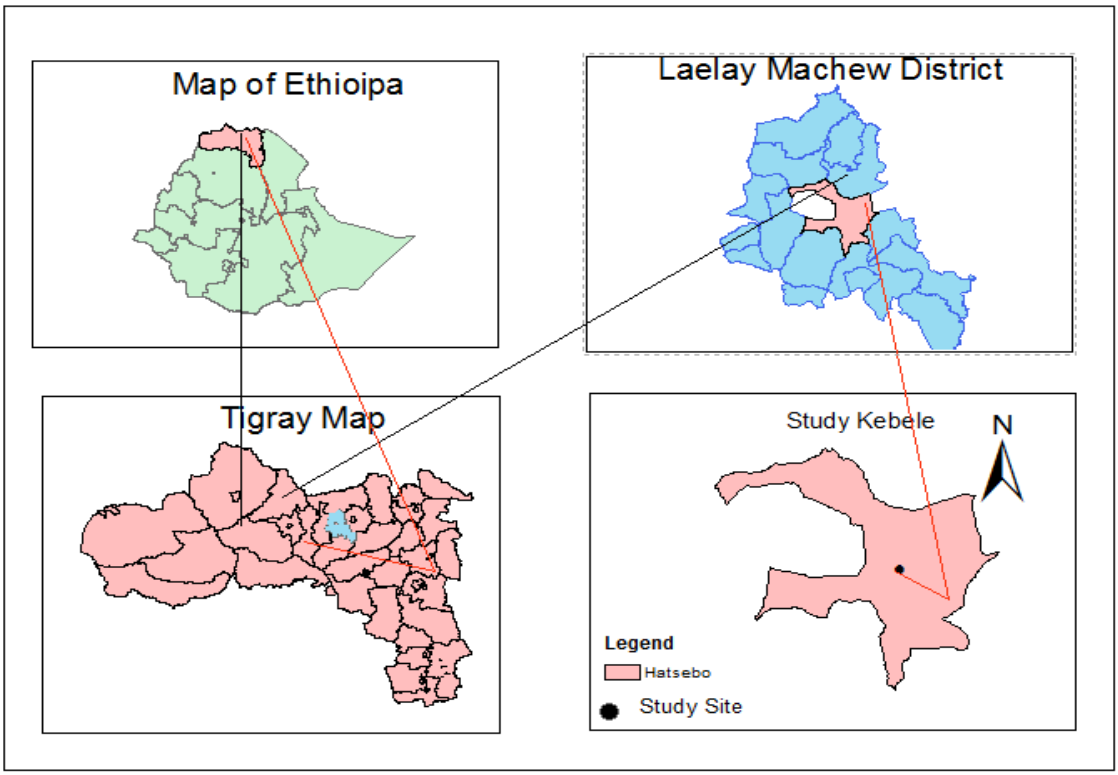

Fig. 1. Map of the study site

was1m, 0.5m and 30cm respectively. Urea was applied in split application for all the treatments.

2.1 Sampling and Analysis of Vermicompost

One composite sample for vermicompost was taken for nutrient analysis. Then organic carbon, pH, EC, total N, total P, and total K of the vermicompost was determined.

Table 1. Chemical properties of vermicompost used for the study

Chemical properties	Vermicompost
pH	7.12
EC(ds/cm)	1.67
OC (%)	20.19
Total N (%)	1.59
Total P (%)	0.89
Total K (%)	1.55

Note: EC= Electrical Conductivity; OC= Organic Carbon; Total N= Total Nitrogen and Total P= Total Phosphorus, and Total K=Total potassium

2.2 Agronomic and Soil Data Collection

During the study agronomic data such as Date of sowing, Days to heading and Days to maturity, Plant height, Biomass weight, Straw yield and Grain yield was taken. Soil samples were collected from the experimental site at 0-20 cm depth using auger following zigzag technique.

The collected soil sample before planting was analyzed for soil texture, pH, EC, organic carbon (OC), total N, available P, and CEC. Soil pH and EC was measured potentiometrically in the supernatant suspension of a 1:2.5 soil: water mixture by using a pH meter as described by [12].

The determination of soil organic carbon was based on the Walkley-Black chromic acid wet oxidation method [13]. The Kjeldhall process as outlined by [14] was followed to determine the total nitrogen. Olsen Method (Bicarbonate extractable P) was used to extract and determine available phosphorus [15]. Determination of CEC at pH 7 was carried out with Ammonium Acetate method as described by [16].

2.3 Selected Soil Properties of the Study Area

Table 2. Soil data of experimental sites in year 1

Parameters	Experimental Site and year					
	Year 1		Year 2		Year 3	
	Site 1	Site 2	Site 1	Site 2	Site 1	Site 2
pH	6.96	7	6.68	6.69	7.2	6.62
EC(mmh)	0.4486	0.7096	0.42	0.45	0.43	0.45
Ava. P	6.136	23.864	26.136	21.864	21.14	21.52
% OC	0.522	0.723	1.16	1.03	1.12	1.02
(%)TN	0.052	0.053	0.055	0.054	0.055	0.054
CEC	59.8	48.8	49.8	38.8	42.8	35.8
% Sand	22	26	21	19	25	28
% Silt	17	25	31	29	30	29
% Clay	61	49	48	52	45	43
Tex. Class	clay	clay	clay	clay	clay	clay

Note: OC= Organic Carbon; CEC= Cation Exchange Capacity; TN= Total Nitrogen and Av. P= Available Phosphorus

2.4 Statistical Analysis

The data was subjected to analysis of variance (ANNOVA) by following the standard procedure of SAS computer software analysis. After performing ANOVA the differences between the treatment means were compared by LSD test at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Effect of the Treatments on Yield and Yield Parameters of Wheat

3.1.1 Days to 50% heading and days to 90% maturity of wheat

The maximum number of days to reach 50% heading was observed on the control plots than the plots treated with vermicompost. This may indicate the increased rate of vermicompost that increase the matrix potential of the soil and short period of moisture content in the study area speed up heading of the crop at that period of time.

It was also observed that the application of different rate of vermicompost hastened significantly the days of maturity of wheat plants as compared to control plots. The early maturity of plants on the plots manures of vermicompost could be due to reduction of stress that causes forced maturity. In line with this study [17] have found that application of any rate of FYM, VC and NPK fertilizers hastened days to heading and maturity as compared to unfertilized plants.

3.1.2 Plant height and panicle length

The application of different rate of vermicompost had significantly influenced plant height (Table 3). Thus tallest plant height was found from treatments that received 100kg/ha NPS, followed by 8.75t/ha vermicompost which resulted in (73.25cm) while the shortest plant (62.73cm) was obtained from control plots, respectively. Similarly longer panicle was obtained from 100kg/ha NPS, followed by 8.75t/ha vermicompost while shortest panicle was obtained from control plots. Similar to this study [18] also reported that height of wheat plant was maximum in treatment with only NPK dose than vermicompost at 20t/ha. They also report that number of spikes/plant was more in NPK fertilizers than control and other treatment of vermicompost doses. Similarly [19] found that maximum plant height of wheat from treatment of RDF + Vermicompost at 2.5 t/ha + FYM at 5 t/ha + Azotobacter) at all the growth stages from 30 DAS till harvest.

3.1.3 Biomass yield and grain yield

The application of different rate of vermicompost had significantly influenced biomass yield (Table 4). Thus the highest biomass (6241.5kg/ha) and grain yield (2642.8kg/ha) was obtained from 100kg/ha NPS followed by vermicompost at 8.75t/ha. This indicates as the rate vermicompost

increase both biomass and grain yield of teff increases. Whereas the lowest bio mass and grain yield was obtained from control plots. At the wheat plants grown in plot received vermicompost compost at 7t/ha ha^{-1} of vermicompost increased the grain yield by 67.78% over the control. Similar with this result total yield/acre of wheat in soil came out to be 1258 kg and 1643 kg in treatments with 20t/ha vermicompost and recommended NPK respectively [18]. The increase in grain and straw yields might be due to adequate quantities and balanced proportions of plant nutrients supplied to the crop as per need during the growth period resulting in favorable increase in yield attributing characters which ultimately led towards an increase in economic yield. Improved physic chemical properties of the soil through the application of organic manure might be the other possible reason for higher productivity [19].

3.1.4 Straw yield and harvest index

The application of different rate of vermicompost had significantly influenced straw yield of wheat as compared to the control plots while there is no significance differences among the fertilized plots (Table 4). Thus the highest straw yield (3598.7kg/ha) and (3210.3kg/ha) was found from treatments that received 100kg/ha NPS and vermicompost compost at 8.75t/ha respectively while the lowest straw was obtained from control plots. At the wheat plants grown in plot received vermicompost at 8.75t/ha increased the straw yield by 60.7% over the control. Similar with this result [20] also report the addition of vermicompost with or without phosphate solubilizing bacteria together with different fertilizer levels produced significantly higher grain and biological yields than the application of fertilizers alone. In addition the maximum straw

Table 3. Means of Days to 50% heading, days to physiological maturity and plant height of wheat under the effect of different rate of vermicompost

Treatment	Days to 50% Heading (days)	Days to 90 % Maturity (days)	Plant Height (cm)	Panicle length (cm)
control	58.500	96.750	62.73^{b}	6.70^{b}
100kg/ha NPS	56.917	96.417	73.25^{a}	7.88^{a}
1.75t/ha vermicompost	56.83	97.167	70.55^{a}	7.69^{a}
3.5t/ha vermicompost	56.50	97.083	71.33^{a}	7.76^{a}
7t/ha vermicompost	56.67	96.833	71.050^{a}	7.82^{a}
8.75t/ha vermicompost	57.17	97.083	71.30^{a}	7.85^{a}
Mean	57.09	96.89	70.036	7.62
LSD (P≤0.05)	NS	NS	5.34	0.88
CV (%)	5.86	9.219	9.35	14.21

Where: CV= coefficient of variation, LSD= least significant difference, numbers in the same column followed by the same letter(s) are not significantly different at α<0.05

Table 4. Means of Biomass yield, Grain yield, Straw yield, and Harvest index of teff under the effect of different rate of vermicompost

Treatment	Biomass yield (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest Index
control	3558.7^{b}	1561.6^{b}	1997.1^{b}	42.94^{ab}
100kg/ha NPS	6241.5^{a}	2642.8^{a}	3598.7^{a}	41.706^{b}
1.75t/ha vermicompost	5601.1^{a}	2415.4^{a}	3185.7^{a}	42.883^{ab}
3.5t/ha vermicompost	5542.5^{a}	2568.4^{a}	2974.1^{a}	46.408^{a}
7t/ha vermicompost	5743.1^{a}	2620.0^{a}	3123.2^{a}	45.618^{ab}
8.75t/ha vermicompost	5828.6^{a}	2618.3^{a}	3210.3^{a}	44.725^{ab}
Mean	5419.263	2404.410	3014.85	44.05
LSD (P≤0.05)	1341	670.99	719.82	4.18
CV (%)	30.35	34.24	29.29	11.65

Where: CV= coefficient of variation, LSD= least significant difference, numbers in the same column followed by the same letter(s) are not significantly different at α<0.05

Table 5. Partial budget analysis under NPS and different rate of vermicompost

Treatments	Grain yield	Adj. yield (10% less) (kg ha-1)	(TR)	(T VC) [Birr]	[TR-TVC]	MRR ratio	MRR (%)
control	1561.6	1405.44	28108.8	0	28108.8	0	0
1.75t/ha vermicompost	2415.4	2173.86	43477.2	1747	41730.2	7.79	779
3.5t/ha vermicompost	2568.4	2311.56	46231.2	2242	43989.2	4.56	456
100kg/ha NPS	2642.8	2378.52	47570.4	3177	44393.4	0.43	43
7t/ha vermicompost	2620	2358	47160	3232	43928	D	D
8.75t/ha vermicompost	2618.3	2356.47	47129.4	3727	43402.4	D	D

Where t= tone; ha= hectare; MRR= Marginal Rate of Return, and D= dominance TR= total revenue, TVC= total variable cost, NR= net revenue

yield 54.05 and 51.86 q ha-1 of wheat was recorded in treatment with 100% NPK application which is statistically in parry with highest rates of vermicompost. However there was no significant difference among the treatments in harvest index.

3.1.5 Partial budget analysis

To assess the costs and benefits associated with the different treatments, the partial budget technique of [21] was applied to grain yield results. According to this manual, experimental yields are often higher than the yields that farmers could expect using the same treatments. Hence, in economic calculations, the grain yield has been adjusted 10% lower than the actual yield obtained from the experimental plots to make the representative yield at the farmers' fields, [21].

The highest marginal rate of return in percent (456) was also recorded from the application of 3.5t/ha vermicompost combined with recommended urea at the study area (Table 5). Therefore, application of 3.5t/ha vermicompost is profitable and is recommended for farmers in the study area and other areas with similar agro-ecological conditions.

4. CONCLUSION

Based on the results obtained there was significance difference among the treatments applied as compared to the control. The highest plant height, biomass yield, and grain yield was obtained from 100kg/ha NPS followed by vermicompost at 7/ha. Though highest grain yield was obtained from the application of chemical fertilizer the most economical treatment was 3.5t/ha vermicompost combined with recommended urea based on the partial budget analysis.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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