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Research Article

Effect of Integrated Application of Vermicompost and Inorganic Fertilizers on Yield and Yield Components of Bread Wheat in Adami Tulu Jido Kombolcha District of East Showa Zone, Ethiopia

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Abstract

A field experiment was conducted at Adami Tulu Agricultural Research Center during 2022 cropping season to evaluate the responses of vermin compost and inorganic fertilizers on bread wheat (Triticum aestivum). The experiment consists of eight treatments: T1= Control (without fertilizer), T2=50% RNP+4t/ha VC, T3= 50% RNP+ 8t/ha VC, T4=100% RNP, T5= 4t/ha VC, T6= 8t/ha VC, T7= 100% RNP+ 4t/ha VC, T8=100% RNP+8t/ha VC. The result revealed that grain yield affected by combined application of these two fertilizes. There are gradual changes in some major soil parameters have statistically affected by combined application of vermin compost and inorganic fertilizer. Accordingly maximum grain yield (4596.3kg/ha) was recorded from T2 where 50% recommended NP+4t/ha VC where as the lowest grain yield (2109.3kg/ka) was from control plot. Lastly partial budget analysis was also calculated to determine best treatment combination for future farther use. Accordingly maximum net benefit (155,870.50ETB) was obtained from T2 where 50% recommended NP+4t/ha VC was combined. Therefore this treatment was used as best treatment combination for this area, for this crop, it needed for large scale soil fertility management and increasing land productivity.

Keywords

Integrated Application, Vermin Compost, Inorganic Fertilizers, Wheat Yield

1. Introduction

Wheat (*Triticum aestivum* L.) is one of the significant staple grains with worldwide production being 672 million tons [5]. In our country wheat is also staple food in the diets of several providing about 15 percent of the caloric intake for the countries over 90 million populations [4]. Wheat placing the second major crop after maize and slightly ahead of teff, sorghum and enset, which contribute 10-12 percent each [10]. High growth of population led to removal of vegetation cover and continuous cultivation of lands with low nutrient replenishment results in depletion of soil nutrients [14].

For the sustainable agricultural production integrated soil fertility management such as using vermin compost is the

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latest approach to supplement chemical fertilizers [7]. Because these source of organic fertilizers are locally available, environmentally sound and economically feasible for small holder farmers [3]. Therefore, the best remedy for soil fertility management is the combination of both inorganic and organic fertilizers, where the inorganic fertilizer provides fixed nutrients and organic fertilizer mainly increases soil organic matter and improves soil structure and buffering capacity of the soil [8].

However, in the study area there is no information on the combined use of vermin compost and chemical fertilizer for bread wheat production. Therefore, this study was initiated to investigate the effects of VC and inorganic fertilizers on major soil chemical properties and wheat yield and yield components, with the following specific objectives.

1. To evaluate the effect of vermin compost integrated with chemical fertilizer on yield and yield components of bread wheat.
2. To evaluate the residual effect of integrated application of vermin compost and chemical fertilizers on soil properties.

2. Materials and Methods

2.1. Description of Study Area

The study was conducted in the central rift valley part of Ethiopia in Oromia Region, Adami Tulu-Jido Kombolcha woreda. Geographically the area is located between 38°25'E and 38 ° 55'E and 7°35'N and 8°05'N and is bordered by Southern Nations, Nationalities and Peoples' Region (SNNPR) in the west and north west, Dugda-Bora woreda in the north, Arsi zone in the east and Arsi Negele woreda in the south. The capital city of the district Batu was found at distance of about 160 km from Addis Ababa which was the capital city of our country. The district has semi-arid and arid agro-climatic zones and lies between 1500_2300 m a.s.l. and it receives unevenly distributed average annual rainfall of 760.9 mm per annum. The long-term mean minimum and the mean maximum temperature is 12.6 and 27 ℃ respectively. Vitric Andosols and Mollic Andosols are the dominant soil group in the district.

2.2. Experimental Materials and Procedures

A bread wheat variety named King bird was used as a test crop at the seed rate of 150kg/ha. Urea used as a source of nitrogen and NPS as a source of P inorganic fertilizer and VC used as organic fertilizers for this experiment. VC was produced from 50% animal manure, 25% haricot bean straw and 25% wheat straw by using earthworm in Adami Tulu Agricultural Research Center; VC samples were collected from well decomposed before they were applied to the field. Then their N and P contents were analyzed in the laboratory using the standard procedure to determine the rate of application of each treatment, which was based on the recommended N equivalent rate for the test crop. Land preparation and Planting was done accordingly.

2.3. Experimental Design and Treatments

The experiment consisted of eight treatments of sole and combinations of inorganic fertilizers (NPS and urea) and organic amendments (vermin compost). The experiment was laid out in a Randomized Complete Block Design (RCBD) replicated three times per treatments. These treatments were combined in the following table.

Table 1. *Treatments and treatment combination.*

No	Amount of Fertilizers/ha	Amount of VC/ha	Description
1.	0	0	Control
2.	50% Recommended NP	4t/ha	50% Recommended NP = 50kgN+80kg NPS
3.	50% Recommended NP	8t/ha	50% Recommended NP = 50kgN+80kg NPS
4.	100% Recommended NP	0	100% Recommended NP=100kgN+160kgNPS
5.	0 NP fertilizer	4t/ha	0 NP fertilizers + 4t/ha VC
6.	0 NP fertilizer	8t/ha	0 NP fertilizers +8t/ha VC
7.	100% Recommended NP	4t/ha	100% Recommended NP+160kg NPS +4tVC
8.	100% Recommended NP	8t/ha	100% Recommended NP+160kg NPS +8tVC

2.4. Soil Sampling and Laboratory Analysis

Soil samples were collected from each plot before treatment application and after yield harvest. These composite soil samples were used for analysis of selected soil chemical properties following the standard laboratory procedures.

2.4.1. Agronomic Data Collection

All yield and yield component data's were collected accordingly. Plant height and spike length were collected before harvesting, grain yield, 1000 seed weight and total biomass were also collected after yield harvesting.

2.4.2. Economic Analysis

To identify the optimum economic rate of fertilizer combinations, economic analysis was done using the [7] partial budget analysis methodology. To estimate economic parameters, NPS, Urea and wheat yield was valued at an average open market price. GAY:-gross average yield of each treatment in t/ha.

$$NB=GFB–TC$$

Where NB= Net Benefit, GFB=Growth Field Benefit and TC= Total Variable Cost

2.5. Statistical Data Analysis

All the collected datas were analyzed using (SAS software 9.3 versions). If there were significant difference between the treatments, the means were separated with LSD treatment comparison.

3. Result and Discussions

3.1. Major Grain Yield and Yield Components

Analysis of variance (ANOVA) showed that there was significant variation observed in grain yield, plant height, spike length, 1000 seed weight and total biomass between the treatments. The maximum spike length (7.66cm) was obtained from treatment (T2) i.e 50% recommended NP+4t/ha VC and the lowest spike length (5.33cm) were obtained from the control plot (Table 2).

In plant height there was no stastiscal difference between the treatments except the control plot. But the tallest plant height (70.00cm) was recorded from the 100% recommended NP+ 8t/ha VC and the lowest plant height (51.66cm) was obtained from the control treatment (Table 2). The present study was in harmony with [11] who reported that plant height was increased with the addition of farm manure over the control. In agreement with this result, [15] reported significant effects of integrated nutrient management on plant height of maize.

Table 2. *Response treatments to grain yield and yield components.*

No.	Treatments	SpL. (cm)	PLH. (cm)	GrainYld kg/ha	TBM kg/ha	000'grain weight (gm)
1.	Control (no fertilizer)	5.33^{d}	51.66^{b}	2109.3^{d}	6074^{b}	35.12^{b}
2.	50% RNP+4t/haV.C	7.66^{a}	64.66^{a}	4596.3^{a}	9981^{ab}	40.10^{a}
3.	50% RNP+8t/haV.C	7.66^{a}	66.66^{a}	3571.1^{bc}	11500^{a}	40.76^{a}
4.	100% RNP	7.00^{bc}	68.33^{a}	4206.7^{ab}	9352^{ab}	39.86^{a}
5.	4MT/haV.C	6.50^{c}	63.33^{a}	3148.1^{c}	8444^{ab}	39.29^{a}
6.	8MT/haV.C	6.50^{c}	63.33^{a}	3329.2^{c}	9870^{ab}	39.88
7.	100% RNP+4t/haV.C	7.33^{ab}	69.00^{a}	3632.2^{bc}	10852^{a}	40.58
8.	100% RNP+8t/haV.C.	7.00^{bc}	70.00^{a}	3864.4^{ab}	10352^{ab}	40.11
LSD		0.63	11.62	735.57	4733.4	1.50
CV		5.35	10.39	11.94	28.62	2.20

Means within column followed by the same letters are not significantly different at $P \leq 0.05$; LSD, SpL= spike length, PLH= Plant height, Yld= Yield, TBM= Total Biomass

The interaction effect of organic and inorganic fertilizer significantly affects spike length. The maximum spike length (7.66cm) was obtained from the 50% RNP+4t/ha VC and the lowest (5.33cm) was recorded from the control plot (Table 2). This is in line with the findings of [6] who claimed that spike length increased significantly with nitrogen.

The grain yield also shows statistical difference between the treatments. The maximum grain yield (4596.3kg/ha) was obtained from 50% recommended NP + 4t/ha VC and the lowest grain yield (2109.3kg/ha) was from control plot (Table 2).

The applied combined application of fertilizers significant-

ly affect 1000 grain seed weight (P<0.05) over the control. The result agreed with [10] who reported that the maximum 1000 grain weight (40.79g) was obtained from the combined application of 50% recommended NP +8t/ha VC and the lowest amount of 1000grain seed weight (35.12g) was recorded from control plot (Table 2). This finding agreed with [9] who found that application of 50% N from manure along with 50% N from mineral fertilizers produced maximum 1000-grain weight (279g). Likewise, [13] reported combined application of compost and mineral fertilizers significantly affect thousand seed weight.

3.2. Major Soil Chemical Properties Before Treatment Application and After Harvesting

Table 3. *Initial soil chemical properties of experimental site.*

Soil Parameters	pH	TN (%)	OC (%)	Ava.P mg/kg	Ava.K mg/kg	CEC mg/kg	Ca mg/kg	Mg mg/kg	Na mg/kg
Amounts	7.60	0.21	2.23	11.45	1279.65	26.60	4139.49	337.58	172.94

TN= Total Nitrogen, OC= Organic Carbon, Ava.P= Available Phosphorous, Ava.K= Available Potassium

Table 4. *Post harvest soil chemical properties.*

No.	Treatments	pH	TN (%)	OC (%)	Ava.P (mg/kg)	Ava.K (mg/kg)	Exc.Ca mg/kg	Exc.Mg Mg/kg	Exc.Na mg/kg
1.	Control (no fertilizer)	8.03	0.2^{c}	2^{c}	9.84	1351.02	4156.8	382.18	129.02^{a}
2.	50% RNP+4t/haV.C	7.97	1.23^{a}	2.35^{a}	11.18	1495.80	4364.4	394.40	92.93^{b}
3.	50% RNP+8t/haV.C	8.19	1.24^{a}	2.32^{a}	10.36	1469.63	4583.0	366.91	98.94^{ab}
4.	100% RNP	7.89	1.1^{b}	2.12^{b}	12.57	1450.34	4485.4	351.31	84.90^{b}
5.	4MT/haV.C	8.10	1.21^{b}	2.37^{a}	13.96	1479.34	5154.1	367.84	74.66^{b}
6.	8MT/haV.C	8.14	1.3^{a}	2.36^{a}	10.92	1473.11	4558.2	369.36	95.36^{b}
7.	100% RNP+4t/haV.C	7.94	1.12^{c}	2.34^{a}	21.63	1471.69	4513.4	357.16	88.54^{b}
8.	100% RNP+8t/haV.C.	7.90	1.11^{c}	2.35^{a}	17.17	1402.53	4399.1	369.14	95.99^{ab}
LSD		ns	0.8	0.11	ns	ns	ns	ns	33.02
CV		3.58	10.6	6.43	50.66	5.79	15.01	7.30	20.08

TN= Total Nitrogen, OC= Organic Carbon, Ava.P= Available Phosphorous, Ava.K=Available Potassium, Exc.Ca =Exchangeable Calcium, Exc. Mg=Exchangeable Magnesium, Exc. Na= Exchangeable Sodium

3.2.1. Soil Reaction (pH), TN (%) and Soil Organic Carbon (%)

Analysis of variance (ANOVA) showed that there was statistically significant variation observed between the treatments in total nitrogen, organic carbon and exchangeable sodium. But other soil parameters such as pH, Ava. P, Ava. K, Exc.Ca and Exc. Mg showed non-significant difference between the treatments after harvesting; on the other hand there was gradual change in these soil parameters compared with initial soil properties.

Soil pH reflects the overall chemical status of the soil and influences a whole range of chemical and biological processes occurring in the soils. The analysis result of this study indicated that the soil was slightly saline soil reaction range (7.89-8.19) as per soil pH rating proposed by [9]. But the combination of vermin compost and inorganic fertilizers shows non-significance difference between treatments in soil reaction. The treatments were statistically similar. This might be due to the combined application of organic and inorganic fertilizer which lowered the soil pH to neutral range owing to the release of H^{+} ions via microbial decomposition of organic fertilizers.

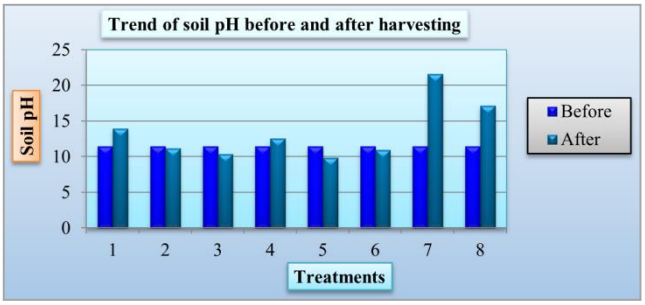

Figure 1. *Trend of soil before and after harvesting.*

Integrated application of organic and inorganic fertilizer showed significant effect on TN between the treatments. The maximum amount of TN (1.24%) was observed from the combined application of 50% recommended NP + 8t/ha VC and the lowest TN (0.2%) were obtained from the control plot (Table 4). This might be due to high nitrogen content of organic fertilizers, as there was no fertilizer applied to the control plots, this could also be attributed to previous cropping systems practiced by the farmers prior to the experiment. Generally TN and OC were directly affected with nature and amount of organic colloids presented in the soil.

The result agreed with [1] who revealed that combined use of NP and compost increased soil TN by 31% compared to the sole application of inorganic NP fertilizers.

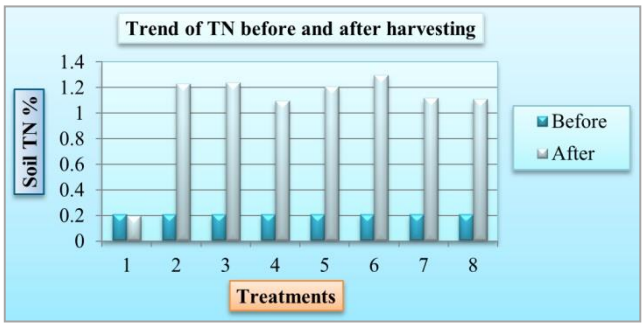

Figure 2. *Trend of TN before and after harvesting.*

Soil organic carbon was also another very important soil fertility determinant soil parameter. After harvesting, the combined application of organic and inorganic NP fertilizer showed statistically significant effect on soil organic carbon between the treatments at ($P<0.05$). The maximum OC (2.37%) was obtained from the application of 4t/ha VC and the lowest organic carbon (2%) were recorded from control plot (Table 4). Similarly, this result was in harmony with [15] who reported that the application of organic fertilizer in combination with inorganic fertilizer increases OC content.

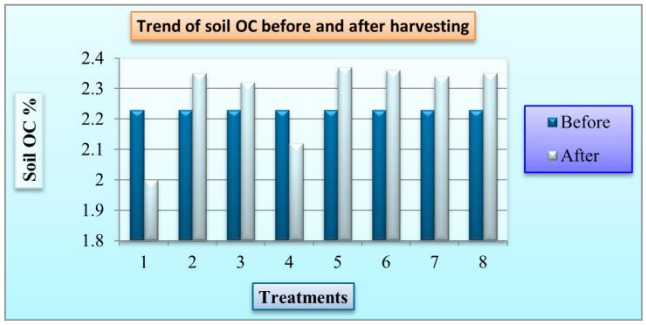

Figure 3. *Trend of SOC before and after harvesting.*

3.2.2. Soil Available P and Available K

Available Phosphorous (P) and Potassium were the most important limiting plant nutrients next to nitrogen for crop production. The result showed combined applications of organic and inorganic fertilizers showed statistically non-significantly affect ava.P and ava.K in soil in this experiment. But relatively the maximum amount of ava.P (21.63mg/kg) was obtained from the combined application of 50% recommended NP +4t/ha VC and the lowest ava. P (9.84mg/kg) was obtained from the control plot (Table 4). This might be due to Every year plants absorb only about 20–30% of the P in applied fertilizers [12].

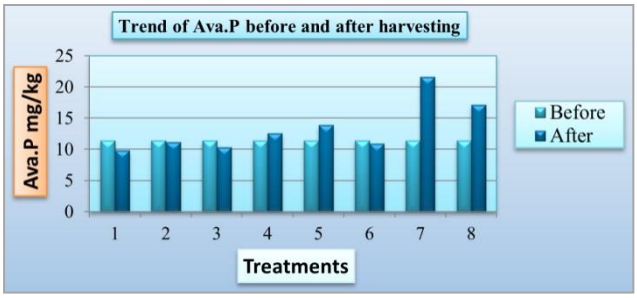

Figure 4. *Trend of Ava.P before and after Harvesting.*

Potassium is needed in large quantities by many crops next to nitrogen and phosphorous. Similarly available potassium was non-significantly affected by the combined application of organic and inorganic fertilizers in this experiment. But the highest amount Ava.K (1495.80mg/kg) was obtained from the combined application of 50% recommended NP + 4t/ha VC and the lowest result (1351.02mg/kg) were recorded from the control plot (Table 4). The increase in Av.K with the application of VC might be due to the K from the organic sources and also could be due to higher microbial activities in the soil which increased the release rate of non-exchangeable or fixed-K forms into available forms.

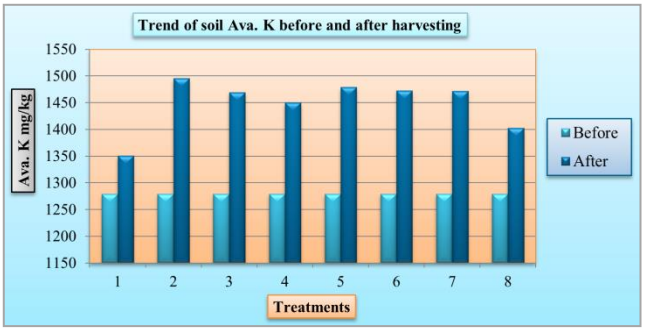

Figure 5. Trend of soil Ava. K before and after harvesting.

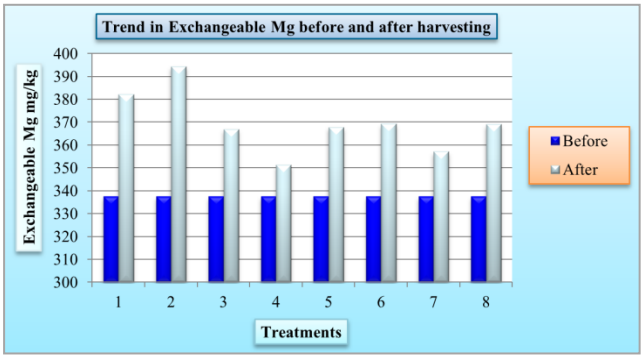

Figure 6. Change in exchangeable Magnesium before and after harvesting.

3.2.3. Exchangeable Bases (Ca, Mg and Na)

The analysis of variance results showed non-significant differences in exchangeable Ca^{+2} and Mg^{+2}, but shows significant difference in exchangeable Na^{+1} between treatments. The maximum amount of exchangeable Ca^{+2} (5154.1mg/kg), Mg^{+2} (394.40mg/kg) and Na^{+1} (129.02mg/kg) were obtained from 50% RNP+8t/ha V.C, 50% RNP+4t/ha V.C and the lowest amount obtained from the control plot respectively (Table 4). This finding was supported by [8] who indicated that an increase in exchangeable bases in treatments where both mineral and organic fertilizers were added.

3.3. Economic Analysis

The partial budget analysis was done by [2]. The highest grain yield (4.59t/ha) was recorded from 100% of recommended inorganic fertilizer and the lowest grain yield (2.11t/ha) was from the control treatment (Table 5).

The economic analysis revealed that the highest net benefit of (155,870.50 ha^{-1} Ethiopian birr) was obtained from the application of 50% recommended inorganic fertilizer +4t/ha VC, whereas the lowest net benefit (73,825.50 ha^{-1} Ethiopian birr) was obtained from the control plot (Table 5).

Table 5. Partial budget and dominance analysis of wheat yield influenced by organic and inorganic fertilizers.

Trt	Urea in kg/ha	NPS in kg/ha	Grain yld in kg/ha	Price of wheat	Price of Urea	Price of NPS	VC in kg/ha	Price of VC	TVC	Growth in come/ha	NB /ha	MRR%
1	0	0	2109.3	35	40	40	0	4	0	73825.5	73,825.50	0
2	50	75	4596.3	35	40	40	4000	4	5000	160871	155,870.50	3117.41
4	100	150	4206.7	35	40	40	0	4	10000	147235	137,234.50	1372.35
5	0	0	3148.1	35	40	40	4000	4	16000	110183.5	94,183.50	-
7	100	150	3632.2	35	40	40	4000	4	26000	127127	101,127.00	
6	0	0	3329.2	35	40	40	8000	4	32000	116522	84,522.00	
3	50	75	3571.1	35	40	40	8000	4	37000	124988.5	87,988.50	237.8
8	100	150	3864.4	35	40	40	8000	4	42000	135254	93,254.00	222.03

T1=Control (without fertilizer), T2=50% RNP +4t/ha VC, T3=50% RNP +8t/ha VC, T4=100% RNP, T5= 4t/ha VC, T6= 4t/ha VC, T7= 100% RNP + 4t/ha VC, T8= 100% RNP + 8t/ha VC

The economic analysis further revealed that the application of 50% recommended NP +4t/ha VC provided the highest marginal rate of the return (MRR) of 3117.41%, suggesting for each birr invested in wheat production, the producer would collect birr 31.17 birr after recovering his cost (Table 5). So that MRR assumed in this study was 100%, the treatment with an application of 50% recommended NP + 4t/ha VC fertilizers gave rise an acceptable MRR.

4. Conclusion and Recommendation

Low soil fertility declined from time to time in the study area. However, continuous and sole use of inorganic fertiliz-

ers may lead to; deterioration soil physicochemical properties. The study was conducted in Adami Tulu Agricultural Research Center site with the following objectives: 1) To evaluate the effect of vermin compost integrated with chemical fertilizer on yield and yield components of bread wheat 2) To evaluate the residual effect of integrated application of organic and inorganic fertilizer on major soil chemical properties. The treatments consist of: T1= Control (without fertilizer), T2= 50% recommended NP + 4t/ha VC, T3= 50% recommended NP + 8t/ha VC, T4= 100% recommended NP, T5= 4t/ha VC, T6= 8t/ha VC, T7= 100% recommended NP + 4t/ha VC, T8= 100% recommended NP +8t/ha VC. The experiment was laid down in RCBD replicated three times. Before the application of treatments to the experimental site composite soil sample were collected to compute N equivalence ratio. All yield and yield component data's were collected and yield data was recorded after maturity. Accordingly there were significant differences between the treatments in plant height, spike length, 1000 seed weight, grain yield and total biomass. The maximum grain yield (4596.3kg/ha) was obtained from the combined application of 50% recommended NP +4t/ha VC and the lowest grain yield (2109.3kg/ha) was recorded from the control plot. Similarly after harvesting composite soil sample were also collected to evaluate the residual effect of these two fertilizers on major soil chemical properties. Combined application of organic and inorganic fertilizer showed significant differences TN, OC and exchangeable sodium soil parameters, But other soil parameters such as pH, Ava. P, Ava. K, exchangeable calcium and magnesium showed non-significance difference, but still show increasing trend compared with initial soil. Considering the economic feasibility use of treatments the maximum net benefit (155,870.50 ETB) and the maximum rate of return (3117.41) was obtained from 50% recommended NP +4t/ha VC. So in order to increase bread wheat production, sustainable soil fertility management and reduce the cost of inorganic fertilizer, this treatment application was the best option for wheat production in this area and this technology need large scale demonstration. So in order to address soil fertility problems in study area, this result should be demonstrated.

Abbreviations

ANOVA	Analysis of Variance
Ava.K	Available Potassium
Ava.P	Available Phosphorous
CV	Coefficient of Variation
ETB	Ethiopian Birr
Exc. Mg	Exchangeable Magnesium
Exc. Na	Exchangeable Sodium
Exc. Ca	Exchangeable Calcium
GAY	Gross Average Yield
GFB	Gross Field Benefit
LSD	Least Significant Difference
M A.S.L	Means Average Sea Level
MRR	Marginal Rate of Return
NB	Net Benefit
NP	Nitrogen and Phosphorous
OC	Organic Carbon
PLH	Plant Height
RCBD	Randomized Complete Block Design
RNP	Recommended Nitrogen and Phosphorous
Spl	Spike Length
TBM	Total Biomass
TC	Total Cost
TN	Total Nitrogen
TVC	Total Variable Cost
VC	Vermin Compost
Yld	Yield

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Conflicts of Interest

The authors declare no conflicts of interest.

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