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Research paper

Effect of Organic and Inorganic Fertilizers on Selected Soil Properties Yield of Bread Wheat *(Triticum aestivum* L.) in Lume District East Shoa, Ethiopia

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Soil fertility depletion is one of the major limiting factors for depletion of soil properties and reduction in grain yield, in the study area. As a result, inorganic fertilizers are commonly supplied to the soil. However, continuous and sole use of inorganic fertilizers may lead to deterioration in soil chemical and physical properties. Therefore, the study was conducted to investigate the integrated use of organic and inorganic fertilizers on selected soil properties, in Lume district, East Shoa Zone, during 2018 cropping season. The organic sources used were compost and vermicompost and urea and NPS where used as inorganic of fertilizers. The treatments consist of:- T1=5.64 t/ha compost, T2=5.68 t/ha vermicompost, T3=100% recommended NPS + urea fertilizers, T4=50% recommended NPS+urea fertilizers+2.82t/ha compost, T5=50% recommended NPS+urea fertilizers+2.84 t/ha vermicompost, T6=No fertilizers (control).The experiment was laid out as a randomized complete block design replicated three times per treatments. Data were collected on, selected soil properties before treatment application and after harvesting and on wheat gain yield. Economic analysis was also performed by estimating the costs of alternative uses of organic and in organic fertilizers as well as grain yield prices. The results showed that the application of organic fertilizer in combination with 50% recommended rates of NPS+ urea significantly improves most of the soil physicochemical properties, over the application of 100% mineral NPS alone and the control. The application of 2.84 t/ha vermicompost in combination with 50% recommended rates of NPS+ urea fertilizers increases soil organic carbon content by 41%, total nitrogen by 22%, available P by 15. 40%, available K by 36.14% and 0.5t/ha over the application of 100% recommended rate of inorganic NPS alone. It can be concluded that the application of 2.84 t/ha vermicompost with 50% recommended rate of inorganic NPS fertilizers has maximum rate of return and can improve soil fertility status than other treatments. This experiment has to be repeated over seasons and locations to make conclusive recommendation for the study area.

Key Words: - Combined, Compost, Nitrogen, Phosphorous, Soil, Soil Properties

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INTRODUCTION

Soil fertility decline is a big issue in agriculture of Ethiopia, because the livelihood of rural population (85%) directly relies on it and soil fertility degradation has been described as the most important constraint to crop production and food security in the country. As a result, inorganic fertilizers are commonly applied to the soil for crop production. However, continuous and sole use of inorganic fertilizers may lead to soil degradation and shortage of other nutrients which are not supplied through chemical fertilizers (Daniel *et. al.,* 2006). Furthermore, excessive use of chemical fertilizers may cause environmental pollution and alter ecosystem balances that are emerging as one of the major environmental problems (Mishira and Nayak, 2004). On the other hand, the country has a high population of livestock and farmyard manure, considerable amounts of organic materials. Organic fertilizers have been used to ameliorate the soil nutrient level (Law- Ogbomo and Remison 2007) owing to their slowly release of nutrients to be taken up by plants and also due to their difficulty to handling (Adediran *et al.,* 2015). This is because it is cheap and affordable, eco-friendly and it had a profound effect on the activity of soil microflora as well as soil physicochemical properties (Gitari *et al*., 2001). In sustainable agricultural system, integrated soil fertility management is an important approach that attempts to make the best use of inherent soil nutrient from locally available and environmentally sound soil amendments and mineral fertilizers to increase land productivity while maintaining or enhancing soil fertility (Efthimiadou *et al.,* 2010). As a result, the use of combined inorganic and organic fertilizer should be practiced to increase the yield of crops and maintain environmental sustainability. As a result many researchers have been conducted in many parts of the countries to see the combined effect of organic and mineral fertilizers for wheat production (Mohamed *et al*., 2000). Oromia Agricultural research Institute (OARI) was conducted constraint analysis survey on soil related problems in Lume district 2016 and clearly indicated that there is continues use of inorganic fertilizer and less attention given on organic fertilizer application in the area that make soil physicochemical deterioration, but any research was not conducted in the district where wheat is one of the potential cereal crops in the area. Therefore, this study was initiated with the following specific objectives:

Specific Objectives:-

- To evaluate the effect of combined and sole application of organic and inorganic fertilizer on selected soil physicochemical properties
- To evaluate the effect of combined and sole application of organic and inorganic fertilizers on wheat yield

MATERIALS AND METHODS

Description of Experimental Site

Location

The experiment was conducted in Lume district, east Shoa Zone, Oromia Regional State. The experimental site was 7 km to the South of Modjo the capital town of the district, 32 km South East of Adama and 84 km from Addis Ababa. The area geographically located in $08^{o}28'0''$N and $39^{o}\,26'0''$E.

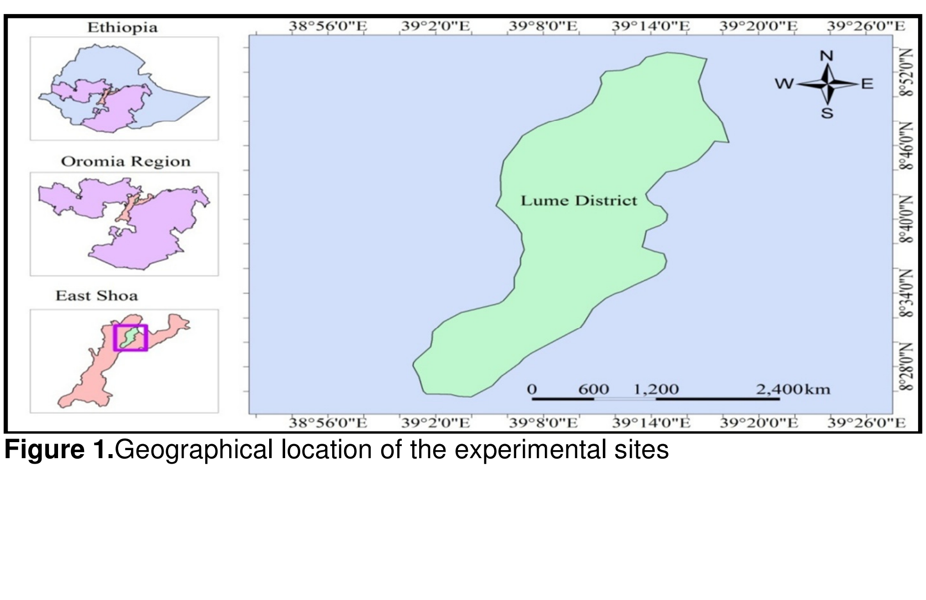

Figure 1. Geographical location of the experimental sites

Topography, climate and soil

The topography of the experimental site is mainly flat and undulating plains with an elevation range of 1590 to 2512 meter above sea level, which is characterized by semi-arid and arid climate. The area has erratic rainfall distribution pattern.

The average daily minimum, mean and maximum temperatures of the area are 20°C, 23°C and 28°C with annual rainfall ranging between 500 mm, 750 mm and 1200 mm respectively, in which the minimum rainfall obtained in May and the muximum in Auguest. The dominant soil type of the district is Vertisols according to (Addis *et al*., 2001) and soil textural class is loam. At the experimental site in order to improve soil fertility status and increase productivity, soil fertility management practice by the farmers is only rotation of crops which is not according to cereal legume based sequence rather than changing crop types per year.

Farming system and land uses

The district has a mixed farming system (crop and animal) production with a number of cereals, pulses and vegetable crops produced for both household consumption and market. In low land and midland ago-ecologies, maize, *teff*, wheat, barley, faba bean, and chickpea produced largely. In addition to the cereals and pulse irrigated lands produce horticultural crops like tomato, onion, and hot pepper. However, rain-fed crop production was only limited to the main rainy season and among this *teff* and wheat are the potential crops in the area. According to the secondary information gathered from the district during constraints analysis survey conducted in 2016 by OARI cultivation was major land use patterns. A fairly large area of cultivable land in the district has been used for irrigated agriculture. Grazing lands and forest lands are the other land use types in the area.

The cropping season of the district extends from May to September. In the lowlands villages *teff* and maize are dominantly grown in the monocropping pattern while in the midland *kebeles* only maize is cropped in the mono-cropping pattern. Unlike the low and midland *kebeles* rotation cropping pattern is widely adopted for all major crops in the high lands. In general, in the main rainy season (*meher*) sole cropping is dominant. While, multiple cropping is practiced in the irrigable. Livestock is mostly dominated by indigenous breeds. However, as a proportion of total cattle population, only a few crossbred cattle of different exotic inheritance level. It is also observed that poultry production using improved chicken breeds and honey production from modern bee hives have been expanding in the study area. However, the area has repeatedly claimed that agro-chemicals are becoming a threat to their honey bees because the area is dominated by the production of horticultural crops which demands higher uses of pesticides.

Experimental Materials

A bread wheat variety named *Ogolcho,* was used as a test crop. It was a semi-dwarf variety known for its high yielding potential and disease resistance. Urea was used as a source of nitrogen and NPS as a source of NP inorganic fertilizer and VC and conventional compost were used as organic fertilizers for this experiment. Compost was prepared following the standard procedure for compost preparation (Getachew *et al*., 2012). Similarly, VC was produced by using earthworm and the same inputs.

Compost samples were collected from well decomposed compost and VC before they are 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. The contents of N and P respectively, were 0.92% and 1.72%, 1.2%, 0.89% for VC and compost. The recommended inorganic fertilizer rate was (65, 38) kg NP and 92 kg urea/ha for the study area.

Treatments and Experimental Design

A field experiment was conducted at *Ejersa* Farmers Training Center (FTC) in Lume district East Shoa, Oromia Regional State. The area was purposively selected due to the high wheat production potential among the PAs of the district. The experiment consists of six treatments (Table 1)

Table 1. Treatment arrangements

Treatments	Dose/ha
T1	5.64 t/ha Compost
T2	5.68 t/ha VC
T3	100% recommended NPS+ urea (65kg N,38 kgP_2O_5,7 S)
T4	50% recommended NPS+ urea + 2.82 t/ha Compost
T5	50% recommended NPS + urea +2.84 t/ha VC
T6	Control (without fertilizer)

The experiment was laid down in randomized complete block design with three replications per treatment. The total treatment combinations of an experiment were 6*3 replication =18. The size of each plot was 3 m*4 m (12 m2) and the distance between plots and blocks was 0.5 m and 150 kg seed rate was used with the 20 cm distance between the rows.

Land and Seed-bed Preparation

The field was ploughed three times with local conventional oxen driven practices followed by manual seed-bed preparation and laid out according to the experimental scheme. Before the application of the treatments to the experimental plot, soil samples were collected from each plot at a depth of 0-30 cm and mixed carefully to prepare one representative composite soil sample for analysis. Two week before planting the compost was mixed with the soil on randomly assigned experimental plots and half of the inorganic fertilizer (urea) was applied at planting and half of them at tilling.

Soil Sampling and Laboratory Analysis

Soil samples were collected from each plot before treatment application and after harvest to prepare composite soil samples. These composite soil samples were used for analysis of selected physicochemical properties of soils following the standard laboratory procedures. Soil physical properties analyzed include texture, bulk density (BD), total porosity (TP) and soil moisture content and the soil chemical properties were soil pH, electrical conductivity (EC), organic carbon (OC), total nitrogen (TN), available phosphorous (Ava. P), available potassium (Ava. K), exchangeable bases (Ca2+, Mg2+, K+ and Na+), cation exchange capacity (CEC) and micronutrients (Fe, Mn, Cu and Zn). Particle size distribution was determined by the hydrometer method (Bouyoucos, 1962). The textural classes of the soils were assigned using textural triangle of the USDA. Bulk density (BD) was determined from undisturbed soil samples using core samplers (Rowell 1994). The moisture content was measured using pressure plate apparatus (Hillel, 1980). While, the average soil particle density (PD) 2.65g/cm3 was used for estimating total soil porosity (TP) (Rowell, 1997) as:

$$\text{TP (\%)} = \left(1 - \frac{\text{BD}}{\text{PD}}\right) * 100$$

$$\text{BS (\%)} = \frac{\text{Sum of exchangeable Bases}}{\text{CEC}} * 100\%$$

Where, TP= Total Porosity; BD= Bulk Density; PD= Particle Density; BS= Base Saturation

The pH of the soil was determined using 1:2.5 soil samples to water ratio using a glass electrode attached to a digital pH meter. The EC was measured by conductivity meter. Organic carbon content was analyzed with the oxidation of acid potassium di-chromate (K2Cr2O7) by Walkley and Black method (1954) and TN was determined by the Micro-Kjeldhal method with sulphuric acid (Jackson, 1973). The Ava.P was determined by the Olsen's method.

The amount of exchangeable calcium and magnesium were measured in the leach of NH4OAC by atomic absorption spectrophotometer (AAS). Similarly, the amount of exchangeable sodium and potassium was measured in the leach of NH4OAC by flame photometer. Cation exchange capacity of the soil was measured by ammonium acetate method. The micronutrients were measured according to DTPA-extractable method (Lindsay and Norvell, 1978).

Economic Analysis

To identify the optimum economic rate of fertilizer combinations, economic analysis was done using the CIMMYT (1988) partial budget analysis methodology. To estimate economic parameters, wheat yield was valued at an average open market price of 16.00 Ethiopian Birr/kg and the costs of NP fertilizer were 15 and 16 Ethiopian Birr/kg, respectively. The costs of organic fertilizer were estimated ha-1. The potential responses of crop towards the added fertilizer ultimately determine the economic feasibility of fertilizer application (CIMMYT, 1988) as follows:-

AJY = GAY - (GAY * 0.15)

Where, AJY: - adjusted yield downward by 15% to reflect the difference between the experimental yield and yield of farmers and GAY: - gross average yield of each treatment in t/ha.

NB = GFB – TC

Gross field benefit (GFB): was computed by multiplying field/farm gate price that farmers receive for the crop when they sale it as adjusted yield.

GFB = AJY * field/farm gate price of a crop

Total cost (TC): mean current prices of Urea (15 Ethiopian Birr /kg), NPS (16 Ethiopian Birr/kg and wage for VC, compost, phosphorus and nitrogen application were considered per hectare.

Net benefit (NB): was calculated by subtracting the total costs from the gross field benefit for each treatment.
The dominance analysis procedure as in CIMMYT (1988) was used to select potentially profitable treatments from the range that was tested using the equation:-

$$MRR = \frac{\text{Change NI}}{\text{Change TVC}} * 100\%$$

Where, NI: change in net income, TVC: change in total variable cost, MRR: Marginal rate of return Thus, (MRR) of 100% implies a return of one Birr on every Birr of expenditure in the given variable input.

Statistical Data Analysis

Parameters from both the soil and grain yield were subjected to ANOVA in order to determine effects of organic and inorganic fertilizers applications on the selected physicochemical properties of soil and yield and yield components of wheat crop. The SAS statistical software was used for this study. Difference among treatment means were separated with LSD treatment comparison at 5% level of significance.

RESULTS AND DISCUSSION

Selected Physicochemical Properties of Soil before Treatment Application

The result of the soil analysis before sowing indicated that the soil was dominated by sand fraction which makes up with 47% sand, 36% silt and 17% clay (Table 2). According to the soil textural triangle the experimental site is grouped under loam soil textural classes, which is characterized by low plasticity and medium surface area. The BD of the soil before treatment application was 1.51g/cm^3 which is high, that is why organic fertilizers are needed to reduce BD for crop production. Similarly, the TP of the soil was found to be 31.14% which is low. Moisture content of the soil was 22.19%, which is low for water holding capacities and all these soil physical properties have improved after organic fertilizer application in combination with mineral NP fertilizers.

The initial soil reaction of the experimental site (pH) was moderately alkaline with a pH of 7.49 according to (FAO, 2006). The EC of the soil was 1.02dS/m found under non saline safe for crop production (Marx, 1995) and the soil of the study site had 2% OC content (Table 2), which is moderate (Tekalign, 1991) indicate moderate potential of the soil to supply nutrients to plants through mineralization of organic matter. The moderate amount of soil OC might be due to small addition of manure and less aeration due to soil compaction. Therefore, regular application of organic fertilizer such as compost and VC is required for the study area. TN was other very important soil parameters which was 0.21% before treatment application which is found under moderate amount (Tekalign, 1991). The moderate soil organic carbon content might also be an indicator of the low soil nitrogen as it is a major source of native mineral nitrogen for plant growth (Murage *et al.,* 2000). So soil of experimental site needs extra nitrogen which required in large quantity for crop production and enough after organic and inorganic fertilizers applications.

Ava.P is the second largely required nutrients next to nitrogen. It is found to be 14.96 kg/mg which is medium in availability according to (Marx *et al*., 1999). The third largely require macro nutrient is Ava.K and in this study it was found to be 34.31mg/kg initially which is moderate.

Table 2. Selected physicochemical properties of soil of the experimental site before treatment application

Physical Properties	**Value**
Sand (%)	47
Silt (%)	36
Clay (%)	17
Texture	Loam
Bulk Density (g/cm^3)	1.51
Total Porosity (%)	31.14
Soil Moisture (%)	22.19

Chemical Properties	
pH	7.49
EC (dS/m)	1.02
OC (%)	2.0
TN (%)	0.21
C:N	9.52
Ava.P (mg/kg)	14.96
Ava.K (mg/kg)	34.31
Exchangeable bases (cmol(+)kg^{-1}	
Ca	9.42
Mg	2.45
K	0.59
Na	0.13
CEC (cmol(+)kg^{-1}	24.11
PBS%	52.21
Micro Nutrients (mg/kg)	
Fe	0.75
Cu	0.16
Mn	0.68
Zn	0.16

Exchangeable bases Ca^{2+}, Mg^{2+}, K^+ and Na^+ where found to be 9.42, 2.45, 1.59 and 0.13 cmol (+) kg^{-1}) respectively which where moderate except sodium content, which is low as per the rating of FAO (2006). Cation exchange capacity is other important fertility determinant soil parameters, because it gives an indication of the type of clay minerals present in the soil or organic matter in exchangeable site and its capacity to retain nutrients against leaching.

The soil of the experimental site had CEC of 24.11 cmol (+) kg^{-1} which is medium in rate according to (Halzelton,P. and Murphy, B. 2007) indicating its medium capacity to retain cations (Table 2). The soil of the study area has low micronutrients (0.75, 0.16, 0.68 and 0.16 mg/kg Fe, Cu, Mn and Zn respectively, before treatment application.

Effect of Organic and Inorganic Fertilizers on Soil Physical Properties

Soil bulk density

The combined application of organic and inorganic fertilizers had significant (P <0.01) effect on the bulk density of the soil. The highest BD 1.56g/cm^3 was recorded for the control plot and the lowest BD 1.25g/cm^3 was for the combined application of 2.84 t/ha VC with 50% recommended NPS + urea fertilizers (Table 3). Low bulk density might be due to the availability of organic matter applied that improve soil aggregation and hence, improve soil total porosity and reducing soil compaction. In line with this result Gangrwar *et al*. (2006), reported further reduced bulk density which might be due to increased soil pore spaces and soil aeration, higher soil organic carbon content, and better soil aggregation by the application of bulky organic manures that ultimately improved soil porosity and water holding capacity as well. Likewise, the same finding was reported by (Mbah *et al.,* 2009) additions of OM significantly decreased bulk density, increased total porosity and aggregate stability. Moreover, Bandyopadhyay *et al*. (2010) reported a negative correlation of soil bulk density of top 15 cm soil layer with the organic carbon contents present in it.

Total porosity

The combined application of organic and inorganic fertilizers in this study had highly significant (P <0.01) effect on total porosity after crop harvest (Appendix Table 1). The highest total porosity (53%) was recorded from the application of 2.84 t/ha VC in combination with 50% recommended NPS+ urea fertilizers (Table 3). On the other hand, the lowest total porosity (41.33%) was recorded from the control. This increased porosity with the combined application of organic and inorganic fertilizer might be due to increased root growth leading to accumulation of more organic residues. The result agreed with the report of Papini *et al*. (2011) who reported that VC application enhanced soil porosity, soil moisture contents and water holding capacity while reduced soil compaction and bulk density. Similarly, the results of Bhatacharyya *et al*. (2008) show increase in total porosity of the soil after crop harvest as a result of organic matter application.

Table 3. Effects of organic and inorganic fertilizers on selected soil physical properties

Treatments	Particle size distribution			BD	TP (%)	Moisture
	Sand %	Silt %	Clay %	(g/cm^3)		content (%)
T1	49	32	19	1.31^c	50.67^c	42.41^c
T2	49	32	19	1.30^d	51^{bc}	41.19^d
T3	49	34	17	1.47^b	44.67^d	28.32^e
T4	47	34	19	1.28^{de}	52^{ab}	45.41^a
T5	45	36	19	1.25^e	53^a	44.34^b
T6	49	34	17	1.56^a	41.33^e	20.16^f
$LSD_{0.05}$				0.03	1.26	0.1
CV (%)				1.17	1.45	0.15

Means within column followed by the same letters are not significantly different at P ≤ 0.05; LSD=Least significant difference; CV= Coefficient variation; VC = Vermicompost; BD = Bulk density; TP = Total porosity, T1 = 5.64 t/ha Compost, T2 = 5.68 t/ha VC, T3 = 100% NPS + urea fertilizers, T4 = 2.82 t/ha Compost + 50% NPS + urea fertilizers, T5 = 2.84 t/ha VC + 50% NPS + urea fertilizers, T6 = Control (without fertilizer)

Soil moisture content

The combined application of organic and inorganic fertilizers in this study had significant effect (P<0.01) on the soil moisture content after crop harvest (Appendix Table 1). The highest moisture content (45.41%) was recorded from the combined application of 2.82 t/ha compost with 50% recommended inorganic NPS + urea fertilizers. On the other hand, the lowest moisture content (20.16%) was in control plots (Table 3). In line with this Khan *et al.* (2010) clearly indicates that soil organic matter content influences the ability of soils moisture contents as organic matter applied with inorganic fertilizers. The result also agreed with the report of Fageria (2009) combined application of fertilizer can increase the productivity of the crop as soil organic matter improves soil moisture content.

Effect of Organic and Inorganic Fertilizer on Selected Soil Chemical Properties

pH and electrical conductivity

The integrated application of organic fertilizers with inorganic NPS showed highly significant decrease in soil pH after crop harvest (P<0.01) among treatments. The highest and lowest pH values were 7.52 and 7.07 were recorded from full doses of inorganic fertilizer and the combined application of 2.84t/ha VC with 50% recommended NPS + urea fertilizers respectively (Table 4). 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. According to (FAO, 2006), the soil at this experimental site from the combined application of 2.84 t/ha VC with 50% recommended NPS + uraa fertilizers can be rated as moderately alkaline that does not require treatment with gypsum in order to reduces soil pH and is optimum for most crop production.

The present result was in agreement with the earlier study of Gopinath *et al*. (2008) who reported that soil pH increased in plots treated with inorganic fertilizers than those treated with organic manures. Similar findings were also reported by Yaduvanshi (2003) that a reduction of soil pH occurs when green manure or FYM was used in alkaline soils. Smiciklas *et al*. (2002), Pattanayak *et al*. (2001) and Yaduvanshi (2001) similarly reported a decrease in soil pH after the application of organic materials. On the other hand, Wokocha and Sopruchi (2010) reported that the application of mineral fertilizer alone reduced the soil pH where it was more pronounced under high in dose. The EC of the soil after harvesting was significantly (P<0.01) affected by the application of organic and inorganic fertilizers (Appendix Table 2).

The highest EC 2.39dS/m was observed from the recommended inorganic fertilizer and the lowest EC 0.17dS/m was from the combined application of 2.82 t/ha compost with 50% recommended NPS + urea fertilizers (Table 4). This might be application of inorganic fertilizer increases the concentration of salts in the soil and because the area is semi-arid. The above findings are in line with the reports of Eghball *et al*. (2004) who reported that the residual effects of applications of sole inorganic fertilizer in arid and semi arid areas significantly increased electrical conductivity. Vanlauwe *et al.* (2001) also observed that the direct interactions between chemical fertilizer and organic matter can improve soil electrical conductivity to the normal level and over all fertility of the soil**.**

Organic carbon, total nitrogen and C: N ratio

After the harvest of wheat yield, the combined application of organic and inorganic NP fertilizer significantly (P<0.01`) increased the soil OC content. The highest soil OC content 2.47% was recorded from the plots treated with combined application of 2.82 t/ha compost with 50% recommended inorganic NPS + urea fertilizers and the lowest organic carbon 1.27% was from the control plots (Table 4). The increased OC content might be due to higher soil OM added through compost application. The result was in line with Yavarzadeh and Shamsadini (2012) who reported that the application of NP along with VC in wheat field gave significantly higher soil OC content (5.6%) after harvest over the application of inorganic NP alone. Similarly, this result was in harmony with Xueli *et al.* (2012) who reported that the application of organic fertilizer in combination with inorganic fertilizer increases OC content.

Likewise, these results support the investigation of Nesgea *et al*. (2012) who reported that the combined application of organic fertilizer with inorganic NP in rice has increased the soil OC content after harvest by 65% as compared to the application of 100% recommended inorganic NP alone. On the other hand, Dadhich *et al*. (2011) reported that application of organic inputs such as compost, in the required amounts significantly increased OC whereas; poor quality organic inputs may cause a reduction in the soil OC contents.

Table 4. Effects of organic and inorganic fertilizers on soil pH, EC, OC, TN, Ava. P and Ava.K

Treatments	pH	EC dS/m	OC %	TN %	C:N	Ava.P mg/kg	Ava.K mg/kg
T1	7.23^{c}	0.21^{c}	2.21^{b}	0.31^{d}	7.45^{b}	26.73^{b}	113.47^{d}
T2	7.17^{d}	0.22^{c}	2.20^{b}	0.33^{c}	6.76^{c}	22.09^{c}	115.62^{c}
T3	7.52^{a}	2.39^{a}	2.06^{c}	0.22^{e}	9.51^{a}	20.04^{d}	92.11^{e}
T4	7.12^{e}	0.17^{c}	2.47^{a}	0.42^{b}	5.99^{d}	33.06^{a}	125.89^{b}
T5	7.07^{f}	0.18^{c}	2.45^{a}	0.44^{a}	5.72^{d}	35.44^{a}	128.25^{a}
T6	7.42^{b}	1.18^{b}	1.27^{d}	0.17^{f}	7.52^{b}	14.69^{e}	31.83^{f}
LSD	0.018	0.72	0.052	0.01	0.62	1.78	1.96
CV%		9.89	1.38	2.12	4.90	3.93	1.09
0.13							

Means within column followed by the same letters are not significantly different at P ≤ 0.05; LSD=Least significant difference; CV= Coefficient variation; VC=Vermicompost; T1 = 5.64t/ha Compost, T2 = 5.68 t/ha VC, T3 = 100% NPS + urea fertilizers, T4 = 2.82 t/ha Compost+50% NPS + urea fertilizers, T5 = 2.84t/ha VC + 50% NPS + urea fertilizers, T6 = Control (without fertilizer)

Integrated application of organic and inorganic fertilizer showed highly significant effect (P<0.01) on soil total nitrogen. The highest TN (0.44%) was recorded for the plots treated with combined application of 2.84 t/ha VC with 50% recommended NPS + urea fertilizers. Whereas, the lowest TN (0.17%) was recorded from control plots (Table 4). This combined application of VC with NPS fertilizer increases the total nitrogen content by 50% over recommended inorganic NPS fertilizer. 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.

The result is in line with Aspasia *et al.* (2010) who revealed that combined use of NP and compost increased soil TN by 31% compared to the sole application of inorganic NP fertilizers. In general, the TN content of the soil was within high rating according to Tekalign (1991), which indicates improvement in the fertility status of the soil due to an integrated nutrient management.

Analysis of variance revealed that the organic and inorganic fertilizers had significant (P<0.05) effect on C: N (Appendix Table 2). Relatively the highest C: N ratio (9.51) was recorded from 100% recommended inorganic fertilizer and the lowest C: N ratio (5.72) was in soils treated with combined application of 2.84 t/ha VC with 50% inorganic NPS+ urea fertilizers (Table 4).

Low C: N ratio in combined application indicates the materials are fully decomposed before utilization and the available nutrients in organic fertilizers were readily available for crop production. This result agreed with Chen *et al.* (2010) who reported that combined application of organic and inorganic fertilizer produces lower C: N due to its retention in the soil. However, the addition of external organic matter with high C: N ratio may also induce accelerated mineralization of the present organic matter thereby releasing the nitrogen trapped in the existing organic matter (Fontaine *et al.,* 2004).

Available phosphorous and potassium

Phosphorous (P) is the most important limiting plant nutrient next to nitrogen for crop production. The combined applications of organic and inorganic fertilizers significantly affect ava.P in soil as compared to 100% recommended NPS inorganic fertilizers and the control. The highest and lowest Ava.P (35.44mg/kg and 14.69mg/kg) were obtained from the application of 2.84 t/ha VC in combination with 50% recommended NPS + urea fertilizers and control plots (Table 4) respectively. The increased in ava. P might be attributed to organic fertilizer application could enhance releasing more ava. P from the soil. The results indicate that a combination of both organic and inorganic fertilizers was better in improving soil ava.P compared to their sole applications. According to Marx *et al*. (1999) soil phosphorous rating of this area is very high.

This result was in line with, Thamaraiselvi *et al*. (2012) who reported that the highest concentration of ava.P in soils (17.22mg/kg) was realized from the combined application of 15 t/ha compost and 100 kg/ha P_2O_5 as compared to control. Organic fertilizer also helps in producing intermediate compounds that interact with phosphorus-fixing cations such as aluminum, iron, etc. via chelating, thereby reducing P adsorption capacity of soil (*i.e.* lowering of P-fixation in the soil). Similarly, Iyamuremye and Dick (1996) also suggested that organic manures are known to decrease P adsorption (fixation) and enhances P availability in P fixing soils. These results was also in harmony with findings reported by Kathuku *et al*. (2011) who reported increased in soil nutrient contributed by mineral NP fertilizer combined with organic fertilizer when compared with sole applications. This result is in support of researcher finding by Tolanur and Badanur (2003) who pointed out that high availability of phosphorous content of the soil could be attributable to the release of organic acids during decomposition, which in turn helped in releasing phosphorous.

Potassium is needed in large quantities by many crops next to nitrogen and phosphorous. Available potassium was significantly affected by the combined application of organic and inorganic fertilizers. The highest Ava.K of 128.25mg/kg was recorded for plots treated with combined application of 2.84 t/ha VC in combination with 50% of recommended NPS + urea fertilizers and the lowest Ava.K 31.83mg/kg were obtained from the control (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.

This result was agreed with findings of Tamado *et al.* (2017) who obtained the highest Ava. K of 124 gm/kg from the application of 5 t/ha compost in combination with 75% of recommended inorganic NP. This could be explained by the regulation of nutrient released from the organic source of potassium combined with inorganic fertilizers, which plays an important role for ensuring efficient utilization of phosphorus and potassium interaction. In line with this result, Hao and Birkhofer (2008) reported that application of organic amendments improved soil NPK concentrations when applied with inorganic fertilizers and have more beneficial effects on soil quality than inorganic fertilizers thereby improving the positive correlations with NPK status of soils.

Exchangeable Bases

The analysis of variance (ANOVA) results showed a significant ($p<0.01$) difference in all exchangeable bases between treatments. The highest exchangeable Ca^{2+}, Mg^{2+} and K^+ are 20.24, 5.26 and 4.31 cmol (+) kg^{-1} from the application of 2.84 t/ha VC with 50% of recommended NPS + urea fertilizers and 0.14 cmol (+)kg^{-1} Na^+ was recorded from 100% recommended NPS + urea fertilizers (Table 5). On the other hand, the lowest value of Ca^{2+}, Mg^{2+} and K^+ 8.13, 1.29 and 1.19 cmol(+) kg^{-1} were recorded from control plots and 0.07 cmol(+)kg^{-1} Na^+ was observed from plots treated with the combined application of 2.82 t/ha compost and 50% NPS + urea fertilizers. Based on the rating by Metson (1961) this study showed high exchangeable $Ca^{2+}$and Mg^{2+}, very high exchangeable K^+ and low in exchangeable Na^+ (FAO 2006). This finding was supported by Kaiser *et al*. (2008) who indicated that an increase in exchangeable bases in treatments where both mineral and organic fertilizers were added.

Cation exchange capacity and base saturation

The combined applications of organic and inorganic fertilizers significantly affected CEC ($P<0.01$) of the soil. The highest CEC of 34.36 cmol (+) kg^{-1} was recorded for plots treated with combined application of 2.84 t/ha VC with 50% recommended NPS + urea fertilizers, while the lowest CEC 22.66 cmol (+) kg^{-1} was recorded from the control plot (Table 5). The lowest CEC values observed in the control plots could be attributed to the complete removal of crop residues. On other hand, the CEC of the soils also depends on the amount and type of clay minerals and amount of SOM contents. This increase in CEC might be due to the effects of compost via increasing humus colloids which is characterized by negatively charged colloidal site.

According to Halzelton and Murphy (2007) the CEC of this soil is rated as high. This esult is in line with that of Johannes (2000) and Sarwar *et al.* (2010) who reported that compost has alkaline substances and cations such as Ca^{2+}, Mg^{2+}, and K^+ which increase CEC. Tolanur (2002) also reported that cation exchange capacity significantly increased with increased organic manure (15 t/ha compost) in conjunction with inorganic fertilizer than the application of inorganic NPK fertilizers alone.

Table 5. Effects of organic and inorganic fertilizers on exchangeable bases, CEC and base saturation

Treatments	Exchangeable bases (Cmol(+)kg^{-1}				CEC	BS (%)
	Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	(cmol(+)kg^{-1}	
T1	15.17^{cd}	4.39^{b}	3.55^{d}	0.08^{d}	28.56^{c}	80.87^{a}
T2	17.33^{bc}	4.80^{b}	3.68^{c}	0.09^{c}	32.06^{b}	80.3^{a}
T3	13.99^{d}	3.85^{c}	3.34^{e}	0.14^{a}	27.66^{c}	77.98^{a}
T4	18.39^{ab}	4.39^{b}	4.06^{b}	0.07^{e}	33.3^{ab}	83.26^{a}
T5	20.24^{a}	5.26^{a}	4.31^{a}	0.08^{d}	34.36^{a}	86.7^{a}
T6	8.13^{e}	1.29^{d}	1.19^{f}	0.12^{b}	22.66^{d}	47.61^{b}
$LSD_{0.05}$	2.84	0.44	0.03	0.01	1.14	18.26
CV (%)	10.28	5.85	0.55	8.09	2.16	13.48

Means within column followed by the same letters are not significantly different at P ≤ 0.05; LSD=Least significant difference; CV=Coefficient variation; VC=Vermicompost; CEC= Cation exchange capacity; BS=Base Saturation; T1 =5.64 t/ha Compost, T2=5.68 t/ha VC, T3=100% NPS + urea fertilizers, T4 = 2.82 t/ha Compost+50% NPS + urea fertilizers, T5=2.84 t/ha VC + 50% NPS + urea fertilizers, T6=Control (without fertilizer)

Integrated application of organic and inorganic fertilizers had significant effect at (P<0.01) on base saturation compared with the control. The highest percent base saturation (86.7%) was obtained from 2.84 t/ha VC integrated with 50% recommended inorganic NPS + urea fertilizers and the lowest value (47.61%) was from the control (Table 5). Base saturation was also rated as high in the soil of the experimental site (Halzelton and Murphy 2007). This is might be also due to the applied organic fertilizer improve soil fertility status, as there is direct relationship with exchangeable bases. These results are in agreement with that of Sarwar et al. (2010) who pointed out that high cations such as Ca2+, Mg2+, and K+ were recorded during compost decomposition and integrated with inorganic fertilizer can increases base saturation.

Micronutrients

The combined application of organic and inorganic fertilizer showed significance difference on soil micronutrients (P<0.01). The highest values of extractable Fe, Cu, Mn (3.72, 2.82, 4.97 and mg/kg) respectively, were observed from combined application of 2.84t/ha VC with 50% recommended NPS + urea fertilizers and 2.43mg/kg Zn was obtained from 2.82 t/ha compost with 50% NPS + urea fertilizers (Table 6). The lowest extractable Fe, Cu, Mn, and Zn (0.67, 0.14, 0.63 and 0.31 mg/kg) respectively) were recorded from control plots. This result show that the soil of experimental site has high extractable micronutrients; as an application of organic fertilizer together with inorganic fertilizers could increases macronutrients, but also increases extractable micronutrients in the soil. This research finding is in agreement with Rasoli and Forghani (2006) who reported that high extractable Fe, Cu, Mn and Zn (5.63, 2.97, 7.23 and 2.32mg/kg respectively) were observed with combined application of composted manure with inorganic fertilizer.

Table 6. Effects of organic and inorganic fertilizers on DTPA extractable micronutrients

Treatments	Fe mg/kg	Cu Mg/kg	Mn Mg/kg	Zn Mg/kg
T1	2.15^{b}	2.57^{b}	4.79^{c}	1.14^{b}
T2	2.28^{b}	2.57^{b}	4.83^{bc}	1.18^{b}
T3	2.28^{b}	1.23^{c}	2.52^{d}	0.58^{c}
T4	3.65^{a}	2.78^{a}	4.90^{ab}	2.43^{a}
T5	3.72^{a}	2.83^{a}	4.97^{a}	2.32^{a}
T6	0.67^{d}	0.14^{d}	0.63^{e}	0.31^{d}
$LSD_{0.05}$	0.18	0.10	0.08	0.12
CV%	4.04	2.79	1.23	5.17

Means within column followed by the same letters are not significantly different at P ≤ 0.05; LSD=Least significant difference; CV=Coefficient variation; VC=Vermicompost; T1 =5.64t/ha Compost, T2=5.68 t/ha VC, T3=100% NPS + urea fertilizers, T4=2.82 t/ha Compost+50% NPS+ urea fertilizers, T5=2.84t/ha VC+50% NPS + urea fertilizers, T6=Control (without fertilizer)

Grain yield

The effect of organic and inorganic fertilizer application was significant ($P<0.01$) on grain yield among treatments. Thus, the highest grain yields (5.93 t/ha) was obtained from the combined application of 50% recommended NPS + urea fertilizers with 2.84 t/ha VC, followed by (5.75 t/ha) from 50% recommended inorganic NPS + urea fertilizers combined with 2.82 t/ha compost. On the other hand, the lowest grain yield (1.53 t/ha) was obtained from control plots (Table 7). In line with this, the study conducted in Ada'a district by Genizeb (2015) indicated that, the grain yield value of bread wheat was 6.67 t/ha in the application of compost along with inorganic fertilizers. This finding was also supported by the results of Akinnifesi *et al.* (2007) and Mugwe *et al.* (2007) who revealed that the combined application of organic and mineral fertilizers ensured higher returns in wheat crop yields.

Straw yield

The analysis of variance illustrated that straw yield of wheat was significantly different among treatments. The maximum straw yields (8.07 t/ha) was obtained from the combined application of 50% recommended NPS + urea fertilizers with 2.84 t/ha VC (Table 8). The minimum straw yields (4.11 t/ha) was recorded from the control plots. This result is in line with that of Sarwar *et al.* (2008) who reported that straw yield was significantly increased by the application of organic fertilizers along with the application of inorganic fertilizers.

Table 8. Effects of organic and inorganic fertilizers on wheat yield

Treatments	Grain Yield t/ha	Straw Yield t/ha
T1	5.11^{d}	7.51^{c}
T2	5.21^{cd}	7.61^{bc}
T3	5.35^{c}	7.72^{b}
T4	5.75^{b}	7.93^{a}
T5	5.93^{a}	8.07^{a}
T6	1.53^{e}	4.11^{d}
$LSD_{0.05}$	0.18	0.18
CV%	2.08	1.40

Means within column followed by the same letters are not significantly different at $P \leq 0.05$; LSD= Least significant difference; CV= Coefficient variation; VC = Vermicompost;
T1 = 5.64t/ha Compost, T2 = 5.68 t/ha VC, T3 = 100% NPS + urea fertilizers, T4 = 2.82 t/ha Compost + 50% NPS + urea fertilizers, T5 = 2.84 t/ha VC + 50% NPS + urea fertilizers, T6 = Control (without fertilizer)

Economic Analysis

The partial budget analysis was done to identify the economic benefits of the proposed and tested rewarding treatments. Yield from on-farm experimental plots was adjusted downward by 15% *i.e.*, 10% for management difference and 5% for the plot size difference, to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment (Getachew and Taye, 2005). The highest grain yield (5.93t/ha) was recorded from the combined application of 50% recommended inorganic NPS + urea combined with 2.84 t/ha VC and the lowest grain yield (1.53t/ha) was from the control treatment. The adjusted maximum and minimum grain yield were (5.04t/ha and 1.3t/ha) respectively, according to CIMMYT (1988). An average market grain price of wheat was (Ethiopian birr 16 kg^{-1}), farm-gate price of N and P fertilizers (Ethiopian birr 15kg^{-1} and 16kg^{-1}) respectively.
The economic analysis revealed that the highest net benefit of (Ethiopian birr 77575 ha^{-1}) was obtained from the application of 2.84 t/ha VC plus 50% recommended NPS + urea fertilizers, whereas the control treatment (plots without treatment) gave the lowest net benefit (19533 ha^{-1} Ethiopian birr) (Table 9).

Table 9. Partial budget and dominance analysis of wheat yield influenced by organic and inorganic fertilizers

Trt	GY t/ha	AJY.GY -15%	GGB ETB	Costs that vary(ETB ha^{-1})				Dominance
				Fert	Labor	TVC	NB ETB	
T6	1.53	1.30	20808	-	1275	1275	19533	D
T4	5.75	4.88	78200	1238	1787.5	3025.5	75174.5	
T5	5.93	5.04	80648	1238	1835	3073	77575	
T1	5.11	4.34	69496	-	3575	3575	65921	D
T2	5.21	4.43	70856	-	3670	3670	67186	
T3	5.35	4.54	72760	2476	2000	4476	68284	

GY:-Grain Yield, AJY.GY: - Adjusted Grain Yield, GGB:-Grain Gross Benefit, TVC:-Total Variable Cost, NB:-Net Benefit, ETB:-Ethiopian Birr, Trt:-Treatment, VC=Vermi compost. The price of wheat was Ethiopian Birr 16/kg and the cost of 1kg of N fertilizer was Ethiopian Birr 15 /kg whereas P was Ethiopian Birr 16 /kg;
T1=5.64t/ha Compost, T2=5.68t/ha VC, T3=100% NPS + urea fertilizers, T4=2.82 t/ha compost + 50% NPS + urea fertilizers, T5= 2.84 t/ha VC + 50% NPS + urea fertilizers, T6= control (without fertilizers).

The dominant treatments were eliminated from further economic analysis. To identify treatments with the optimum return to the farmer's investment, the marginal analysis was performed on non-dominated treatments. For a treatment to be considered as an option to farmers, between 50% and 100 % marginal rate of return (MRR) was the minimum acceptable rate of return (CIMMYT, 1988). The economic analysis further revealed that the application of 2.84 t/ha VC with 50%

The economic analysis further revealed that the application of 2.84 t/ha VC with 50% recommended NPS + urea fertilizers provided the highest marginal rate of the return (MRR) of 5053.68%, suggesting for each birr invested in wheat production, the producer would collect birr 50.53 birr after recovering his cost. So that MRR assumed in this study was 100%, the treatment with an application of 2.84 t/ha VC with 50% recommended NPS + urea fertilizers gave rise an acceptable MRR

Table 10. Marginal analysis of organic and inorganic fertilizer effects on wheat yields

Treatment	TVC	NB	MVC	M NB	MRR%
T6	1275	19533	-	-	-
T4	3025.5	75174.5	1750.5	6890.5	393.6
T5	3073	77575	47.5	2400.5	5053.68
T1	3575	65921	502	-	-
T2	3670	67186	95	1265	1366.3
T3	4476	68284	806	1098	136.2

TVC=Total variable cost, NB=MVC=Marginal variable cost, MRR=Marginal rate of return,
T1=5.64 t/ha compost, T2=5.68 t/ha VC, T3=100% NPS + urea fertilizers, T4=2.82t/ha Compost+50% NPS + urea fertilizers, T5=2.84t/haVC+50% NPS + urea fertilizer,
T6= control (without fertilizer)

SUMMARY AND CONCLUSION

Soil fertility degradation has been described as the most important constraint for crop production in the study area. As a result inorganic fertilizers are continuously applied to the soil. However, continuous and sole use of inorganic fertilizers may lead to deterioration in soil chemical, physical, biological properties. This study was conducted in Lume district of east Shoa Zone of Oromia National Regional State, Central Ethiopia with the following objectives: To evaluate the effect of combined application of organic and inorganic fertilizer on selected soil physicochemical properties and to evaluate the combined and sole application of organic and inorganic fertilizers on wheat yield. The organic fertilizers were compost and vermicompost and urea and NPS used as inorganic fertilizers. The treatments consist of : T1= 5.64 t/ha compost, T2= 5.68 t/ha vermicompost, T3= 100% recommended NPS + urea fertilizers, T4= 50% recommended NPS + urea fertilizers + 2.82 t/ha compost, T5= 50% recommended NPS + urea fertilizers + 2.84 t/ha vermicompost, T6= Control (without fertilizers).

The experiment was laid out in a randomized complete block design and replicated three times per treatment. Composite surface (0-30 cm depth) soil samples were taken from the experimental field before sowing and after harvesting for laboratory analysis of selected physicochemical properties of the soil. Compost samples were collected from well decomposed compost and VC before they are applied to the field. Then their nutrient contents were analyzed in the laboratory using standard procedure to determine the rate of application of each treatment, which was based on recommended rate for the test crop. Two week before sowing the dried collected compost was mixed with the soil on randomly assigned experimental plots and half of the inorganic fertilizer (urea) applied at planting and half of them at tilling.

The soil test results after wheat harvest revealed significantly decreasing in soil bulk density from 1.51g/cm^3 to 1.25g/cm^3, soil pH (moderately alkaline) from 7.49 to 7 07, EC from 1.02dS/m to 0.17dS/m and C/N from 9.51 to 5.72 from the combined application of treatments. On the other hand, integrated fertilizers application increases the remaining soil physicochemical parameters such as:-total porosity from 31.14% to 53%, moisture content from 22.19% to 45.41%, TN from 0.21% to 0.44%, OC from 2.00% to 2.47%, CEC from 24.11 to 34.36 cmol(+)kg^{-1}, ava. P from 14.96mg/kg to 35.44mg/kg, ava.K from 34.31mg/kg to 128mg/kg, even increased exchangeable bases, base saturation and micronutrients.

Likewise, application of combined inorganic with organic fertilizers (50% recommended NPS + urea fertilizers with 2.84 t/ha VC) has the maximum grain and straw yield of 5.93 t/ha and 8.07 t/ha respectively. Considering the economic feasibility use of 2.84t/ha VC and 50% recommended NPS + urea fertilizers have maximum rate of return. This current result from a single cropping season highlighted, the VC addition have potential in improving the productivity of wheat.

Therefore, in order to address soil fertility problems, the following conclusions can be made for the study area

- Integrated use of chemical fertilizers and locally available soil amendments could be the best approach for achieving higher crop yields and economic feasibility.
- From sustainable wheat production and immediate economic point of view, the combined application of 2.84 t/ha vermicompost with 50% recommended NPS + urea fertilizers is better than other treatments for wheat production in the study area in this single cropping season.
- However, it is suggested that the experiment has to be repeated over seasons and locations using this and other improved bread wheat varieties to make a conclusive recommendation.

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