AMBO UNIVERSITY

SCHOOL OF POST GRADUATE STUDIES

GUDER MAMO MEZEMIR CAMPUS

SCHOOL OF NATURAL RESOURCES

DEPARTMENT OF NATURAL RESOURCE MANAGEMENT

EFFECTS OF INTEGRATED USE OF INORGANIC AND ORGANIC FERTILIZERS ON SELECTED SOIL PHYSICO-CHEMICAL PROPERTIES AND YIELD OF DURUM WHEAT *(Triticum turgidum L.)* ON VERTISOLS OF ADA'A DISTRICT, EAST SHEWA ZONE

MSc. Thesis

BY

ELENI GETACHEW BOGALE

JUNE, 2022

GUDER, ETHIOPIA

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M. Sc. Thesis

BY

ELENI GETACHEW BOGALE

A Thesis Submitted to the Department of Natural Resource Management, School of Natural Resources, School of Graduate Studies, Guder Mamo Mezemir Campus, Ambo University, in Partial Fulfillment of the Requirements for the degree of Master science in Soil Science

Major Advisor: Gizachew Kebede (Ph.D.)

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CERTIFICATION SHEET

As thesis research advisor, we hereby certify that we have read and evaluated this thesis prepared under our guidance by Eleni Getachew Bogale entitled "**Effects of Integrated use of Inorganic and Organic Fertilizers on Selected Soil Physico-Chemical Properties and Yield of Durum Wheat *(Triticum Turgidum L.*) On Vertisols of Ada'a District, East Shewa**". We recommended that it to be submitted as fulfilling the thesis requirement.

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As members of the Board of Examiners of the M.Sc. Thesis Open Defense Examination, we certify that we have read and evaluated the Thesis prepared by Eleni Getachew Bogale and examined the candidate. We recommend that the Thesis to be accepted as fulfilling the Thesis requirement for the Master of Science Degree in Soil Science.

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STATEMENT OF AUTHOR

I declare that this thesis is my genuine work and I have duly acknowledged all sources of materials used for writing it. This thesis is submitted to Ambo University in partial fulfillment of the requirements for the Master of Science Degree in Soil Science and deposited at the University Library to be made available to borrowers under the rules of the library. I solemnly declare that this thesis was not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

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Name: Eleni Getachew

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Place: Ambo University

Date of Submission: June, 2022

DEDICATION

I dedicate this Thesis work to my father Getachew Bogale and my Mother Sinke Mengesha for their continuous contribution throughout my life.

BIOGRAPHICAL SKETCH

The author, Eleni Getachew was born on October 11, 1997 G.C in Ada'a District, East Shewa Zone, Oromia National Regional State. She attended her elementary education at Beza School and secondary School at Bethlehem and Preparatory School at Bishoftu Preparatory school between 2002 and 2014 G.C.

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The author joined Ambo University, Guder Mamo Mezemer Campus to pursue her M.Sc. degree in Soil Science in September 2019 G.C academic year.

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ACRYNOMYS AND ABBREVATIONS

AN	Ammonium Nitrate
ANOVA	Analysis of Variance
ATA	Agricultural Transformation Agency
BD	Bulk density
CEC	Cation exchange Capacity
CSA	Central Statistical Agency
DAP	Di-ammonium Phosphate
DNA	Deoxyribonucleic acid
DTPA	Di-etylene triamine penta acetatic acid
DZARC	Debrezeit Agricultural Research Center
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agricultural Organization
LSD	Least Significant Difference
OC	Organic Carbon
OM	Organic matter
RNA	Ribonucleic acid
SOM	Soil organic matter
UK	United Kingdom

ABSTRACT

Durum wheat is one of the major cereal crops produced in East Shewa Zone, Oromia Regional state for the purpose of both home consumption and market. However, its productivity is low due to low availability of soil nutrients. Therefore, field experiment was carried out in 2020–2021 cropping seasons using different organic fertilizer sources as a supplement to the recommended NPSZnB blend fertilizes to see the effect on soil properties and on the productivity of durum wheat. The experiment was laid out in a randomized complete block design as one factor arrangement and replicated three times per treatment. The post-harvest soil analytical result showed insignificant ($P>0.05$) influence of the fertilizers on soil properties. Analysis of the results revealed that, plant height (PH), spike length (SL), effective tiller number (ETN), harvest index (HI), thousand kernels weight, aboveground biomass yield (AGBY), grain yield (GY), and straw yield (SY) were significantly ($p < 0.05$) affected by the organic and NPSZnB fertilizers. However, days to heading and days to maturity were not significantly ($p > 0.05$) affected by the organic and NPSZnB fertilizer application. The highest, AGBY (11930 kg ha^{-1}), and SY (6350.9 kg ha^{-1}) were recorded with the application of T7 and also the highest, SL (5.2cm), ETN (3), and GY (5579 kg ha^{-1}) were obtained with the application of T7. The highest net benefits (NB) of birr 123806.6 with acceptable marginal rate of return (MRR 2765.948%) was achieved from the combined application of NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha). All the other treatment combinations except T2, T3, and T6 gave low net benefit with non-acceptable MRR. Thus, the supplement of recommended NPSZnB with organic amendments is very important with the most economically productive treatment combination for small scale farmers with higher benefit return was from the application of 200 kg/ha NPSZnB + 1.85t /ha v/compost + urea (50kg/ha).

***Keywords:* Blend fertilizer; durum wheat; nitrogen; organic amendments; phosphorus; sulfur; Zinc**

1. INTRODUCTION

1.1. Background and Justification

Soil fertility is the capacity of a soil to provide plant nutrients to crops, which allow appropriate growth of plants and ensure preservation and recycling of nutrients over a substantial period of time (Tanner *et al.,* 2000). Most of the Ethiopian soils are low in nutrient content due to erosion and absence of nutrient recycling and being often cited as one of the countries in the world with most seriously affected by land degradation (Seyoum *et al*., 2011). As stated by Tekalign (2001), nitrogen (N) is deficient in almost all soils and phosphorus (P) is deficient in about 70% of the soils in Ethiopia. That is why most of the areas used for production of grains especially tef, wheat, and barley fall under the low fertility soils (Hurni and Bruno 1990). Therefore, Low availability of N and P has been demonstrated to be major constraint to cereal production a result of intensive cultivation, unbalanced nutrient supply and low organic matter. This necessitated the application of inorganic N and P fertilizers, a common practice these days, to increase crop yield in most part of the country (Daniel *et al.,* 2006).

Efforts to alleviate the soil fertility problem through the application of mineral fertilizer have been ongoing for more than 5 decades. As a result of different agricultural extension efforts, farmers have been convinced to apply fertilizer to increase production. The recommendation was initially 100 kg/ha Di-ammonium phosphate (DAP) for all crops and later improved to 100 kg DAP and 100 kg/ha urea by the Ministry of Agriculture (Demiss *et al*., 2015). This is blanket recommendations of fertilizer, containing only nitrogen and phosphorus prevailing for so long in the country (Brhane *et al.,* 2017) and national fertilizer application is as low as 43 kg urea and 65 kg/ha DAP (Elias *et al.,* 2019). The drive for higher agricultural production without balanced use of fertilizers created problems of soil fertility exhaustion and plant nutrient imbalances not only of major, but also of secondary and micronutrients (Patel and Singh, 2009). Previously, only N and P were considered to be the limiting nutrients in Vertisols of Ethiopia (Tekalign, 2001). However, the results of national soil fertility mapping initiative indicated that other nutrients; including K, S, Fe, Zn and B are also found to be deficient in these soils (ATA, 2014).

Nutrient mining due to sub optimal fertilizer use in one hand and unbalanced fertilizer uses on other have favored the emergence of multi nutrient deficiency in Ethiopian soils that in part may contributed to fertilizer factor productivity decline experienced over recent past (Wassie and Shiferaw, 2011). Different research reports indicate that nutrients like K, S, Ca, Mg and all micro-nutrients except Fe are becoming depleted and deficiency symptoms are being observed on major crops in different areas of the country (Asgelil *et al*., 2007 ; Wassie and Shiferaw, 2011). Recently acquired soil inventory data from EthioSIS (2014) also revealed that in addition to nitrogen and phosphorus, sulfur, born and zinc deficiencies are widespread in Ethiopian soils, while some soils are also deficient in potassium, copper, manganese and iron, which all potentially hold back crop productivity despite continued use of N and P fertilizer as per the blanket recommendation.

Wheat *(Triticum turgidum L.*) is the most important food crops in the world (Smith, 2010). It is one of the first domesticated food crops 8000 years back and it has been the main food crop and has major contribution for the civilizations of Europe, West Asia and North Africa (Curtis, 2019). Currently, wheat is the most widely grown crop in the world, grown on more than 218 million ha, and its world trade is greater than all other crops combined. In Ethiopia wheat has become one of the most important cereal crops ranking fourth both in total grain production (4.54 million tons) and area coverage (1.69 million hectare) next to teff, maize and sorghum (CSA, 2017).Though Ethiopian agro-climatic condition is suitable for wheat production, however the productivity of wheat is low (2.67 tha^{-1}) (CSA, 2017) due to several factors. Among these depletion of soil fertility, low levels of chemical fertilizer application, limited knowledge on time and rate of fertilizer use, and lack of other modern crop management practices (Anderson and Schneider, 2010; Ercoli *et al*., 2008).

Ethiopian farmers used to grow wheat on major soil type like Vertisols, Nitisols, and Andisols. Vertisols have crucial importance for increased and sustained food production in Ethiopia. Vertisols are usually very dark colored, with widely variable organic matter content (1 – 6%) on the surface horizon (Zhukova *et al*, 2015).The modified wheat achievements in the past decade, and the choices of fertilizer type are one of the best recognized cultivation techniques which have large influence on yield quantity and quality in wheat grain production (Ryan, 2008).

For example, Chaudry *et al*. (2007) stated that micronutrients (Zn, Fe, B) significantly increased wheat yield over control when applied in combination with N, P, and S nutrients. It has been long understood that the role of macro and micronutrients is crucial in crop nutrition and important for realizing higher yields. Soil test-based application of plant nutrient rather than the blanket recommendation of urea and DAP, especially those containing sulfur, boron, and other nutrients, is recommended in averting problems caused due to soil nutrient deficiency (EthioSIS, 2014).

Therefore, the use of balanced fertilizers containing both macro and micronutrients, which is based on the site-specific soil fertility assessment, is believed to be one of the solutions for reducing such production constraints. Although nutrient content of the fertilizer that suits the needs and the productivity of crops is available in most part of Ethiopia, farmers in Ada'a district of East Shewa zone have limited information on the impact of balanced fertilizer types, except urea and DAP, which are source of N and P. However, new blended fertilizer such as NPSZnB (17.8% N, 35.7% P_2O_5, 0%K, 7.7% S, 2.2% Zn, and 0.1% B), a mixture of inorganic plant nutrients is currently being used by farmers in the study area based on the soil fertility map generated by ATA (EthioSIS, 2014). However, nitrogen content per 100 kg of the blended fertilizer (NPSZnB) is only 17.8kg, which is very low rate to satisfy the nitrogen demand of crops on one hectare of land as compared to the blanket nitrogen recommendation (46 kg N in 100kg Urea ha^{-1}).

The low nitrogen content of the blended NPSZnB fertilizer also makes it unsuitable to use it as the only N source (ATA, 2014), making it necessary to double the NPSZnB amount or add organic fertilizers and urea to meet the N demand of durum wheat and increase production and productivity of the crop for small-scale producers.

In addition, macronutrients such as N, P and K, and soil micronutrient deficiencies limit crop productivity and affect the nutritional quality, which together may affect human health (Alloway, 2008). Insufficient micronutrient availability in Ethiopian soils not only causes low crop productivity, but also resulted in poor nutritional quality of the crops grown on this type of soils (Saha *et al*., 2008). Nutrients such as S, Zn, and B can often be included cheaply in new fertilizer formula, when targeted to deficient soils, which can dramatically improve fertilizer-use efficiency and crop profitability (John *et al*., 2000).

However, this was not the case in Ethiopia and farmers were applying a blanket recommendation of DAP and Urea for long time in Ethiopia. However, the application of organic fertilizer can solve this problem as fertilizers from organic sources can provide different plant nutrients to the soil and to the plant. Balanced fertilization not only guarantees optimal crop production, but results in better food quality and benefits both the growers and the consumers. It is also the best solution for minimizing the risk of nutrient losses to the environment (FAO, 2012).

Based on the EthioSIS (2014) map of blended fertilizers containing N, P, S, Zn and B blend, Ada district and its surrounding villages were identified as deficient areas. Therefore, the use of inorganic fertilizers together with organic fertilizer is a sustainable approach for efficient nutrient usage and enhances efficiency of the chemical fertilizers while reducing nutrient losses; improve soil acidity, and nutrient imbalance (Schoebitz and Vidal, 2016).Therefore, this study was initiated with the following objectives:

1.2. Objectives

1.2.1. General Objective

To investigate the role of the application of different organic fertilizers and urea to the recommended inorganic blend fertilizers (NPSZnB) on selected soil physico-chemical properties and yield of Durum wheat *(Triticum turgidum L.*) on Vertisol.

1.2.2. Specific Objectives

- To assess the effect of NPSZnB and different organic fertilizers (vermicompost, compost, vermiwash)application on selected physico-chemical properties of soil of study area;
- To see the effect of supplementing mineral fertilizers with organic fertilizer such as vermicompost/compost in improving yield of Durum wheat.

2. LITERATURE REVIEW

2.1. Soil Fertility Status in Ethiopia

Soil loss is a worldwide risk and adversely affects the productivity of all natural ecosystems as well as agricultural, forest, and rangeland ecosystems (Perkins *et al.*, 2013; Lemenih, 2014; Van Leeuwen *et al*., 2015).That is why the changes in soil quality affected by accelerated erosion are significant and have resulted in decreased production and land abandonment.

Food production in the tropics and subtropics usually relies on available soil nutrient stocks/soil fertility. This means soil fertility is a major production factor for most farmers in Sub-Saharan Africa in general and in Ethiopia in particular where agriculture is the backbone of the country's economy (Sheldrick *et al.,* 2003). However, soil fertility is declining from time to time due to rapid population growth, change in Agricultural practices, absence of crop rotation, poor soil conservation/land management practices and so on. The changes in agricultural activities also change the soil chemical, physical, and biological properties, and play the major role for soil degradation mainly, due to soil fertility decline as a result of lack of nutrient inputs (Getachew *et al.,* 2014).It is not questionable that the fertility of any soil declines if the nutrient contents of the harvest removed from the system exceeds the nutrient inputs as a result of natural and anthropogenic sources (Gruhn *et al.,* 2000).

This mainly happens when there is low natural soil fertility, limited fill-up of removed nutrients and high erosion rates in mountainous areas which in turn causes a major threat to current and future food production (Gachimbi *et al.,* 2005; Harris and Consulting, 2014).

2.2. Soil Fertility and Nutrient Depletion Status of Wheat Growing Central Highlands of Ethiopia

Soil fertility is a quality of a soil to supply nutrients in proper amounts without causing toxicity. Whereas soil productivity is the capacity of a soil to produce a specific crop or sequences of crops at a specific management system. Optimum productivity of any cropping system depends on adequate supply of plant nutrients. Continued removals of nutrients, with little or no replacement, have aggravated the potential for future nutrient related plant stress and yield losses (Sheldrick *et al*., 2002; FAO, 2006).

Soil fertility depletion is the major environmental challenge that affects agricultural production and the livelihoods of farmers in Ethiopia. Soil fertility depletion estimated by Mahmud *et al.*, (2005), showed that about 106,000 km^2 (9.6% of the total area of the country) was not able to sustain crop yield. On the other hand, about 41% of the total arable land of the country is acidic, of which nearly one-third faces the problem of aluminum toxicity (ATA, 2013). The direct cost of this soil fertility depletion was estimated to be 3-7% of agricultural GDP (Berry *et al*., 2003).

A nutrient balance study conducted by van Beek *et al*., (2016), in the Highlands of Ethiopia, showed that the high potential areas for agricultural productions are currently exposed to severe nutrient depletion. Studies on nutrient flow also revealed that the nutrient balance in different soil fertility classes varied from -20 to -185 kg N, from +11 to -83 kg P, and from +23 to -245 kg K ha-^{1} yr^{-1} (Balesh, 2005). On the other hand, the average annual soil loss from agricultural land is estimated to be 137 t ha-1 yr^{-1}, which is approximately an annual soil depth loss 10 mm (Gete *et al*., 2010). These indicate that major nutrients outflow far exceeds inflows in a range of soil types, which results negative nutrient balances. Recently, Gedefa (2018) also indicated that the nutrient depletion of -7 to -10 kg N, 1.5 to -0.1 kg P, and -12 to -19 kg K ha^{-1} yr^{-1} were observed under different classes of land units. The results of national soil fertility mapping initiative have also indicated that the mineral nutrient status of most soils in high lands of Ethiopia is low including N, P, K, S, Fe, Zn and B (EthioSIS, 2014). Similarly, many soils in Ethiopia are poor in organic matter content (Alemu *et al.*, 2016).

Even though the extent of this problem varies spatially, it depends on variation in geology, relief, ecology, rainfall, land use, soil types and population density (Adugnaw, 2014).The problem is exceptionally severe in the highlands of the country, where 88% of human and 77% of the total livestock population is concentrated (Teklu, 2005). But in Ethiopian highlands there are many factors that contribute to the decline of soil fertility status from which the major one is land degradation due to deforestation, human and livestock population pressure, continuous cropping and inadequate use of crop residues for soil fertility management and little or no use of modern technologies to replenish soil fertility (Hillette *et al*., 2015).

2.3. The Effects of Land Management on Soil Fertility and Nutrient Balance

Cropping systems are generally characterized by high nutrient losses, especially for N, P and K (Tabi *et al*., 2013). Long-term processes that adversely affect sustainability, such as decrease and eventual depletion of soil nutrient stocks, are not readily apparent and receive little attention (Ehabe *et al.,* 2010).

Exportation of crop residues reduces the stock of easily exchangeable elements, leading after four years to the mineralization of soil organic matter by 50% and to the leaching of some of the released nutrients, exposing therefore the soils to erosion (Harmand *et al.*, 2000). Therefore, to prevent the effects of poor land management practices mentioned above, sustainable soil management in agricultural land is needed for a sustainable world (Costa *et al*., 2015).

The effects of different land management practices on soil fertility can be estimated using different measurement techniques. Soil nutrient balance defined as the difference between the sum of nutrient input and output flows within a specific system (field, farm, nation) over a certain period (season or year) is a commonly used indicator of soil fertility (Assefa, 2005).Soil nutrient balances reflect the net change in soil fertility and indicate trends in time, but do not necessarily determine the current state of soil fertility (Vanlauwe *et al.*, 2015). Nutrient balance assessment indicates the direction of soil fertility and is a critical indicator of sustainability (Sparovek and Schnug, 2001).

2.4. Ecological Requirements of Wheat

Wheat and barley are the most important cereals of the temperate regions, but they are also grown at high altitudes in the tropics and even extend into the tropical lowlands, and its production is concentrated between latitudes 30°N and 60°N and 27°S and 40°S (Fageria, 2011). Wheat is grown in the highlands at altitudes ranging from 1500 to 3000 masl (Demeke *et al*., 2013). The ideal daily temperature for different stages of wheat development varies from 20 to 25^0C for germination, 16-20^0C for good tillering and 20-23^0C for proper plant development (Bekele, 2000). Wheat is produced across a wide range of soil conditions, although it is best adapted to the fertile well drained silt and clay loam soils (Sinha, 1999).

In terms of soil pH, wheat is considered medium acid tolerant with permissible ranges of 5.5-7.0. Wheat is also considered to be medium salinity tolerant (Gooding and Davies, 1997).

2.5. Wheat Production Constraints in Ethiopia

Wheat is among the cereal crops widely grown in Ethiopia. The yields have been consistently well below African and world average, indicating low productivity of the crop. According to FAO (2008), Ethiopian wheat yields fluctuated between 88% and 99% of the regional average yield between 2004 and 2008. Even in the highest yielding year (2008), production amounted to only 77% of the average African wheat yields and 56% of world's wheat average yields. The national average yield of wheat in Ethiopia is about 2.67 t ha^{-1} (CSA, 2017). In Ethiopia, under improved production technologies grain yield ranges from 3-6 tha^{-1} on farmers' field and at research center it goes up to 5-7 t ha^{-1}(Anderson and Schneider, 2010).This indicates the existing gap between potential yield and yield at farmers' level (Abdulkadir *et al.*, 2017; USDA, 2017). The low mean national yield for wheat is primarily due to depleted soil fertility and low fertilizer application; but, limited information is available on various sources of fertilizers K, S, Zn and B and other micronutrients (Adamu, 2013).The unavailability of other improved crop management inputs such as improved seeds, diseases and weed control measures, and inaccessibility of farmers to finance, farm machinery and training (Anderson and Schneider, 2010).

Yield reduction is mainly due to poor tillage and competition from weeds (Jones, 2003). Weeds are major problems in wheat production in Ethiopia, causing 10-40 % reduction in yield depending on the intensity of infestation. Most of weed competition is during the first 30-40 days (Hargreaves *et al.*, 2008). In Siya Debrena Wayu District, Canary grass (*Phalaris minor)* and common wild Oat (*Avina fatua)* species are major grass weeds and also wheat stem rust is a common disease which reduces the grain yield. The use of appropriate agronomic practices in wheat production is essential for high and sustainable yield (Asefa *et al.*, 1996). Thus, soil nutrient management, weed and disease protection and some other agronomic practices are essential for obtaining high and sustainable wheat yield.

2.6. Importance of Wheat

Cereal grains are major contributors to human nutrition throughout the world (Ayoub *et al.*, 2009), and comprise about 87.42% of total crop production in Ethiopia (CSA, 2017). From the earliest times, wheat has played an important role in the development of civilization. Nutritionally, wheat provides an optimum amount of energy (339 kcal of energy), protein (10.3 g), calcium (49 mg) and iron (1.5 mg) per 100 g of whole grain (Ayoub *et al.*, 2009). Bread wheat is used in many food products, such as *kitta* (unleavened bread), *anebaberro* (double layered injera), porridge, and local alcoholic beverages, such as *tella* and *katikala* (Hailu, 2000).

According to FAO (2008), the economic importance of bread wheat between the years 2008–2015 is estimated to the average world production of 692.16 million t/year from 254.56 million ha of wheat grain (bread wheat and durum wheat together).

2.7. The Requirement for Blended Fertilizer

Blended fertilizer developed in the Togo and production has spread around the world, but these are not a primary production sources. These products use solid finished fertilizer materials such as urea, DAP, borax, sulfate, and muriate of potash blended to form various grades of fertilizers (Siddiqui *et al*., 2009). The primary plant nutrients, (N, P, and K) which are needed by plant in higher amount are the most limiting factors on the nutrient side. Blended fertilizer is defined as the mechanical mixing of two or more granular fertilizer materials to produce mixtures containing N, P, K and other essential plant nutrients. Plants need those and others macronutrients and micronutrients in appropriate ratio for proper growth and development (Sinclair and Vandez, 2002).

Since fertilizers were introduced to Ethiopia in the Freedom from Hunger Campaign, almost all fertilizers used in Ethiopia are limited to DAP and urea. However, recent completed research and soil tests through the Ethiopian Soil Information System Project revealed that Ethiopian soils are deficient in various other nutrients that are not provided by DAP and urea (EthioSIS, 2013).

Previously, nitrogen (N) and phosphorus (P) were considered to be the only limiting nutrients in Vertisols of Ethiopia (Tekalign *et al.*, 2000). However, the results of national soil fertility mapping initiative indicated that other nutrients including S, Zn and B are also found to be deficient in these soils (ATA, 2014). Recently, some studies showed that sulfur (S) and zinc (Zn) are also limiting nutrients for tef production (Bereket *et al.*, 2011).

Balanced fertilizers containing N, P, K, S, B and Zn in blend form are recommended for ameliorating site specific-nutrient deficiencies and thereby increasing productivity for crops (ATA, 2014). The need for site-specific fertilizer prescriptions is increasingly apparent, though; fertilizer trials involving multi-nutrient blends that include micronutrients are rare in the Ethiopian context. Although there is a general perception that the new fertilizer blends are better than the traditional fertilizer recommendation (urea and DAP), their comparative advantage is not explicitly examined and understood under various production environments.

Application of balanced fertilizers could be the basis to produce more crop output from existing land under cultivation and to meet nutrient needs of crops according to their physiological requirements and expected yields (Ryan, 2008). Balanced fertilization not only guarantees optimal crop production, better food quality and benefits for the growers, but is also the best solution for minimizing the risk of nutrient losses to the environment. Based on the EthioSIS soil fertility map (ATA, 2014), N, P, S, Zn and B in blend were identified as deficient nutrients in Ada'a woreda (district).

2.7.1. Effect and Availability of Macronutrient for Yield and Yield Components of Wheat

Macronutrient includes nitrogen (N), phosphorus (P), sulfur (S), magnesium (Mg) and calcium (Ca), which are needed in large amounts, and large quantities have to be applied if the soil is deficient in one or more of them (FAO, 2000).

2.7.1.1. Nitrogen

Nitrogen is one of the essential macro elements needed by plants, and has a greater limiting effect on plant productivity than any other element. This is because of the fact that a large amount of N is required by plants and because of its lack of durability in the soil environment (Crawford and Glass, 1998). We live in an ocean of N, yet the supply of food for human beings and other animals is more limited by nitrogen than any other element. The atmosphere is made up of 79% N_2 by volume as inert N_2 gas that resists reacting with other elements to create a form of N that most plants can use.

However, the amount of this element in available forms in the soil is small, while the quantity withdrawn annually by crops is comparatively large (Brady, 2002).Nitrogen is the major nutrient affecting wheat yield. Increased yield of wheat occurs on all soils with increased N rate, but such increases are reported more frequently on heavy clay soils. And also the increased usage of N fertilizer is considered a primary means of increasing wheat grain in Ethiopia (Asnakew *et al*., 1991). Karamity (1998) indicated that straw yield of wheat was significantly increased at the highest N level (92 kg N ha^{-1}) compared with those at lower levels. Such straw increase at higher N rates is probably due to increased plant height and tillering.

According to Sorour *et al*., (1998), increased grain yield with N application resulted from an increase in one or more of the important yield components. According to Rehman *et al*., (2006), wheat plant height was significantly increased by the recommended N rate (125 kg ha^{-1} N) as compared to the farmers practice (80 $kgha^{-1}$ N) and half of the recommended dose of N (62.5 $kgha^{-1}$ N).

The highest grain and biological yields of any crop is the result of positive relationships of most of the yield components. The effects of N on grain and dry matter yields of wheat were found to be significant and increased as the N levels increased from 0 to 200 kg ha^{-1} N and the corresponding grain yields were increased from 0.8 to 2.3 t ha^{-1} (Samuel, 2006).

In another study conducted by Tilahun *et al.,* (2006), in the central and southeastern Ethiopia application of 120 kg ha^{-1} N gave the highest wheat yield of 2.84 tha^{-1} and the straw yield raises from 24 to 29% with the raises N level from 60 to 120 kg ha^{-1}.Moreover, the result from the experiment done on Vertisols of the central highlands of Ethiopia by Selamyihun *et al*., (2002), showed that straw yield of durum wheat increased significantly with each incremental dose of N. Other reports by Teklu *et al.,* (2002), also indicated that application of N fertilizer significantly enhanced the straw yield of wheat, since N promotes the vegetative growth of the plant. Also, Taye *et al.,* (2002), reported linear and quadratic responses of straw yield to N rate with mean values ranging from 15.45 to 27.73 t ha^{-1}during favorable growing seasons.

2.7.1.2. Phosphorus

Phosphorus has long been known to be an essential element in the nutrition of plants. It plays key role in cellular energy transfer, respiration, and photosynthesis (Price, 1970). In addition, P plays an essential role in many physiological and biochemical processes (Mathews *et al*., 1998) and is an essential component of deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) (Khasawneh, 1980). As stated by Degeus (1973), P promotes the development of the root systems, seed formation, and hastens ripening. In order to stimulate early growth and development, care should be taken to provide the crop with a sufficient amount of easily available P (Tisdale *et al*., 1993).

Phosphorous has a lower mobility than any other nutrients and it does not remain in a free state for long in which it is slowly available to plants (Parnes, 1990).Phosphorous is not considered a mobile element in the soil (Sander and Penas, 2000), but it is mobile in the plant as P is translocate from vegetative plant parts to the developing seed (Karlen *et al*., 1992). Phosphorus makes up 0.1 to 0.4% of the dry matter of the plant (FAO, 2000). By far, the greater part of P taken up by the plant is accumulated in the grain (Degeus, 1973).

Plants absorb P in the form of HPO_4^{-2} and $H_2PO_4^-$ (Tisdale *et al.,* 2002). As to which of the two anions plants take up depends primarily on the soil pH. In high pH soils, it is taken up mainly as HPO_4^{-2} while in low pH soils it is taken up mainly as $H_2PO_4^-$ (Archer, 1998). Daniel *et al*., (1998), reported readily availability of P during early season which saved the plants from early stresses and its higher uptake at higher levels resulted into enhanced number of grains per spike and 1000-grain weight due to its involvement in grain formation and development. According to Endalkachew (2006), increasing levels of applied P from 0 to 30 kg P ha^{-1} consistently decreased days to heading and maturity.

The same author also reported application of 30 kg P ha^{-1} has significantly increased grain yield over application of 10 kg P ha^{-1}, but not over 20 kg P ha^{-1}. Moreover, Asnakew *et al.,* (1991), revealed that the effect of P on grain yield was highly significant with a general increase in yield as the level of P increased up to 69 kg ha^{-1}. Rehman *et al.,* (2006) indicated that wheat plant height was significantly increased by the recommended P rate (40 kgha^{-1} P) as compared to the farmers practice (26 $kgha^{-1}$ P) and half of the recommended dose of P rates (20 $kgha^{-1}$ P). At early stages of development, wheat absorbs P faster from fertilizer than from soil, and high proportion of the total P absorbed by young plants was derived from the fertilizer and its application at later stages may result in greater uptake of P but less effect on yield (Gupta, 2006).

2.7.1.3. Sulfur

Sulfur is one of the essential nutrients for plant growth and it accumulates 0.2 to 0.5% in plant tissue on dry matter basis. It is required in similar amount as that of P (Ali *et al*., 2008). It is a building block of protein and a key ingredient in the formation of chlorophyll (Duke and Reisenaue, 1996). It is required for the synthesis of S containing amino acids such as cystine, cysteine and methionine. Their deficiency results in stunted growth, reduced plant height, tillers, spikelets and delayed maturity. Sulfur deficient plants have also less resistance under stress conditions (Doberman and Fairhurst, 2000).Sulfur fertilizer enhancing the uptake of N, P, K and Zn in the plant.

Due to its synergistic effect, the efficiency of these element is enhanced which results in increased crop productivity. Application of S fertilizer is a feasible technique to suppress the uptake of undesired toxic elements (Na and Cl) because of the antagonistic relationship, thus its application is useful not only for increasing crop production and quality of the produce but also improves soil conditions for healthy crop growth (Zhang *et al*., 1999).

2.7.1.4. Urea

Since the early 1950s, urea has been the world's main source of fertilizer N. However, in the UK, the great majority of fertilizer N has been applied as ammonium nitrate (AN). Gasser (1964), reviewed the use of urea as a source of fertilizer N, concluding it was somewhat inferior to AN, because it either damaged germinating seeds and young plants (e.g. cereals and sugarbeet), or lost ammonia to the atmosphere after application. Field experiments in the UK showing that urea may be less effective than other nitrogen fertilizers (e.g. Devine & Holmes 1963) and have limited its use in the UK from 1990 to 1994 only 15–20% of N topdressing to cereals was in the form of urea(Galloway *et al.,* 2008).

Chaney and Paulson (1988), found urea to be an inferior N source when applied to arable crops. However, their comparisons included only one or two rates of N application and so the feasibility of using extra urea to compensate for its lesser efficiency could not be evaluated. No consistent differences in yield loss could be related to texture, pH or climate by Chaney & Paulson (1988), or Lloyd (1992).

2.7.2. Effect and Availability of Micronutrient for Yield and Yield Components of Wheat

The micronutrients or trace elements are Fe, Mn, Zn, Cu, Mo, Cl, Ni and B (FAO, 2000; Barker and David, 2007; Fageria, 2009). They are part and parcel of the key substances in plant growth and are comparable with the vitamins in human nutrition. Being taken up in minute amounts, their range of optimal supply is very small (FAO, 2000). Their plant availability depends primarily on the soil reaction.

2.7.2.1. Zinc

Zinc (Zn) is a micronutrient needed in small amounts by crop plants, but its importance in crop production has increased in recent years. Zn is an integral component of many physiological processes. It is important in plant nutrition and functions in enzymes, stability of cytoplasmic ribosomes, oxidation processes, and transformation of carbohydrates and synthesis of auxinindole acetic acid (Barker and David, 2007). Moreover, the presence of Zn plays an important role in protein synthesis, formulation of some growth hormones and promotes seed maturation and production (Tisdale *et al*., 2002).

Application of Zn fertilizers with high water solubility is the most effective way to correct Zn deficiency. Zinc fertilizer, with water solubility levels of about 40–50% of the total applied Zn, are needed to meet the Zn requirements for the current crop, and high correlations have been found between Zn fertilizer water solubility and plant growth and Zn uptake (Slaton *et al.,* 2005). Form of Zn availability to plants can be affected by water- solubility of Zn, exchangeable Zn, and adsorbed Zn on the surface of colloids or organic matter, and Zn substituted for Mg^{2+} in the crystal lattices of clay minerals (Tisdale *et al*., 2002).

Zinc is available to the plant mainly as a divalent cation (Zn^{+2}) while at high pH it is probably absorbed as monovalent anions (ZnOH). Hence Zn availability is greatly affected by soil pH. As soil pH increases, Zn availability decreases and vice versa (Barker and David, 2007).Application of Zn fertilizer at 23 kg ha^{-1} has increased the grain yield by 37% over the control wheat crops (Torun *et al*., 2001).

Fayera *et al.*, (2014), reported that application of Zn with macronutrient fertilizer in increasing spike length, yield and yield components in teff production. Moreover, Zn application between 0 and 10 kg ha^{-1} levels has showed statistically non-significant difference on plant height of wheat (Riffat *et al*., 2007). Gangloff *et al*., (2002), found that in maize plants application of zinc sulphate has increased dry matter, leaf and grain Zn accumulation. Finally, application of Zn on soil increased growth, yield and leaf Zn concentration on pepper plant (Aktas *et al.*, 2006).

2.7.2.2. Boron

Boron (B) is an essential micronutrient for plants, and plant requirements for this nutrient are lower than the requirements for all other nutrients except molybdenum and copper. It is the only non-metal among the micronutrients and also the only micronutrient present over a wide pH range as a neutral molecule rather than an ion (Epstein and Bloom, 2005). B is required for normal development of reproductive tissues and deficiency results in low grain set and poor seed quality. Even the cereals (like wheat and rice) with small B requirement can suffer from impaired seed set due to B shortage at a critical growth stage (Shorrocks, 2005).

B is involved in N and P metabolism, in plants poorly supplied with B, NO_3^-, N accumulated in the roots, leaves, and stems, showing that NO_3^-reduction and amino acid synthesis were inhibited. B is mainly associated with cell wall pectin, and physical characteristics of the growing cell wall were altered under B deficiency (Brown and Huri, 1997).Plants absorb B in the form H_3BO_3, and it moves to plant root mainly by mass flow and diffusion. Uptake of B in crop plants is mainly determined by yield level. Variation in B uptake was about 99% in rice and 97% in dry bean with increasing plant age. This variation in B uptake may be associated with increasing dry matter of shoot in both crop species (Fageria, 2009).The decrease in B uptake at harvest was associated with translocation of this element to grain. B recovery under field conditions by annual crops is generally in the range of 5 to 15% the year of application, and for most annual crops, uptake of 100 to 200 g B ha^{-1} of applied B could be expected to be sufficient (Shorrocks, 2005).The total B content of most agricultural soils ranges from 1 to 467 mg kg^{-1}, with an average content of 9 to 85 mg kg^{-1}.

Available B, measured by various extraction methods in agricultural soils varies from 0.5 to 5 mg kg^{-1}(Fageria, 2009).Most of the available B in soil is believed to be derived from sediments and plant material (Barker and David, 2007).Fageria (2009), determined adequate and toxic rates of B for five annual crops grown on Brazilian Oxisol. Adequate B rates were 2 kg ha^{-1} for dry bean, 4.7 kg ha^{-1} for corn, and 3.4 kg ha^{-1} for soybean applied to a Brazilian Oxisol in a greenhouse experiment. The toxic rates were 4.4 kg B ha^{-1} for upland rice and dry bean, 8.7 kg B ha^{-1} for corn, 6.8 kg B ha^{-1} for soybean, and 7.4 kg B ha^{-1} for wheat.

2.8. Concept and definition of organic fertilizer

Organic fertilizers are fertilizers derived from animal matter, human excreta or vegetable matter (E.g. compost, manure). Naturally occurring organic fertilizers include animal wastes from meat processing, peat, slurry and guano. Organic fertilizers are carbon-based compounds that increase the productivity and growth quality of plants. The main organic fertilizers are in ranked order, peat, animal wastes (often from slaughter house), and plant wastes from agriculture and sewage sludge (Demmel, 1980; Alleman, 1982).

Organic fertilizers, far from being purified and simplified chemicals, are complex compounds that add numerous secondary and micro-nutrients beyond the one or two for which they are best known. Organics amendments such as manures, powdered rocks (such as lime, rock phosphate, and greensand), blood meal, bone meal, wood ash and compost, all contain important micronutrients and their texture will improve soil quality rather than degrading it (Hoitink and Keener, 1993).

2.8.1. The requirement of organic fertilizers

2.8.1.1. Compost

Compost is a soil amendment produced through the metabolism of an organic substrate a surface on which organisms grow by aerobic (oxygen-requiring) microbes under controlled conditions.

Composting is an ancient agricultural technology going back to biblical times that still has important applications in modern agriculture. Recent years have seen a resurgence of interest in compost for modern cropping systems. Compost use in field crops should be part of any long-term crop management plan. Composting also helps dairies manage manure, it has agronomic benefits, and it controls plant diseases, and adds nutrients to the soil (Barker, 2010).

Composts and manure are commonly used in organic and low input farms to maintain or improve soil fertility; they are used to supply nutrients within a season and play an important role in SOM accumulation. Compost enhances long-term improvement in soil quality and is effective in building soil microbial biomass (Flieβbach and MaÈder, 2000; Olsen *et al.,* 1954). Compost carryover is the persistence of positive effects of compost by supplying essential nutrients beyond the year of application. Compost carryover is also influenced by non-nutritive effects, which are related to the physical benefits of increased soil organic matter on the soil (Reeve *et al.,* 2012).

The most important benefit of compost use is the capacity to increase the soil organic matter. With the increase in the soil organic matter, soil physical characteristics are improved through compost application by increasing aggregate stability, porosity, infiltration and decrease bulk density (Diacono and Montemurro, 2009). This will increase water-holding capacity due to enhanced soil structure (Barker, 2010). In addition, (Stukenholtz *et al.,* 2002) reported that the previously stated non-nutritional benefits of compost, which improve soil moisture retention, might surpass its nutrient benefits in dryland farming systems where moisture is the yield-limiting factor. From sustainable standpoint, compost application will increase the soil moisture, water infiltration, soil structure and SOM.

2.8.1.2. Vermicompost

Vermicompost is finely divided peat-like material with low C: N ratio, high porosity, aeration, drainage, water holding capacity, microbial activity and is the end product of non-thermophilic biodegradation of organic materials by combined action of earthworms and associated microbes (Edwards and Burrows, 1988; Atiyeh *et al.,* 2000a, 2000b; Arancon *et al*., 2004). Earthworms act as mechanical blenders and by comminuting the organic substrate they alter its physical and chemical status thereby increasing the surface area favorable for microbial decomposition

(Dominguez, 2004). Earthworms after consuming soil and organic substances excrete tiny pellets or vermicast which is a nutritive organic fertilizer rich in humus, macronutrients (nitrogen, phosphorus and potassium), micronutrients, beneficial soil microflora, actinomycetes, and plant growth regulators (Adhikary, 2012).

Earthworm gut plays a vital role in processing of soil and organic matters (Drake and Horn, 2007). Activities of endosymbiotic microbes and gut enzymes (cellulase, protease, chitinase acid and phosphatase) of earthworm aid in transformation of ingested soil and organic matters into valuable product constituting essential nutrients and active components of microbial biomass (Zhang *et al*., 2000).

2.8.1.3. Vermiwash

The quality of vermiwash produced by earthworms depends on the vermicompost that is used (Sreenivas *et al.,* 2000). The water that passes through the vermiculture, resulting in washing of the live and dead earthworms, soil microorganisms and decomposed organic matter, carries all the dissolved substances. As the water can dissolve some vermicasts, containing lots of nutrients, they find their way into vermiwash. The basic principle of vermiwash preparation is very simple. Earthworm worked soils have burrows formed by them called as drilosphere. Water that passes through these burrows washes the nutrients from these burrows to the roots to be absorbed by the plants (Somani, 2008).

This principle is applied in the preparation of vermiwash. Vermiwash is rich in dissolved nutrients and amino acids which are easily available for plants. It is also a non-toxic and ecofriendly compound, which arrests the bacterial growth and forms a protective layer for their survival and growth. Vermiwash at 5-10 percent dilution inhibits the mycelial growth of pathogenic fungi. It also has the capacity to encounter worms thereby saving the crops and their productivity. As a foliar spray, it was reported to initiate flowering and long lasting inflorescence. It can also be used as a liquid fertilizer applied to the rhizosphere. No pathogen can survive in this fluid, thereby protecting the earthworms from the diseases caused by pathogens. It acts as a plant tonic and thus helps in reducing many plant pathogenic fungi. It increases the rate of photo synthesis in crops/plants. It also increases the number of micro-organisms in the soil which helps in decomposing soil organic matter (Tripathi *et al*., 2005).

2.9. Effect of organic and inorganic fertilizer application on soil properties

Soil fertility decline is one of the constraints to food production in Sub-Saharan region. Low soil fertility in the region caused inherently low soil nutrient content and loss of nutrient through erosion and crop harvests (Ugboh and Ulebor, 2011). Soil fertility and crop yields are lower in developing countries because loss of nutrients from farm lands exceeds inflows (Vanlauwe *et al.*, 2015). Application of inorganic fertilizers together with organic manures were increased the total N content of soil than when used individually (Moe *et al.,* 2019). Application of organic fertilizer not only increases the nutrient content of soils, but also improves the physical and biological condition of soils.

Improvement in soil properties especially soil bulk density and soil structure enhance crop root development and distribution which enable soil C and N cycles. A well-developed root system may play a dominant role in soil C and N and may have relatively greater influence on soil organic C and N levels than the aboveground plant biomass (Norby and Cotrufo, 1998 cycles; Gale *et al.,* 2000; Puget and Drinkwater, 2001). Girma and Zeleke (2017), revealed that combined application of organic and inorganic fertilizers improved productivity of crop as well as soil nutrient content thus improve soil fertility status.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location

The field experiment was conducted during off season at Debrezeit Agricultural Research Center (DZARC) which is located at a distance of 47km from Addis Ababa within the Oromia National Regional State (ONRS). DZARC is found in Ada’a district East Shewa zone at latitude of 08^0 44’N and longitude of 38^0 58’E. The total area of land under cultivation in the research Center is about 148 ha.

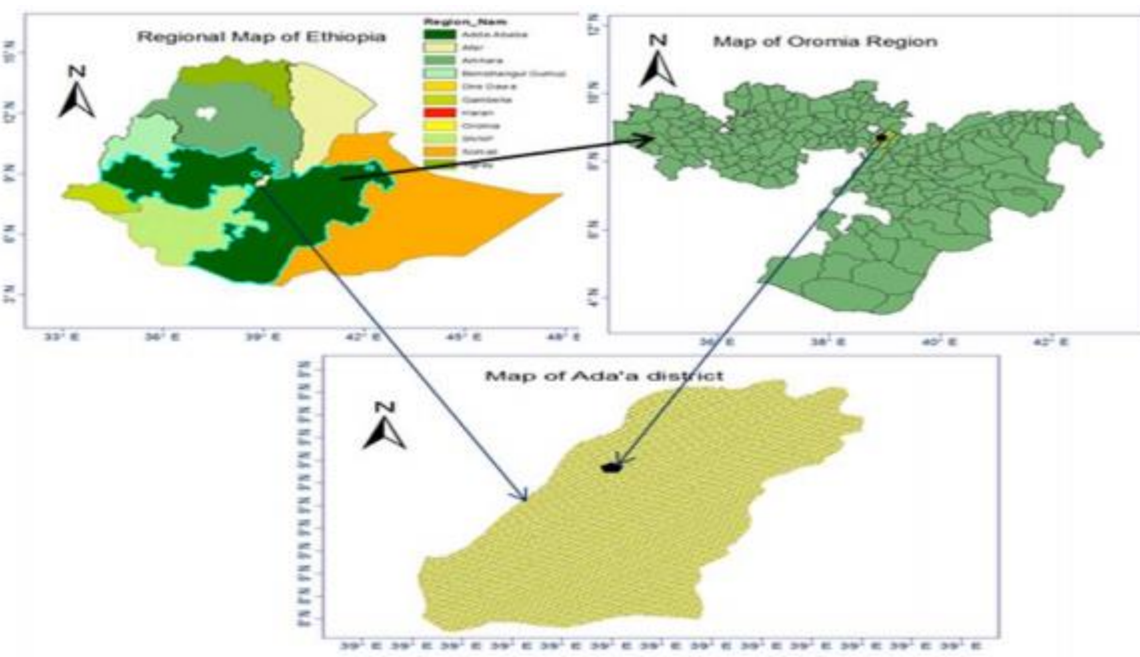

Figure 1: Map of Ada’a District, where DZARC is located

3.1.2. Climate and Topography

The mean annual rainfall of DZARC is 851mm. Average minimum and maximum temperatures are 8.9°C and 28.3°C, respectively. Debrezeit Agricultural Research Center (DZARC) is situated at an altitude of 1900 m.a.s.l (meters above sea level).

3.1.3. Soil Types and Parent Materials

The dominant soil types at Debrezeit Agricultural Research Center (DZARC) are Vertisols, the majority of trial fields are heavy soils (Vertisol) with few pockets of light soils (Alfisols/ Mollisols) (World Reference Base [WRB], 2006). Vertisols are generally fertile with good moisture holding capacity. They are hard and crack during dry, and sticky when wet (FAO, 1986).

The soils in the research center have very deep depth for most of agricultural crops grown in the area, dominated by black ($10YR^{2/1}$) mist color on top and very dark gray ($10YR\ ^{3/1}$) color in surface with high clay content in depth (Bogale, 2014).Physiographic feature of the research area is largely characterized by flat to gently undulating plain land form with a slope less than 6% which could be categorized as level land (Workineh, 2013). The geology of the area consists of pyroclastic rocks, mainly tuffs and ignimbrites of the recent volcanic eruptions (World Reference Base [WRB], 2006). The upper soil layer consists of tephritic materials, whereas the substratum consists of calcareous material enriched through secondary precipitation over the bedrock (WRB, 2015).

3.1.4. Population and Farming System

There are 60 PAs (45 in rural and 15 urban) in Ada'a district. Majority of the population of the district lives in rural area. Mixed farming system that combines crops and livestock husbandry characterizes the Central Highland of Ethiopia in general and the Ada'a district in particular. The major crops commonly grown in the district are Teff (white, red and mixed), durum wheat, and bread wheat, Barley, Maize and Sorghum.

3.2. Methods of Study

3.2.1. Vermicompost Materials and Preparation Procedures

The raw materials used for vermicompost bedding was Tef straw, surface soil and partially farm yard manure (FYM). Matured earthworms species *Esienia fetida* were used as decomposer for both the bedding and feeding materials. The earthworms were fed with weighed amount of cabbage and avocado leaves every 2 weeks except the last 2 weeks before vermicompost harvest.

Vermicomposting process was undergone at normal temperature and 60% moisture level. Vermicompost was ready for harvest at 65 days. Harvesting of vermicompost was done using hand method starting from one side of the bin to the next side. Composite vermicompost samples were collected from DZARC vermicompost and vermiculture unit at DZARC both for N and pH determination (% dry weight basis).

3.2.2. Vermiwash Materials and Preparation Procedures

Vermiwash used for this study was prepared from vermicompost sunk down in tanker water for one night and harvested the next day morning. The concentrated vermiwash amount was diluted with water and applied to the plants 2 times at seedling and at tillering stage as a foliar organic fertilizer.

3.2.3. Compost Materials and Preparation Procedures

Compost was prepared from partially decomposed cow manure, wheat and teff straw, green weed leaves (appropriate for composting), ash, and surface soil in the presence of water for moisture. The dry and green leaf materials repeatedly layered with the proportion of 1:2 ratio respectively i.e. (15cm green: 30cm dry material depth), while thin layers of soil, ash and manure in between the main layers. Three compost hills were prepared on the top of small plots with 1m x 1m width and 1.5m height using wooden pegs and covered with polyethylene sheet. Compost was moistened with water every 3 days interval before all the materials gained the optimum temperatures (heat level). Compost hill turned over and mixed at various times (~3weeks interval). Compost making was completed within 75 days. Composite compost sample were collected from each hill for N and pH determination (% dry weight basis). The result used for treatment weighing. Composite compost sample was taken for treatment amount weighing Compost Based on Nitrogen Equivalent (CBNE) at full and half rate (See 3.5).

3.3. Experimental Material

3.3.1. Plant Material

Durum wheat seed variety *"Mangudo"* was obtained from durum wheat breading section at DZARC. *Mangudo* seeds were used at the seed rate of 120kg /ha. Prior the seed rate weighing seed germination test had been made in laboratory and later on seed rate for field experiment was adjusted based on the average germination test result for seeds germinated in three petri plates.

3.3.2. Fertilizers Nutrient Contents and Forms

The N sources fertilizers used for the study were from Blend fertilizer (NPSZnB) (Figure 2.), Urea, Compost and Vermicompost. All fertilizers obtained from DZARC. NPSZnB was blend fertilizer product from Tulu Bolo factory. The percent content of NPSZnB, Urea, Compost and Vermicompost indicated in parenthesis: NPSZnB (17.8, 35.7, 7.7, 2.2, and 0.1), Urea (46), Compost (3.19N) and Vermicompost (3.5N). Blanket recommendation of 200kg NPSZnB was suggested to use by farmers (ATA, 2016). Blended fertilizer map obtained from the EthioSIS project map in Ethiopia as the case for Oromia (Figure 2). The nutrient P, Zn, and B were calculated as P_2O_5, ZnO and Borax ($Na_2B_4O_7$.10H2O) respectively and the remaining N and S as elemental form ($Na_2B_4O_7.10H_2O$).

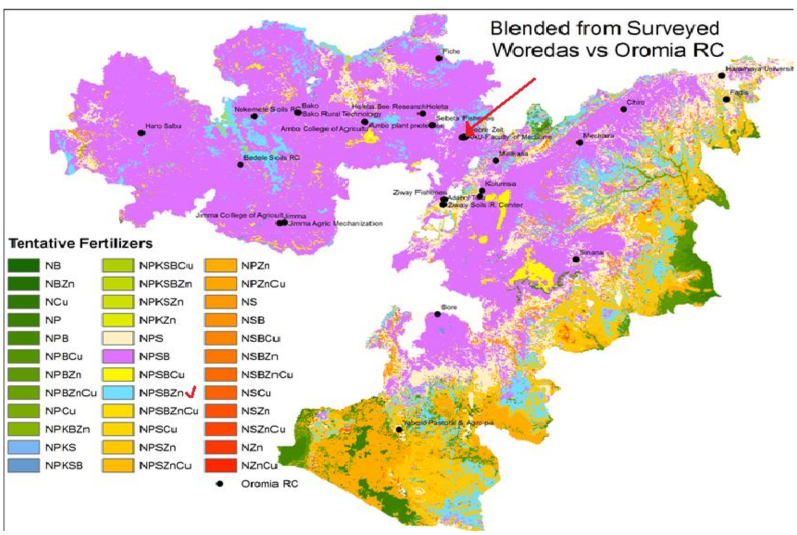

Figure 2: EthioSIS suggested map for blended fertilizers use based on district soils in Oromia region

3.4. Experimental Design and Treatments

Eight treatments (Table 1) were arranged in randomized complete block design (RCBD) with three replications. The experimental area was disc-ploughed and harrowed to bring the soil to a fine tilth. After harrowing twice, it was leveled and then divided into 24 experimental plots.

The experiment was a total of 8 treatments. Blend NPSZnB and half of the Urea treatments were applied in bands at planting. While the remaining half of Urea at the end of full tillering or grain filling as top dressing. Both vermicompost and compost were applied on the soil of each plot and incorporated with the surface soil 20 days before planting. Vermiwash application was twice at seedling and tillering.

Table 1: Amount of the treatment application

Treatments
T1-Control (0-0-0)
T2-NPSZnB (200kg /ha)
T3-NPSZnB (200kg/ha) + 100kg /ha Urea
T4-NPSZnB (200kg/ha) + 3.2t /ha Compost(BNE)
T5-NPSZnB (200kg/ha) + 2.7t /ha V/compost(BNE)
T6-NPSZnB (200kg/ha) + 1.6t /ha Compost + Urea (50kg/ha)
T7-NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha)
T8-NPSZnB (200kg/ha)+ vermiwash (1000Lt/ha) (twice at seedling and tillering)

N.B.: BNE= based N equivalent for N in fertilizer recommendation (69kg N /ha).

3.5. Determination of Organic Fertilizer Nitrogen Base Equivalence

Treatment nutrient conversion of applied organic fertilizers was calculated from the pre-determined N content of these fertilizers in the laboratory. The percent compost nitrogen base equivalence (CNBE) and percent Vermicompost nitrogen base equivalence (VCNBE) was therefore calculated as:

$$\% \, FE = \frac{FE \times 100}{N \text{ applied}}$$

Where, FE = CNBE or VCNBE value

Table 2: Treatments (N kg/ha)

	Treatments	% N
1	Control (0-0-0)	0
2	NPSZnB (17.8,35.7, 7.7, 2.2, and 0.1 respectively)	35.6
3	NPSZnB (17.8N + …) + 46Kg N Urea	81.6
4	NPSZnB (17.8N + …) + 69Kg N Compost	104.6
5	NPSZnB (17.8N + …) + 69Kg N /ha Vermicompost	104.6
6	NPSZnB (17.8N + …) + 23Kg N /ha Compost + Urea (23kg N /ha)	81.6

7	NPSZnB (17.8N + …) + 23Kg N /ha Vermicompost + urea (23 Kg N /ha)	81.6
8	NPSZnB(200kg/ha) + 1.5%N vermiwash (1000Lt/ha twice at seedling and tillering)	60

N.B.: The N rate in NPSZnB doubled when it applied at 200kg/ha; BNE= based N equivalent for N in fertilizer recommendation (69kg N /ha). Total N in vermiwash was 1.5% from vermiwash concentration 40:60.

3.6. Field Management and Irrigation

The experiment was conducted in DZARC research field. The experimental area was disc-ploughed and harrowed to bring the soil to a fine tilth. After harrowing twice, it was leveled and then divided into 24 experimental plots. The field was leveled and divided into blocks which were then divided into plots. The spacing between blocks, plots and rows was 1.5m, 0.5m, and 20cm, respectively. NPSZnB and half Urea were applied within the band at planting.

The sizes of each experimental plot were 2.5m x 2.5m, furrow after two rows of wheat planting at 30cm distance. The spacing between blocks, plots and rows was 1.5m, 0.5m, and 20cm, respectively. Each plot consists of 8 rows. Six middle rows were harvested for yield record. The total area of trial site was 242 m^2.

Weeds were removed by hand when required. Rouging of lately emerging grasses and off-type plants was done to avoid interference with the wheat cultivars. Wheat was harvested from each plot at full maturity.

All treatments were supplied with uniform amount of irrigation water at 6 days interval until booting stage of the plant and 10 days interval from booting to full maturity stage (as per the recommendation given from Agriculture water department of DZARC). Source of irrigation water is ground water and applied to wheat field through slow flooding. Irrigation was non-experimental variable applied for all treatments uniformly.

3.7. Soil Samples Collection and Preparation

Soil samples were taken both before and after planting from the experimental field. Disturbed (using auger) soil samples which were composited by thoroughly mixing and undisturbed (using core) was also collected. Before planting, soil samples were taken from five spots of each block in a zigzag pattern at a depth of 0-30 cm. Then, one composite per block was formed and mixed thoroughly following a standard procedure for soil sampling and sample preparation to describe the field (Paetz and Wilke, 2005). The composite soil sample was air dried in the laboratory and sieved (2.0 mm) and readied for analysis at DZARC. After harvested, soil samples were also collected from each experimental plot at a depth of 0-30 cm using the same procedure. Then, soil samples were analyzed for physicochemical properties following standard laboratory procedures.

3.8. Soil Sample Analysis

3.8.1 Soil Physical Analysis

Particle size distribution was determined by the hydrometer method (Day, 1965) and the soil textural classes were assigned based on the relative contents of the percent sand, silt, and clay separates using the soil textural triangle of USDA as described by Rowell, (1994). Bulk density was determined using the core method as described by Jamison *et al*., (1950). The average soil particle density (2.65 g cm^{-3}) was used for estimating total soil porosity (Rowell, 1994). Soil moisture was determined using gravimetric method following the procedures described by Reynolds, (1970).

Total porosity = (1-BD/PD) x 100; Where the average value of PD was considered as $2.65 g/cm^3$

3.8.2 Soil Chemical Analysis

The pH of the soil was measured from suspension of 1:2.5 (weight/ volume) soil to water ratio using a glass electrode attached to digital pH meter (McLean, 1982). Organic carbon contents were determined by the wet combustion or dichromate oxidation methods (Walkely and Black, 1934). Soil organic matter was calculated from the organic carbon content by multiplying by 1.724.

The available phosphorus content of the soil was analyzed using 0.5M sodium bicarbonate extraction solution (pH 8.5) following the method of Olsen (Olsen *et al.,* 1954). Total nitrogen content was determined following the Kjeldahal method as described by Jackson (1958). Cation exchange capacity (CEC) was determined using ammonium acetate method with 1N NH4OAc (Black, 1965). Available S and exchangeable K of the soils were extracted by Mehlich-III multinutrient extraction method (Melich, 1984) and were measured with their respective wave length range by Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES) at Horticoop PLC Soil and Water Analysis Laboratory, DebreZeit, Ethiopia.

3.8.3. Vermicompost, Vermiwash and Compost Analysis

The pH of vermicompost/compost and vermiwash was measured using a pH meter glass electrode and in the extract of the saturated vermicompost/compost and vermiwash (McLean, 1982). Total Nitrogen content of vermicompost/compost and vermiwash was analyzed using the Kjeldahl digestion, distillation and titration method as described by (Nelson and Sommers, 1973**)**. Phosphorus content of vermicompost/compost and vermiwash was analyzed according to (Jackson, 1958). Organic Carbon was determined following (Walkley and Black, 1934).

3.9. Plant Data Collection and Measurements

3.9.1. Phenological Data

Days to 50% spike Heading (DH): This refers to the number of days from the date of sowing to the stage when 50% of the spikes fully emerged (headed), and was estimated visually.

Days to 50% physiological maturity (DPM): Days to physiological maturity was determined as the number of days from emergence to 50% maturity based on visual observation, which was indicated by senescence of the leaves as well as free threshing of seeds from the glumes when pressed by thumb and the forefinger.

3.9.2. Growth Parameters, Yield and Yield Components

Plant height (PH): Plant height was measured at heading and physiological maturity from the ground level to the tip of the panicle from five randomly selected plants in each plot.

Spike length (SL): is length of the spike from the node, where the first spike branch starts, to the tip of the panicle as the average of five select plants per plot.

Number of effective tillers (NET): The number of effective tillers was determined by counting the tillers from five select plants per plot.

Aboveground biomass yield (AGBY): At maturity, the whole aboveground plant parts, including leaves, stems, and seeds from the net plot area in each plot was harvested and sun dried until a constant weight and then the aboveground biomass was weighed and then expressed in kg ha^{-1}.

Thousand Kernels Weight (TKW): grain weight of thousand seed sampled at random from total grain harvest of experimental plot was recorded on analytical balance.

Grain yield (GY): Grain yield was measured by threshing the already harvested crop from the net middle plot area of 2 x 2m to avoid edge effects.

Straw yield: straw yield was calculated as the difference between biomass yield and grain yield.

Harvest index (HI): Harvest index was calculated by dividing grain yield to the total above ground biomass yield.

3.10. Statistical Analysis

The collected data was subjected to statistical analysis using SAS software version9.4. Analysis of variance (ANOVA) was computed following GLM procedure at 5% level of significance. When the ANOVA showed significant difference, mean separation was done using least significance difference (LSD) test at 5% probability level (Gomez and Gomez, 1984).

3.11. Economic Analysis

To evaluate the economic feasibility of chemical and organic fertilizer treatments, economic cost and benefit analysis was done based on the partial budget analysis techniques detailed in (CIMMYT, 1988). For the economic analysis, the prevailing market price for inputs during planting time and prevailing market price for outputs (wheat grain and straw yield) during harvesting time was considered. The mean wheat yield for each treatment was averaged. All costs and benefits were calculated on a hectare (ha) basis. The partial budget analysis was conducted. Mean wheat yield was computed as the average yield (kg ha^{-1}) of each treatment minus 10% of the yield (to estimate what can be expected for a farmers' field). Market price for grain of Durum wheat = 21 ETB kg^{-1}, Market price of straw= 3 ETB kg^{-1}, cost of vermicompost = 4 ETBkg^{-1}, Cost of Urea (N-source) fertilizer = 16 ETB kg^{-1}, Cost of compost= 3 ETBKg^{-1}, Cost of vermiwash= 2 ETB in litter and Cost of NPSZnB= 29 ETB Kg^{-1}.

4. RESULTS AND DISCUSSION

4.1. Physico-Chemical Properties of the Experimental Soil Before Planting

The results indicated that the soil texture was clay (sand 14.3%, silt 36.3% and clay 49.5%) with a neutral pH 7.08 (Murphy 1968); the organic carbon content of the soil was 1.23%, total N content was 0.12%, The soil of the experimental site had low nitrogen and requires nitrogen application as wheat is highly exhaustive crops for nitrogen and the production potential of them was highly affected by N deficiency. Available P of 12.73ppm, available sulfur of 7.61 ppm, and CEC of 44.1 cmol kg^{-1} soil (Table 3).

The measured bulk density (1.30 $g.cm^{-3}$) at the study site was close to the critical value of bulk density for plant growth at which root penetration is likely to be severely restricted for clay soil as described by Hazelton and Murphy (2007). The high bulk density at top surface layer soils of the study area might be attributed to intensive farming practices undertaken by tractor at the same depth for long time as well as due to low soil organic matter content of the area. In line with this, Tesfaye *et al.,* (2018), also reported that high bulk density can be associated with intensive mechanized cultivation and low organic matter content of soil. That mean total soil porosity of the study area was 50.94 percent. Nevertheless, according to Brady and Weil (2008), the ideal total porosity values for healthy root growth is >50% and thus porosity value of this surface soil was in a minimum acceptable range for crop production including wheat crop. In line with this, Tesfaye *et al*., (2018) reported that soils with total porosity < 50% are less optimum for crop production. The percentage of soil moisture content in the study area was 17.43.

As per the ratings for Ethiopian soils by Murphy (1968), the pH of the experimental soil was within the range for productive soils. In accordance with Tekalign (1991), the organic carbon content and total nitrogen could be rated as low. According to Landon (2014) the CEC value of greater than 40 cmol kg^{-1} showing that the CEC value of the experimental soil was high. Similarly, based on Olsen, *et al.,* (1954) for P rating (ppm), available P content of the study was in the medium range.

Table 3: Selected Physico-chemical characteristics of the experimental soil before planting

Parameter	Values
Physical properties	
Texture Clay (%)	49.5
Silt (%)	36.3
Sand (%)	14.3
Textural class	Clay
Bulk density (gcm^{-3})	1.30
Total Porosity (%)	50.94
Soil moisture content (%)	17.43
Chemical properties	
pH	7.08
Total Nitrogen (%)	0.12
Available Phosphorus (ppm)	12.73
Available Sulfur (ppm)	7.61
Organic carbon (%)	1.23
Available potassium (cmol+/kg)	4.94
CEC [Cmol (+)/kg)]	44.1

4.1.1. Chemical Composition of Vermicompost/Compost and Vermiwash

The pH of vermicompost, compost and Vermiwash (7.60, 7.48 and 7.51 respectively) was slightly alkaline (Table 4). Moreover, the results of the analysis showed the mean organic carbon of vermicompost, compost and vermiwash were 9.00%, 7.46% and 6.16% respectively, and total nitrogen contents of vermicompost, compost and vermiwash were 1.5%, 1.19% and 0.98% respectively (Table 4). The vermicompost/compost used for this experiment was well decomposed and can release N to soil so that plant can use it. Similarly; Phosphorus content of vermicompost, compost and vermiwash were 12.00, 10.04 and 11.70 ppm respectively.

Table 4: Chemical characteristics of vermicompost, compost and vermiwash before application

Chemical property values	Vermicompost	Compost	Vermiwash	Means
Soil pH (%)	7.60	7.48	7.51	7.53
Organic carbon (%)	9.00	7.46	6.16	7.54
Total Nitrogen (%)	1.5	1.19	0.98	1.22
Phosphorus (ppm)	12.00	10.04	11.70	11.25

4.2. Effect of NPSZnB and Organic Fertilizers on Soil Physical Properties at Harvest

4.2.1. Bulk Density and Total Porosity

Bulk density is an important physical property which could affect root developments of plants. Application of blended and organic fertilizers at different levels negatively influenced soil bulk density (Table 5). Decreased in the value of soil bulk density could be observed due to increment in application of T7. Accordingly, the lowest soil bulk density (1.13g cm^{-3}) was observed in the plot that treated with T7 and the highest bulk density value (1.27 g cm^{-3}) was recorded in control plot. In line with this, Ibrahim *et al.*, (2015) and Azimzadeh (2015) reported that application of blended and organic fertilizers significantly decreased soil bulk density. Similarly, Tesfaye *et al.*, (2019) also reported the inverse relationship between bulk density and organic matter sourced from industrial wastes.

The total porosity had showed consecutive increment from 50.94 to 57.36% as application of T7. Accordingly, maximum total porosity of the soil (57. 36%) was observed in plot that was treated with T7, while the lowest value (51.82%) was recorded from control treatment. The highest values of total porosity obtained from plot that treated with T7 corresponded to the highest amount of organic matter contents and the lowest bulk density values for this plot. The present finding was supported Rao *et al.*, (2017) in which the low total porosity was described as the reflection of the low organic matter content and the high bulk density values. Similarly, Azarmi *et al.*, (2008) also reported that addition of blended and organic fertilizers significantly improved porosity of soil and other soil physicochemical properties when compared with control plots.

4.2.2. Soil Moisture Content

Increased in the value of soil moisture content was obtained as result of the application of T7. Accordingly, maximum soil moisture content (20.92%) was obtained from T7, while the minimum value (16.17 %) was recorded from control plot (Table 4). Improvement in soil water content after applying blended and organic fertilizers might be attributed to enrichment of soil with blended and organic fertilizers which have high surface area and high-water retaining capacity. Similar results have been reported that soil moisture content significantly increased due to application of blended and organic fertilizers (Gopinath *et al.*, 2008; Lazcano and Dominguez, 2010).

Table 5: Effects of organic and NPSZnB on bulk density, total porosity and moisture content of soil at harvest

Treatment	Bulk density (g/cm^3)	Total porosity (%)	Soil moisture content (%)
T1-Control (0-0-0)	1.27^{a}	51.82^{d}	16.17^{c}
T2-NPSZnB (200kg /ha)	1.25^{b}	52.83^{c}	16.85^{c}
T3-NPSZnB (200kg/ha) + 100kg /ha Urea	1.14^{cd}	53.08^{c}	18.72^{b}
T4-NPSZnB (200kg/ha) + 3.2t /ha Compost(BNE)	1.15^{c}	56.60^{b}	17.08^{c}
T5-NPSZnB (200kg/ha) + 2.7t /ha V/compost(BNE)	1.14^{cd}	56.85^{ab}	20.59^{a}
T6-NPSZnB (200kg/ha) + 1.6t /ha Compost + Urea (50kg/ha)	1.25^{b}	56.73^{ab}	16.74^{c}
T7-NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha)	1.13^{d}	57.36^{a}	20.92^{a}
T8-NPSZnB + vermiwash(1000Lt/ha) (twice at seedling and tillering)	1.24^{b}	53.08^{c}	16.45^{c}
LSD (0.05)	0.01	0.72	0.96
CV (%)	0.9	0.76	3.06

Where, LSD= Least Significant Difference at 5% level; CV= Coefficient of Variation; Means in columns followed by the same letters are not significantly different at 5% level of significance.

4.3. Effect of NPSZnB and Organic Fertilizer Applications on Soil Chemical Properties at Harvest

Soil pH, organic matter, CEC, available P, total N, available S, and available K were measured to assess the postharvest status of the soil.

4.3.1. Soil pH

Soil pH greatly affects a number of important processes including activity of soil microorganisms and availability of nutrient to plants. The analysis of variance showed that there were non-significant differences in soil pH values between the different levels of inorganic and organic fertilizers application. The soil pH ranged from 7.20 to 7.49 across the whole experimental plots (Table 6), showing that application of blended and organic fertilizer residuals did not influence the soil pH significantly. These may be due a one year fertilizer filed experiments, which may not influence soil pH. The pH values observed in the plot with maximum level of treatment combinations was within the ranges of moderately alkaline soil reaction as indicated by Tekalign (1991). Similarly, Tesfaye *et al.*, (2020) also reported application of blended and organic fertilizer residuals did not influence the soil pH significantly.

4.3.2. Soil Organic Matter

Soil OM arises from the debris of green plants, animal residues and excreta that are deposited on the surface and mixed to a variable extent with the mineral component (White, 1997). According to Tekalign (1991), the entire plots had low OM content (Table 6). This is because of continuous cultivation without returning residue to the soil. Similarly, Fassil and Charles, (2009), reported that Vertisols of Ethiopia had low soil OM content. Other authors also reported low soil OM in Vertisols (Giday *et al*., 2015).

4.3.3. Cation Exchange Capacity

Cation exchange capacity (CEC) is also an important parameter of soil, because it gives an indication of the type of clay mineral present in the soil and its capacity to retain nutrients against leaching. It is also a major controlling agent of stability of soil structure, nutrient availability for plant growth, soil pH, and the soil's reaction to fertilizers and other ameliorants. The analysis of variance showed non-significant differences ($P>0.05$) in CEC values among the blended and organic fertilizers. Results showed that the cation exchange capacity of the whole experimental plots ranged from 40.43 –44.73cmol (+) kg^{-1} (Table 6). Landon (2014) classified CEC of <6, 6-12, 12-25, 25-40, >40 cmol (+) kg^{-1}very low, low, moderate, high and very high. Therefore, the CEC of the whole experimental plots could be rated as very high. However, the value of CEC was inconsistent with both fertilizers types. The result is within the range reported by Berhanu (1985), which indicate CEC of 35-70 cmol (+) $kg-^{1}$soil for nearly all the Vertisols of Ethiopia.

4.3.4. Total Nitrogen

Total nitrogen measures the total amount of nitrogen present in the soil, much of which is held in organic matter. There was non-significant difference ($P>0.05$) in total nitrogen due to both blended and organic fertilizers effect with respect to total soil nitrogen at harvesting.

Total N content of the soil, analyzed from composite samples per treatment tended to remain almost the same irrespective of blended and organic fertilizer application. Total N content of the soil before planting was (0.12%) and it was ranged from 0.11 to 0.14% at harvest (Table 6). Similar values before planting and at harvest may be due leaching or denitrification soon after application (very volatile in nature), high uptake of N, and mobility of N in soil. According to EthioSIS (2013), the optimum N needed for crop production under most soils of Ethiopia is reported to be <0.2 %. The result was in line with Tekalign (1991), who classified soils based on their N content. Masresha (2014) also reported low amount of N content in soils which are cultivated repeatedly, due to N leaching and N mining. Most Ethiopian black soils are N-depleted and more than 50% of cultivated lands are N-responsive soils (Yihenew, 2002).

4.3.5. Available phosphorus

Post-harvest analysis of available phosphorus values were not significantly different (P>0.05) due to organic and blended fertilizer applications. Available P contents of the experimental soil after harvest of the entire treatments were above the critical level except for the control plots. However, numerically the highest mean value (15.96 ppm) was obtained from T7 followed by T5. While; the lowest (14.26 ppm) was obtained from the control plots (Table 6). The value of available P before planting was lower as compared to the values at harvest. This implies that available P levels in plots that received P fertilizer were slightly higher than that of control (no P application). EthioSIS (2014), suggested optimum P content for most Ethiopian soil as 15 ppm. Based on this, the available phosphorous of the study area is optimum. This may be due to long term P fertilizer application which may be beyond the plant uptake.

4.3.6. Available Sulfur

The analysis of variance showed that available sulfur was not significantly (P>0.05) affected by application of blended and organic fertilizers. Due to the effect of blended and organic fertilizer, numerically maximum residual was obtained from T7 containing blended and organic fertilizer. However, even by application of sulfur containing fertilizer, the value of residual available S was below the critical level. This may be due to low initial sulfur and higher uptakes in grain and straw of wheat. Based on Hariram and Dwivedi (1994), soil classification for sulfur values, soils in the study fall in very low range. The classification is < 9 very low, 10-20 low, 20-80 optimum, and > 80 ppm high. So addition of fertilizer containing S is relevant. This low S content of the soil may be due to loss of organic matter, less sulfur deposition from the atmosphere and lack of using S containing mineral fertilizer. It can also be related to continuous cultivation, which results in intensive mining of S from soil. This is similar with the report of Hillette (2015), which indicates soils around Bishoftu were deficient in S content.

4.3.7. Exchangeable potassium

Mean value of available K was ranged from 5.33 to 5.57 cmol+/kg (Table 6). Exchangeable K was analyzed per treatment, but the value of K was almost comparable throughout treatments because K fertilizer source was not applied as a treatment or blanket recommendation. According to Ethiosis (2014), soil K value is classified as very low (<0.2), low (0.2-0.5); optimum (0.51-1.5); high (1.51-2.3), and very high (>2.31) cmol+/kg. Therefore, K content of the study area was in very high levels showing that there is no need of adding K fertilizer to the soil.

Table 6: Effects of organic and NPSZnB fertilizer application on soil pH, N, Av.P, Av.S, OC, CEC and Ex.K at harvest

Treatments	pH	N, %	Av.P ppm	OC, %	CEC, cmol+/kg	Av.S, Ppm	Ex. K, cmol+/kg
T1-Control (0-0-0)	7.2	0.11	14.26	1.17	40.43	6.93	5.33
T2-NPSZnB (200kg /ha)	7.42	0.13	15.3	1.33	42.33	7.03	5.42
T3-NPSZnB (200kg/ha) + 100kg /ha Urea	7.42	0.13	15.33	1.46	43.76	8.11	5.38
T4-NPSZnB (200kg/ha) + 3.2t /ha Compost(BNE)	7.41	0.12	15.53	1.24	43.6	7.84	5.42
T5-NPSZnB (200kg/ha) + 2.7t /ha V/compost(BNE)	7.44	0.13	15.93	1.35	43.26	7.97	5.51
T6-NPSZnB (200kg/ha) + 1.6t /ha Compost + Urea (50kg/ha)	7.34	0.13	15.83	1.46	43.83	7.93	5.42
T7-NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha)	7.49	0.14	15.96	1.48	44.73	8.38	5.57
T8-NPSZnB + vermiwash(1000Lt/ha) (twice at seedling and tillering)	7.23	0.12	15.56	1.23	41.66	7.7	5.34
LSD (0.05)	Ns	Ns	Ns	Ns	Ns	Ns	Ns
CV (%)	1.59	11.21	5.17	11.48	5.31	17.44	2.87

Where, TN=Nitrogen, Av.P=Available phosphorus, Av.S= Available sulfur, OC= Organic carbon, Ex.K =exchangeable Potassium, CEC= Cation exchange capacity, LSD= Least Significant Difference at 5% level; CV= Coefficient of Variation; NS= non-significant.

4.4. Effects of Fertilizer Application on Wheat Phenological Traits

4.4.1. Days to Spike Heading and Physiological Maturity

The number of days taken to heading was not significantly (P>0.05) affected by the organic and inorganic blended fertilizers application. The most prolonged duration to reach 50% heading was observed in the control treatments, however, the minimum duration of 50% heading was observed in the application of T7, T3, T4, and T8 had no significant difference with the blended and other organic fertilizer treatments, also T5 and T6 has no significant difference with treatment T2 (Table 7). This result suggested application of NPSZnB and organic fertilizers had no effect on days to 50% heading of wheat crop. This result is in line with Debritu (2013), which reported ample supply of N results in vigorous, rapid growth and early heading of wheat crop. However, this result contradicted the finding of Adera (2016), who reported that with the increase in blended fertilizer and organic fertilizers, the number of days required for flowering, maturity and grain filling period was reduced in teff.

The days to attain physiological maturity did not significantly differ due to the effects of organic and inorganic blended fertilizers application.

The absence of significant effect on days to heading and maturity might be due to the optimum levels of macro and micro nutrients availability that can affect the phenological parameters and also higher lodging problems for most of the treatments, which exposed the plant to false maturity. In general, results showed that organic and inorganic blended fertilizer application had no significant effect on crop maturity (Table 7).

Table 7: Number of days to Spike Heading and physiological maturity of Durum *Mangudo* wheat as affected by the organic and inorganic blended fertilizers.

Treatment	**Day to spike heading**	**Days to physiological maturity**
T1-Control (0-0-0)	58	103
T2-NPSZnB (200kg /ha)	57	100
T3-NPSZnB (200kg/ha) + 100kg /ha Urea	56	101
T4-NPSZnB (200kg/ha) + 3.2t /ha Compost(BNE)	56	101
T5-NPSZnB (200kg/ha) + 2.7t /ha V/compost(BNE)	57	100
T6-NPSZnB (200kg/ha) + 1.6t /ha Compost + Urea (50kg/ha)	56	100
T7-NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha)	55	99
T8-NPSZnB + vermiwash(1000Lt/ha) (twice at seedling and tillering)	56	100
LSD (0.05)	Ns	Ns
CV (%)	2.32	1.41

Where, LSD= Least Significant Difference at 5% level; CV= Coefficient of Variation, Ns= Non-significant

4.5. Growth Parameters, Yield and Yield Components

4.5.1. Plant Height

The effect of organic fertilizer, inorganic blended fertilizers were showed significant ($P< 0.05$) influence on plant height of *Mangudo* Durum wheat. The tallest plant (99 cm) was obtained at the T7 which was statically at par with the T5. Whereas, the shortest plant height (81.7cm) was obtained from the control plot (Table 8). This significant increment may be attributed to the fact that NPSZnB usually favors vegetative growth of Durum wheat, resulting in higher stature of plants. A similar result was reported by (Fissehaye *et al.*, 2009 and Haftamu *et al*., 2009) showing that wheat plant height could be higher by applying NPSZnB and organic fertilizer.

Similar to this finding, Sate (2012), also reported that plant height of wheat was significantly affected by application of P and N with blended fertilizer and organic fertilizer. The highest mean plant (99 cm) was recorded at the combined application of T7 and T5 blended and organic fertilizer. (Table 8).Whereas, other treatment combinations were statistically at par to each other.

Table 8: ***Mangudo*** **Durum wheat plant height as affected by the organic and inorganic blended fertilizers.**

Treatment	Plantheight (cm)
T1-Control (0-0-0)	81.7[b]
T2-NPSZnB (200kg /ha)	95.8[a]
T3-NPSZnB (200kg/ha) + 100kg /ha Urea	98.0[a]
T4-NPSZnB (200kg/ha) + 3.2t /ha Compost(BNE)	96.3[a]
T5-NPSZnB (200kg/ha) + 2.7t /ha V/compost(BNE)	98.3[a]
T6-NPSZnB (200kg/ha) + 1.6t /ha Compost + Urea (50kg/ha)	95.3[a]
T7-NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha)	99.0[a]
T8-NPSZnB + vermiwash(1000Lt/ha) (twice at seedling and tillering)	97.3[a]
LSD (0.05)	5.6
CV (%)	3.4

Where, LSD= Least Significant Difference at 5% level; CV= Coefficient of Variation, means in the same column followed by the same letters are not significantly different at 5% level of significance

4.5.2. Spike Length

Spike length is one of the yield attributes of wheat, which contributes to high grain yield. Spike length was significantly ($P<0.05$) affected by the application of organic and blended fertilizer (Table 9). The longest spike length (5.2cm) was obtained with blended fertilizer T7 which had no significant difference with all blended fertilizer (T2, T3, T4, and T5). However, the shortest spike length (3.9cm) was obtained from control plot (Table 9). The result indicated that macro nutrient and micro nutrient might be enhanced spike length of plant, even if it was parity with recommended treatment. On other hand, Nitrogen and phosphorus had play major role for cell division and elongation. This result corroborates the finding reported by (Debnath *et al.*, 2011; Fayera *et al*., 2014 and Nasser 2009), who reported that the spike length of wheat significantly increases as a result of applying Zn and B blend with macronutrient.

Table 9: *Mangudo* Durum wheat spike length as affected by the organic and inorganic blended fertilizers.

Treatment	**Spike Length (cm)**
T1-Control (0-0-0)	3.9[b]
T2-NPSZnB (200kg /ha)	5.0[a]
T3-NPSZnB (200kg/ha) + 100kg /ha Urea	5.1[a]
T4-NPSZnB (200kg/ha) + 3.2t /ha Compost(BNE)	5.1[a]
T5-NPSZnB (200kg/ha) + 2.7t /ha V/compost(BNE)	5.1[a]
T6-NPSZnB (200kg/ha) + 1.6t /ha Compost + Urea (50kg/ha)	4.9[a]
T7-NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha)	5.1[a]
T8-NPSZnB + vermiwash(1000Lt/ha) (twice at seedling and tillering)	4.7[a]
LSD (0.05)	0.67
CV (%)	7.9

Where, LSD= Least Significant Difference at 5% level; CV= Coefficient of Variation, means in the same column followed by the same letters are not significantly different at 5% level of significance

4.5.3. Number of Effective Tillers

Number of effective tillers was significantly ($P < 0.05$) influenced by the effect of organic and inorganic blended fertilizer.

The highest number of fertile tillers per plant (3) was recorded with the application of T7, while the lowest (1.6) was obtained from the control plot. Effective tillers from plots treated with T2, T3, T4, T5, T6 and T8 were in statistical parity, and only significantly differed from the control plot (Table 10). Consistent with this result, Haftamu *et al.* (2009) and Tekalign *et al. (*2000) reported significantly higher number of tillers in response to the application of blended fertilizer on Durum wheat. Mossedaq and Smith (1994) also revealed that tillering is enhanced by increased light and N availability during the vegetative growing period of the crop.

Table 10: *Mangudo* Durum wheat effective number of tillers as affected by the organic and inorganic blended fertilizers.

Treatment	**Number of effective tillers**
T1-Control (0-0-0)	1.6[b]
T2-NPSZnB (200kg /ha)	2.9[a]
T3-NPSZnB (200kg/ha) + 100kg /ha Urea	2.9[a]
T4-NPSZnB (200kg/ha) + 3.2t /ha Compost(BNE)	2.8[a]
T5-NPSZnB (200kg/ha) + 2.7t /ha V/compost(BNE)	2.9[a]
T6-NPSZnB (200kg/ha) + 1.6t /ha Compost + Urea (50kg/ha)	2.8[a]
T7-NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha)	3.0[a]
T8-NPSZnB + vermiwash(1000Lt/ha) (twice at seedling and tillering)	2.7[a]
LSD (0.05)	0.6
CV (%)	12.02

Where, LSD= Least Significant Difference at 5% level; CV= Coefficient of Variation; Means in columns and rows followed by the same letters are not significantly different at 5% level of significance.

4.5.5. Aboveground Biomass Yield

The analysis of variance showed highly significantly ($P<0.05$) difference aboveground biomass yield due to the application of organic and inorganic blended fertilizer.

The highest aboveground biomass yield (11930 kg ha^{-1}) was recorded at the application of T7 which was statistically at par with T5. The lowest aboveground biomass yield (7485 kg ha^{-1}) was obtained from the control plot (Table 11). Higher aboveground biomass yield obtained from T7 may be due to the increased investment of assimilates to leaves and stems that finally increase the aboveground biomass yield. Also this result was in conformity with the findings of (Adera 2016 and Bereket *et al.,* 2011), which showed that aboveground biomass yield of wheat was significantly affected by application of organic and inorganic blended fertilizer. Others authors also reported that application of 200 kg ha^{-1} NPSZnB fertilizer produced the maximum biomass yield of tef (eg.Wakjira, 2018).

4.5.6. Grain Yield

Grain yield of *Mangudo* Durum wheat was highly significantly ($P < 0.05$) influenced by the application of organic and blended fertilizer.

The highest grain yield (5768kg ha^{-1}) was obtained with the application of T7 which was statistically similar with T3, T4, T5 and T6. While the smallest (2739 kg ha^{-1}) was obtained from the control treatment (Table 11). Moreover, increased application of NPSZnB and organic fertilizer significantly increased grain yield. The result is in conformity with the finding of Lemlem (2012), who reported increased application of blended fertilizer, urea, and compost/vermicompost which significantly increased the NPSZnB concentration of teff grains and increased grain yield on both Regosols and Vertisols.

In general, combined application of blended NPSZnB with organic fertilizers gave more than twofold enhancements in grain yield over the control plot. This yield advantage was achieved, due to the positive effect of blended NPSZnB and organic fertilizers that had increased plant height, spike length, and biomass yield that cumulatively increased the grain yield. The results agree with the findings of Hiwot (2012), who reported that application of blended fertilizer, and urea, compost/vermicompost fertilizer significantly increased teff grain yield in both Regosols and Vertisols.

4.5.7. Straw Yield

The straw yield of cereal crops is an important agronomic parameter that is sensitive to nutrient level of soils or the nutrient applied from external sources. Analysis of variance revealed that straw yield was significantly ($P<0.05$) influenced by the organic and blended fertilizers (Table 11). The highest straw yield (6350.9tha^{-1}) was recorded from the application of T7 which had no significant difference with organic and blended fertilizer T3, T4, T5 and T8. However, the lowest straw yield was obtained from control treatment. The highest straw yield was recorded from T7; which could be due to the combined effect of organic and blended fertilizer like NPSZnB which might have boosted growth and development of crop compared to the rest of the formulations. Additional application of blended and organic fertilizer increased straw yield by 22% over the recommended NPSZnB treatment. This result is in line with that of Teklay *et al.* (2016), who reported that straw yield of teff was significantly affected by application of blended and organic fertilizer which exceeds 7% and 49% of straw yield over the recommended NPSZnB and control plots respectively.

4.5.8. Harvest Index

Harvest index of *Mangudo* Durum wheat was significantly (P<0.05) influenced by organic and blended fertilizer. The highest harvest index (0.49) was recorded at T7, the combined organic and blended fertilizers, while the lowest harvest index (0.36) was recorded from the control (Table 11). This implies that harvest index is the balance between the productive parts of the plant and the reserves, which form greater improvement in grain yield compared to the corresponding increase in straw yield contributed to the increase in harvest index across the increasing levels of organic and blended fertilizer. This result is supported by the findings of Tagesse *et al.,* (2018), where harvest index of wheat was significantly affected by organic and blended NPSZnB fertilizer.

Table 11: *Mangudo* Durum wheat AGBY, GY, StrY, HI as affected by the organic and inorganic blended fertilizers.

Treatment	**AGBY (kg ha^{-1})**	**GY(kg ha^{-1})**	**Str. Y (kg ha^{-1})**	**HI (kg ha^{-1})**
T1-Control (0-0-0)	7485^{d}	2739^{c}	4204.9^{c}	0.36^{d}
T2-NPSZnB (200kg /ha)	8302^{cd}	4097^{bc}	4746^{bc}	0.46^{ab}
T3-NPSZnB (200kg/ha) + 100kg /ha Urea	11649^{ab}	5578.9^{a}	6336.8^{a}	0.46^{ab}
T4-NPSZnB (200kg/ha) + 3.2t /ha Compost(BNE)	10295^{abc}	4503^{ab}	5791.5^{ab}	0.43^{bc}
T5-NPSZnB (200kg/ha) + 2.7t /ha V/compost(BNE)	11889^{a}	5593^{a}	5880.7^{ab}	0.48^{a}
T6-NPSZnB (200kg/ha) + 1.6t /ha Compost + Urea (50kg/ha)	10035^{abcd}	4702^{ab}	5333.3^{abc}	0.46^{ab}
T7-NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha)	11930^{a}	5768.4^{a}	6350.9^{a}	0.49^{a}
T8-NPSZnB + vermiwash(1000Lt/ha) (twice at seedling and tillering)	9193b^{cd}	3677^{bc}	5515.8^{ab}	0.39^{cd}
LSD (0.05)	2557	1404	1291	6.05
CV (%)	14.45	17.5	13.35	5.9

Where, AGBY=Aboveground biomass Yield, GY=Grain Yield, Str. Y= Straw Yield, HI= Harvest Index LSD= Least Significant Difference at 5% level; CV= Coefficient of Variation; Means in columns and rows followed by the same letters are not significantly different at 5% level of significance.

4.5.9. Thousand Kernels Weight

Analysis of variance revealed that there is significant difference among plots treated with organic and blended fertilizer treatments on thousand grain weight (Table 12). However, there was a variation from 42.33g to 53g among the treatments. This significance result on thousand grain weights might be because of the application of organic fertilizer throughout blended treatments, which played the major role in growth and development of the crop. The result is consistent with that of Debnath *et al.* (2011), who found that application B fertilizer had significant effect on thousand grain weight of wheat crop. These results are also similar to another report by Esayas (2015), who reported that blended fertilizer (NPSZnB) application and organic fertilizer had significant effect on thousand grain weight of wheat. Also, Fayera *et al.* (2014) reported that thousand grain weights had significant difference with application of micronutrients (zinc + boron) and macronutrients in blended form of fertilizer and organic fertilizer markedly increased thousand grain seed weight of wheat crop.

Table 12: Effect of organic and blended fertilizer on Thousand Kernels Weight of *Mangudo* Durum wheat.

Treatment	**Thousand Kernels Weight(gm)**
T1-Control (0-0-0)	42.33[c]
T2-NPSZnB (200kg /ha)	49.33[ab]
T3-NPSZnB (200kg/ha) + 100kg /ha Urea	47.66[b]
T4-NPSZnB (200kg/ha) + 3.2t /ha Compost(BNE)	47[bc]
T5-NPSZnB (200kg/ha) + 2.7t /ha V/compost(BNE)	47[bc]
T6-NPSZnB (200kg/ha) + 1.6t /ha Compost + Urea (50kg/ha)	45.66[bc]
T7-NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha)	53[a]
T8-NPSZnB + vermiwash(1000ml/m^2) (twice at seedling and tillering)	46.33[bc]
LSD (0.05)	4.99
CV (%)	6.03

Where, LSD= Least Significant Difference at 5% level; CV= Coefficient of Variation; Means in columns and rows followed by the same letters are not significantly different at 5% level of significance

4.6. Associations among the Agronomic Parameters of Durum Wheat after Application of NPSZnB and Organic Fertilizers

The analysis of association among agronomic parameters was indicated in Table 13. The correlation analysis showed that most of the agronomic parameters was correlated and exhibited either positive or negative relation with each other after treatment application. Heading date of Durum *Mangudo* Wheat was negatively correlated with Maturity date (r = -0.76), Harvest index (r =-0.04), Thousand kerenel weight (r = -0.28), Heading date was positively correlated with plant height (r= 0.5), Spike length (r = 0.8), Number of effective tiller (r=0.95), Aboveground biomass (r =0.80), Grain yield (r=0.59), Straw yield (r =0.95). Maturity date positively correlated with plant height (r=0.19), grain yield (r=0.08), Harvest index (r=0.69), Thousand kerenel weight (r=0.84), while negatively correlated with Spike length (r=-0.99), Number of effective tiller (r=-0.50), Aboveground biomass (r=-0.21), Straw yield (r=-0.51). Plant height positively correlated with Number of effective tiller (r=0.76), Aboveground biomass (r=0.92), Grain yield (r=0.99), Harvest index (r=0.85), Straw yield (r=0.75), Thousand kerenel weight (r=0.70), while negatively correlated with spike length (r=-0.11). Spike length positively correlated with Number of effective tiller (r=0.56), Aboveground biomass (r=0.28), Straw yield (r=0.57), while negatively associated with Grain yield (r=-0.005), Harvest index (r=-0.62), Thousand kerenel weight (r=-0.79). Number of effective tiller positively correlated with Aboveground biomass (r=0.95), Grain yield (r=0.82), Harvest index (r= 0.29), Straw yield (r=0.99), Thousand kerenel weight (r=0.05). Aboveground biomass yield positively correlated with Grain yield (r=0.96), Harvest index (r=0.58), Straw yield (r=0.95), Thousand kerenel weight (r=0.36). Grain yield positively correlated with Harvest index (r=0.79), Straw yield (r=0.82), Thousand kerenel weight (r=0.61). Harvest index positively correlated with Straw yield (r=0.29) and Thousand kerenel weight (r=0.97). Straw yield positively correlated with Thousand kerenel weight (r=0.05) as shown in Table 13.

Table 13: Association among the Agronomic parameters of Durum Wheat after application of NPSZnB and organic fertilizers

	HD	MD	PH	SL	NET	AGB	GY	HI	Str.Y	TKW
HD	**1.00**									
MD	-0.76	**1.00**								
PH	0.5	0.19	**1.00**							
SL	0.8	-0.99	-0.11	**1.00**						
NET	0.95	-0.50	0.76	0.56	**1.00**					
AGB	0.80	-0.21	0.92	0.28	0.95	**1.00**				
GY	0.59	0.08	0.99	-0.005	0.82	0.96	**1.00**			
HI	-0.04	0.69	0.85	-0.62	0.29	0.58	0.79	**1.00**		
Str.Y	0.95	-0.51	0.75	0.57	0.99	0.95	0.82	0.29	**1.00**	
TKW	-0.28	0.84	0.70	-0.79	0.05	0.36	0.61	0.97	0.05	**1.00**

Where, HD= Heading Date; MD= Maturity Date; PH= Plant Height; SL= Spike Length; NET= Number of Effective Tiller; AGB= Aboveground Biomass; GY= Grain Yield; HI= Harvest Index; Str.Y= Straw Yield; TKW= Thousand Kerenel Weight

4.7. Economic Analysis

As farmers attempt to evaluate the economic benefits of shift in practice, partial budget analysis was done to identify the rewarding treatments. Yield from experimental plots was adjusted downward by 10% for management difference to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment. The partial budget analysis revealed that the highest net benefit of birr 123806.6 was obtained from NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha) with the highest marginal rate of return, 2765.948% (Table 13). However, the lowest net benefit of birr 68050.53 and non-acceptable MRR% was obtained from control plot. All the other treatment combinations except T2, T3, and T6 gave low net benefit with non-acceptable MRR%.

The identification of treatment recommendation is based on a change from one treatment to another if the marginal rate of return of that change is greater than the minimum rate of return. From the economic point of view, all the treatments which have a marginal rate of return are advantageous; however, it was apparent from the results that the most economically productive treatment combination for small scale farmers with higher benefit return was using NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha).

Table 14: Calculation of the percent marginal rate of return (MRR) for treatment combinations

Trt	Adj. GY kg/ha	Adj. SY kg/ha	Total GR	TVC	NB	MRR %
T1-Control (0-0-0)	2465.1	3784.41	100096.8	0	68050.53	
T2-NPSZnB (200kg /ha)	5021.01	5703.12	197865.7	4640	92982.1	537.3183
T3-NPSZnB (200kg/ha) + 100kg /ha Urea	3687.3	4271.4	145557	5933.333	126659.3	2603.904
T8-NPSZnB + vermiwash(1000ml/m^2) (twice at seedling and tillering)	4231.8	4799.97	166744.7	8640	82366.56	D
T6-NPSZnB (200kg/ha) + 1.6t /ha Compost + Urea (50kg/ha)	3309.3	4964.22	134027.5	9460	102271.3	2427.409
T5-NPSZnB (200kg/ha) + 2.7t /ha V/compost(BNE)	5191.56	5715.81	204043.6	11780	97069.15	D
T7-NPSZnB (200kg/ha) + 1.85t /ha v/compost + urea (50kg/ha)	4052.7	5212.35	161534.3	12746.67	123806.6	2765.948
T4-NPSZnB (200kg/ha) + 3.2t /ha Compost(BNE)	5033.7	5292.63	197091.1	16640	115013	D

Where, Trt=Treatment, GR = Gross return, GY=Grain yield, SY=Straw yield, TVC= Total Variable Cost, NB= Net benefit, MRR= Marginal Rate of Return

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

Wheat is an important food crop to Ethiopian people. However, its productivity is low due to soil fertility depletion. This may be caused as a result of removal of surface soil by erosion, crop removal of nutrients from the soil, total removal of plant residues from farmlands, low or absence of fertilizer use and lack of proper crop rotation program. Rational fertilizer promotions and recommendations, based on actual limiting nutrients for a given crop is not only revealed to supply adequate plant nutrients but also helped to understand the long-term ecological and economic benefits of the studied crop. Accordingly, all the studied blended and organic fertilizers effects on wheat yield and yield components showed that the blended and organic fertilizers would be promising to grow wheat in the study area, whereas wheat productivity for the previously existing recommended NPSZnB fertilizers in the country was low as compared to the blended and organic fertilizers; which indicated that wheat productivity in the study sites was reduced due to high demand for external nutrient inputs rather than NPSZnB fertilizers. The soil of the experimental field was clay in texture with a pH of 7.08 which was neutral in reaction. The CEC was very high. Experimental field had low organic carbon, optimum available P and very high Exchangeable K content. The experimental soil also had very low available S and low total N. Generally the result of the study showed that the soils of the study sites had very low available S, which indicated that potentially limited the yield of wheat crops. However, the soils of the study site had very high exchangeable K. Thus, additional application of S had response to increase the grain yield of wheat but, additional application of K had no response to increased grain yield of wheat crop particularly in the study area. The analysis of variance revealed that all the crop parameters were significantly affected by application of blended and organic fertilizer treatments except days to 50% maturity and days to 50% heading. The highest aboveground biomass yield (11930kg ha^{-1}) was recorded from T7, highest grain yield (5768kg ha^{-1}) and straw yield (6350.9 kg ha^{-1}) was recorded from the application of T7-200 kg/ha NPSZnB + vermicompost (1.85t/ha) + urea (50kg/ha). From an economic point of view, the use of T7 gave high net benefit with high marginal rate of return and economically feasible and recommended for wheat growers around Bishoftu area. Thus, it would be advisable for farmers in the study area to apply blended and organic fertilizer 200 kg/ha NPSZnB + 1.85t /ha v/c + urea (50kg/ha) for enhancing wheat grain yield. This same treatment also resulted in the most economical profitable grain and straw yield. Generally, the current experiment revealed that the recommended rate of the blended is not sufficient to increase wheat yield rather a supplement of organic fertilizer could increase wheat yield in the study area.

5.2. Recommendations

Based on the findings and conclusions of this study the following recommendations are given:

- Introducing soil management practices that can increase the availability of nutrients and reduce toxicity of other nutrients are important at Debrezeit Agricultural Research Center farming fields;
- Combined application of blended and organic fertilizers 200 kg/ha NPSZnB + 1.85t /ha v/c + urea (50kg/ha) can be the best alternative in both improving soil fertility and increasing the production in place of sole application of fertilizers at study area tentatively;
- Nevertheless, since the experiment was conducted for one season and at one location only, this research has to be replicated over season and location in order to give conclusive recommendation that can increase production of this improved wheat variety.

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7. APPENDIX

Appendix 1: Mean square value of ANOVA for soil physical properties

		Mean square values		
Source of Variation	DF	BD	TP	SMC
Rep	2	0.00001	0.1656	0.2284
Trt	7	0.01123^{**}	15.5935^{**}	10.7922^{**}
Error	14	0.00012	0.1731	0.3015
Total	23			
CV (%)		0.9	0.76	3.06

*Where, DF=Degree of freedom, Rep=Replication, Trt=Treatment, CV=Coefficient of Variance, BD=Bulk density, TP=Total porosity, SMC=Soil moisture content, NS=Non-significant, *, **, = Significant at 0.05 and 0.01.*

Appendix 2: Mean square value of ANOVA for soil chemical properties

		Mean square values						
Source of Variation	DF	pH	TN	Av.P.	OC	CEC	Av.S.	Ex.K.
Rep	2	0.00553	3.04E-04	1.79542	0.23405	3.00042	4.85638	0.00102
Trt	7	0.03206^{ns}	$1.851E\text{-}04^{ns}$	0.90095^{ns}	0.04362^{ns}	5.79042^{ns}	0.77049^{ns}	0.01990^{ns}
Error	14	0.01381	2.14E-04	0.63827	0.02379	5.19756	1.82193	0.02426
Total	23							
CV (%)		1.59	11.21	5.17	11.48	5.31	17.44	2.87

*Where, DF=Degree of freedom, Rep=Replication, Trt=Treatment, CV=Coefficient of Variance, pH=power of Hydrogen, TN=Total Nitrogen, av.P=available phosphorous, OC=Organic carbon, CEC= Cation exchange capacity, Av.S=Available Sulphur, Ex.K=Exchangeable Potassium, NS=Non-significant, *, **, = Significant at 0.05 and 0.01.*

Appendix 3: Mean square value of ANOVA for wheat agronomic Phonological and Growth parameters

Source of Variation	DF	Mean square values				
		50% DH	50% DPM	PH	SL	NET
Rep	2	3.29167	2.16667	7.1817	0.12167	0.03167
Trt	7	3.89881^{ns}	3.18452^{ns}	93.1102^{*}	0.53185^{*}	0.62452^{*}
Error	14	1.72024	2.02381	10.3817	0.15167	0.10595
Total	23					
CV (%)		2.32	1.41	3.39	7.95	12.02

*Where, DF=Degree of freedom, Rep=Replication, Trt=Treatment, CV=Coefficient of Variance, 50% DH= 50 Percent Days to Heading, 50% DPM=50 Percent Days of Physical Maturity, PH=Plant height, SL=Spike length, NET=Number of effective tiller, NS=Non-significant, *, **, = Significant at 0.05 and 0.01.*

Appendix 4: Mean square value of ANOVA for wheat agronomic Growth parameters

Source of Variation	DF	Mean square values				
		AGBY	TKW	GY	SY	HI
Rep	2	177512	5.7917	135630	175710	6.62E-04
Trt	7	8523741^{*}	27.9464^{*}	3384031^{*}	1682058^{*}	$6.208E\text{-}03^{*}$
Error	14	2131987	8.125	642882	543322	7.34E-04
Total	23					
CV (%)		14.46	6.03	17.5	13.35	6.05

*Where, DF=Degree of freedom, Rep=Replication, Trt=Treatment, CV=Coefficient of Variance, AGBY=Aboveground Biomass Yield, TKW=Thousand Kerenel Weight, GY=Grain yield, SY=Straw yield, HI=Harvest Index, NS=Non-significant, *, **, = Significant at 0.05 and 0.01.*