EFFECTS OF BLENDED NPS FERTILIZER RATES ON YIELD COMPONENTS AND YIELD OF BREAD WHEAT (*Triticum aestivum* L.) VARIETIES AT JARSO DISTRICT, EASTERN ETHIOPIA

MSc THESIS

ALIYI JEMAL MUME

DECEMBER 2020

HARAMAYA UNIVERSITY, HARAMAYA

Effects of Blended NPS Fertilizer Rates on Yield Components and Yield of Bread Wheat (*Triticum aestivum* L.) Varieties at Jarso District, Eastern Ethiopia

A Thesis Submitted to Postgraduate Program Directorate

(School of Plant Sciences)

HARAMAYA UNIVERSITY

In Partial Fulfillment of the Requirements for the Degree of

MASTER OF SCIENCE IN AGRICULTURE

(AGRONOMY)

Aliyi Jemal Mume

December 2020

Haramaya University, Haramaya

APPROVAL SHEET

HARAMAYA UNIVERSITY

POST GRADUATE PROGRAMME DIRECTORATE

We here by certify that we have read and evaluated this thesis entitled **"Effects of Blended NPS Fertilizer Rates on Yield Components and Yield of Bread Wheat** (*Triticum aestivum* **L.**) **Varieties at Jarso District, Eastern Ethiopia"** prepared under our guidance by **Aliyi Jemal Mume**. We recommended that the Thesis be submitted as it fulfills the requirements for the award of the degree of Master of Science.

Abdulatif Ahmad (PhD)	_____________	_______________
Major Advisor	Signatures	Date
Kiya Adare (Assistant professor)	_____________	_______________
Co-Advisor	Signatures	Date

As members of the Board of Examiners of the MSc Thesis Open Defense Examination, we certify that we have read and evaluated the Thesis prepared by Aliyi Jemal and examined the candidate. We recommend that the Thesis be accepted as it fulfills the Thesis requirements for the degree of Master of Science in Agriculture (Agronomy).

__________________________	_____________	_______________
Chairperson	Signature	Date
__________________________	_____________	_______________
Internal Examiner	Signature	Date
__________________________	_____________	_______________
External Examiner	Signature	Date

Final approval and acceptance of the Thesis is contingent upon submission of the final copy to the Council of Graduate Studies (CGS) through the Graduate committee (SGC) of the School of Plant Sciences.

DEDICATION

This thesis is dedicated to my wife Naima Hamid for her special care and provided me, unconditional support, love, patience and encouragement throughout my life.

STATEMENT OF THE AUTHOR

By my signature below, I declare that this Thesis is a result of my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of this Thesis. Any scholarly matter that is included in the Thesis has been given recognition through citation.

This Thesis is submitted in partial fulfillment of the requirements for a Master of Science degree in Agriculture (Agronomy) at Haramaya University. The thesis is deposited in Haramaya University Library and is made available to borrowers under the rules of the Library. I solemnly declare that this Thesis has not been submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Brief quotations from this Thesis may be made without special permission provided that accurate and complete acknowledgement of the source is made. Requests for permission for extended quotations from or reproduction of the Thesis in whole or in part may be granted by the Head of the School or Department when in his or her judgment the proposed use of the material is the interest of scholarship. In all other instances, however, permission must be obtained from the author.

Name: Aliyi Jemal Mume Signature: ____________

Date of submission: __________

School: School of Plant Sciences

BIOGRAPHICAL SKETCH

The author was born in 1990 at Meda Jalela kebele, Deder district, Eastern Hararghe Zone Oromia region, Ethiopia to his father Jemal Mume and his mother Nuriya Dawe. He attended his Primary education at Abera Gizaw from 1995 to 2001 (1-8). From 2002 to 2003 at Deder secondary school. After successfully passed the Ethiopian General Secondary Education Certificate Examination (EGSECE), he joined Chiro ATVET College in 2004 and graduated with Diploma in Plant Sciences in June 2006.

After graduation, he was employed as an Extension Agent to East Hararghe Zone, Jarso District Agricultural and Natural Resource Office in September 2007. He joined in Regular program to Haramaya University from 2011 to 2013 and he graduated with Bachelor of Science (BSc) degree in Plant Science in June 2013. After graduation, he was employed as an agronomist in Eastern Hararghe Zone, Jarso District Agriculture and Natural Resource Office in September 2014 and worked until he joined Haramaya University, Post Graduate Program Directorate in October 2018 to pursue study leading to Master of Science Degree in the field of Agronomy.

ACKNOWLEDGMENTS

I express my heart-felt thanks to Almighty Allah (God), who gave great encouragement and allowed me to complete this study.

I wish to express my sincere thanks and appreciation to my major advisor Abdulatif Ahmad (PhD) for his critical comments, supervision, support, attentive guidance and directing, encouragement, his fatherly advised from proposal preparation to the final write-up of thesis, additionally by arranging inputs for the research study. My special thanks also to co-advisor Kiya Adare (assistant Professor) for his guidance, constructive comments, suggestions, encouragement, and facilitating me to work during the study.

My sincere thanks to Haramaya University for their financial support that I need for conducting the research and writing this thesis and for giving me this chance to pursue my MSc study just after graduation with BSc degree. My sincere thanks also go to Mr. Abadir Siraj (Head of Jarso Agriculture and Natural Resource office), as well as Abdi Mohammede and Tofik Abdureman' Afugug Kebele Agriculture and Natural Resource office for their notable support during the research from arranging the farmer training center to facilitating works, materials, follow up and field management.

I would also like to thanks Jarso Woreda Agriculture and Natural Resource Office for giving me the opportunity of study. Finally, yet importantly, I render thanks to all staff members of our office and for those who assisted me during entire process from the research proposal development up to the write up of the thesis.

LIST OF ACRONYMS AND ABBREVIATIONS

CEC	Cation Exchange Capacity
CIMMYT	International Center For Wheat And Maize Improvement
CSA	Central Statistical Agency
EthioSIS	Ethiopian Soil Information System
FAO	Food And Agriculture Organization
KARC	Kulumsa Agricultural Research Center
MoA	Ministry of Agriculture
MRR	Marginal Rate of Return
NPS	Nitrogen, Phosphorous, Sulphur
RCBD	Randomized Complete Block Design
SARC	Sinana Agricultural Research Center

TABLE OF CONTENTS

TABLE OF CONTENTS (Continue...)

LIST OF TABLES

LIST OF TABLES IN THE APPENDIX

Effects of Blended NPS Fertilizer Rates on Yield Components and Yield of Bread Wheat (*Triticum aestivum* L.) varieties at Jarso District, Eastern Ethiopia

ABSTRACT

Use of inappropriate fertilizer type and rate, cultivation of unimproved low yielding varieties and low soil fertility are among the major constraints limiting the productivity of wheat in Ethiopia in general and in particular to the study area. Thus, field experiment was initiated to evaluate the effects of blended NPS fertilizer rates on yield components and yield of bread wheat varieties and to identify economically feasible rates of blended NPS fertilizer in the study area. The experiment was laid out in RCBD with three replications in which three bread wheat varieties (Ogolcho, Jalane and Sanate) and five levels of blended NPS fertilizer (0, 50, 100, 150 and 200 kg ha^{-1}) in a factorial combination were evaluated. The results showed that all characters of the bread wheat varieties were significantly affected ($p<0.01$) by main effect of variety and blended NPS fertilizer. The highest (8.67cm) and the lowest (6.62cm) spike length, (64.56) and (44.56) kernels per spike were obtained from plots received 200 kg NPS ha^{-1} and from control, respectively. While, the highest (0.43) and the lowest (0.36) harvest index was obtained from 150 kg ha^{-1} NPS. The two main factors interaction affect only number of total tillers, number of productive tillers, above ground biomass, grain and straw yield. The highest (379.6) and the lowest(128.1) productive tillers was recorded from the combined application rate of 150 and 0 kg ha^{-1} NPS fertilizer with Sanate and Jalane varieties, respectively. Whereas, the highest (6424 kg ha^{-1}) and the lowest (2701 kg ha^{-1}) grain yield was recorded from the combined application rate of 200 and 0 kg NPS ha^{-1} fertilizer with Sanate and Jalane varieties, respectively. The partial budget analysis indicated that the highest net benefit of 82710 ETB ha^{-1} with a marginal rate of return 2305.8% obtained by planting of Sanate variety with the application of blended NPS fertilizer at a rate of 150 kg ha^{-1}. Based on the result of this study, it can be concluded that the application of 150 kg ha^{-1} NPS and the growing of Sanate variety could be better choice of the farmers of the study area to obtain high yield with higher rate of return. However, since the experiment was conducted for one season at one location, it is suggested that the experiment has to be repeated over seasons and locations using this and other improved bread wheat varieties in order to give a comprehensive recommendation.

Key words: Blended fertilizer, Economic analysis, Grain yield, Variety, Yield attributes.

1. INTRODUCTION

Wheat is a self-pollinating annual plant belongs to the true grass family poaceae and the tribe Hordeae (Mollasadeghi and Shahryari, 2011) . It is one of the three cereals which is the most cultivated in the world and dedicated itself about one third of the world's arable land (Emam, 2007). It ranks first in the world cereal crops accounting 30% of all cereal food worldwide and is a staple food for over 7.6 billion people in as many as 43 countries of the world (Reddy, 2004).

Wheat is an important cereal crop in Ethiopia, which is cultivated in a wide range of altitudes (Hailu, 1991). Wheat can grow in the Ethiopian highlands, which are situated between 6^o and 16^o N and 35^o and 42^o E, at altitude ranging from 1500 to 3000 m.a.s.l. However, the most suitable altitude zones of wheat fall between 1900–2700 m.a.s.l (Bekele *et al.*, 2000). Wheat is used in different forms such as bread, porridge, soup and roasted grain, and the straw of wheat is used for animal feed, hatching roofs and bed decking (Amare *et al.,* 2015). The two types of wheat are grown in Ethiopia; bread wheat and durum wheat. The bread wheat production covered 15% in 1967 and 40% in 1991, but currently, it covers about 60% of the total wheat area, while durum wheat covers about 40% (Eyob *et al.,* 2015).

Data from the Central Statistics Agency (CSA) in Ethiopia indicated that the observed increase in wheat production over the last ten years was attributed both to expansion of production area and adoption of improved technologies. For example, between 1995 and 2017 wheat production area increased from 0.8 million ha to 1.69 million ha, and yield increased from 1.20 t ha^{-1} to 2.68 t ha^{-1}, respectively (CSA, 2017). However, the large increment of wheat in area and production is below the world's average which is about 3 t ha^{-1}. It is cultivated on about 1.69 million hectares and contributing about 4.54 million tons of grain yields, accounting for 13.49 percent of total grain output in the country in 2016/2017 *meher* cropping season which makes Ethiopia the second wheat producer in sub Saharan Africa next to South Africa (CSA, 2017).

Oromia region is the major wheat producer in Ethiopia with 2.5 million tons from the production area of 872,252.80 hectares (CSA, 2016). In East and West Hararghe, the total area under wheat production was 18289.94 ha and 4143.26 ha, respectively. The zonal average yield of wheat is 2.1 t ha^{-1} for East Hararghe and 1.9 t ha^{-1} for West Hararghe Zone, which is less than the national average of 2.5 t ha^{-1} (CSA, 2016/17). The national average yield for wheat is 2.5 tons ha^{-1} which is lower than the world average yield (3.19 tons ha^{-1}) (FAOSTAT, 2013).

The yield gap between the country and other world might be attributed by many factors both biotic and a biotic factor such as disease and pests , poor management practices, poor soil fertility and moisture stress (MOA, 2012) that hinders the potential production of the crop. Low soil fertility and, cultivation of unimproved low yielding varieties, use of inappropriate fertilizer type and rate, inadequate level of technology generation and adoption are the most significant constraints limiting wheat production in Ethiopia and including study area. Thus, addition of nutrients such N, P and S, and developing wheat cultivar with durable resistance to diseases, insect and stress of moisture and drought is important to increase yield and yield components of wheat, be it for consumption or industrial purpose. Among the several factors responsible for low yield in Ethiopia, the use of unbalanced rate of fertilizers is important agronomic practices, so research on these limiting factors will surely lead to high yields of wheat crop.

Nitrogen is the major nutrient affecting wheat yield and quality. Yields of cereals have been reported as being roughly proportional to amount of N applied (Greenwood, 1981). Increased yield of wheat occurs on all soils with increased rate of N application, but such increases are reported more frequently on heavy clay soils. Several reports have also indicated that increased usage of N fertilizer is considered as a primary means of increasing the productivity of wheat grain in Ethiopia (Asnakew *et al*., 1991; Tanner *et al*., 1993; Amsal *et al*., 2000). Nitrogen is considered as the most deficient nutrients in soils of Ethiopia (Asnakew *et al*., 1991; Wakene *et al*., 2014). Increasing N fertilizer greatly affected grain yield and quality of wheat such as protein content, wet gluten and zeleny values (Dawit *et al*., 2015).

Phosphorus is the second most limiting nutrient for crop production next to nitrogen and soils are also low in available phosphorus (Asnakew *et al*., 1991; Schulthesis *et al*., 1997; Wakene *et al*., 2014). Plants deficient in phosphorus are stunted and in contrast to those lacking nitrogen, are often dark green. Deficiency of P in wheat caused reduced tillering, reduced leaf area and increased susceptibility to number of diseases. Besides, maturity is often delayed in P deficient plants as compared to plants receiving abundant phosphate (Marschner, 1995).

Sulfur (S) 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 phosphorus (Ali *et al*., 2008). The deficiency of sulfur 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). Wheat requires a relatively high amount of supplemental S due to incompatibility of conditions with its period of most rapid growth, when the rate of S release from soil organic matter is quite slow (Johnson, 1999). Its fertilization enhances the uptake of N, P, K and Zn in the plant.

According to Ethio-SIS (2014) in addition to N and P reported that the deficiency of K, S, Zn, B and Cu in major Ethiopian soils, S particularly in the study area studied was found to be low. In general the farmers in most parts of the country and in particular Jarso district have limited information on impact of different types and rates of blended fertilizers except (100 kg urea and 100 kg DAP ha^{-1}), effect of blended NPS fertilizers on yield components and yield of wheat unknown even though currently being used by the farmers in study area. Improved wheat Varieties are one of the factors which play an important role in producing higher yield of wheat **(**Dercon *et.al*., 2009; Byerlee *et al*., 2007). Moreover, the response of wheat plant to application of fertilizer varies with varieties, rainfall, soils, agronomic practices, expected yield. Thus, there is a need to conduct location specific recommendation on the fertilizer rates for major varieties to increase the productivity of bread wheat. Therefore, this study is initiated with the following objectives:

- to evaluate the effects of blended NPS fertilizer rates on yield and yield components of bread wheat varieties; and
- to identify economically feasible rate (s) of blended NPS fertilizer in the study area

2. LITERATURE REVIEW

2.1. Adaptation and distribution of Wheat

Wheat is a self-pollinating annual plant that belongs to the genus *Triticum* and the true grass family *poaceae* and the tribe Hordeae that grown as staple food sources in the world (Mollasadeghi and Shahryari, 2011). It is one of the most important cereal crops globally which is **c**ultivated worldwide and one of the first crops to be domesticated 10,000 years ago and is the main food for about one third of the world's population (Hussain *et al*., 2002). It is exclusively produced under rain fed conditions (long and short rainy seasons), respectively. The species of Triticum and their close relatives can be divided into diploid, tetraploid (T. turgidum sub sp. Durum) and hexaploid bread wheat (Triticum aestivum L) groups, with chromosome numbers of 2n = 14, 28 and 42, respectively, in which the basic chromosome number of wheat is x = 7 (Abu, 2012).

In Ethiopia, the crop is grown at an altitude ranging from 1500 to 3000 meters above sea level (masl), between 6-16° N latitude and 35-42° E longitude. The most suitable ecological zones, however, fall between 1900 and 2700m a.s.l (Bekele *et al*., 2000). Wheat in Ethiopia is produced from 1600-3200 masl. However, wheat is best grown from 1800-2800 m a.s.l with average temperature of 15-25° C. On the average, rainfall of 400-2000 mm is required. The distribution of rainfall throughout the crop growth period is very important. Wheat can be produced on different soil types such as black clay soils, red and brown soils. Sandy soils and soils with problems of water logging are unsuitable for wheat production. Suitable soil pH for wheat ranges from 5.5-8.0 (MoA, 2012).

2.2. Production and Importance of Wheat in Ethiopia

Wheat is one of the most important among all cereals cultivated in Ethiopia. Ethiopia is the second largest producer of wheat in sub-Saharan Africa following South Africa and about 1.69 million hectare of land is cultivated in 2016/2017 cropping season for both bread and durum wheat production (CSA, 2017). In area of production, wheat ranks 4th after *teff*, maize, and sorghum and 3rd in total grain production after maize and teff and 2nd in yield to maize. It is cultivated by 4.846 million farmers and accounts for more than

15.63% of the total cereal production and 4.54 million tons of wheat was produced on an area of 1.69 million ha in 2016/2017 cropping season (CSA, 2017).

Despite the large area under wheat, the national average yield in Ethiopia is about 2.68 t ha^{-1} (CSA, 2017). This is completely below the world's average wheat is about 3 t ha^{-1}. However, Data from the Central Statistics Agency (CSA) in Ethiopia indicated that the observed increase in wheat production over the last ten years was attributed both to expansion of production area and adoption of improved technologies. For example, between 1995 and 2017 wheat production area increased from 0.8 million ha to 1.69 million ha, and yield increased from 1.20 t ha^{-1} to 2.68 t ha^{-1}, respectively (CSA, 2017).

Oromia region is the major wheat producer in Ethiopia with 2.5 million tons from the production area of 872,252.80 hectares (CSA, 2016/2017). Bread wheat is mainly grown in eastern Ethiopia. Hararghe highlands are considered to be suitable for wheat cultivation. Type of varieties grown in the Hararghe highlands and midlands including *Jarso* disrrict are include *Kubsa* (HAR1685), *Hidase* (HAR710), HAR1522, ET13, ET30, *Pavon76* and various local genotypes specially *Adulal* (East Hararghe Rural Development and agricultural office, 2009 and 2010). These varieties are old and susceptible to rust disease. However, to day in the study area bread wheat varieties including *Ogolcho*, *Sanate* and *Jalane* are selected based on their adaptability to aggro ecological conditions and resistance to disease such as stem rust and yellow rust (MOALR, Crop variety register, 2017). In East and West Hararghe, the total area under wheat production was 18289.94 ha and 4143.26 ha, respectively (CSA, 2016). The zonal average yield of wheat is 2.1 tons ha^{-1} East Hararghe and 1.9 tons ha^{-1} for West Hararghe Zone, which is less than the national average of 2.5 tons ha^{-1} (CSA, 2016).

The crop is produced almost in all highland parts of the country with the major wheat belt areas of Arsi and Bale areas of Oromia region; other areas of wheat production include Shoa, Gojam and Gonder areas of the country; with minor production found almost in all parts of the highlands (Hailu *et al*., 1991). Wheat is one of the important cereal crops in the world and it has the widest distribution among cereal crops. Substantial amount of wheat is produced in tropical and subtropical environments, although the crop is more produced cereal in the temperate regions. Nutritionally, wheat provides an optimum amount of energy (339 k cal of energy), protein (10.3g of protein), calcium (49 mg of calcium) and iron (1.5 mg of iron) per 100 g grain. Wheat is the most widely grown crop in the world with its unique protein characteristics that serves as an important source of food and energy (Cooke and Law, 1998). Mature wheat grains contain 8–20% protein, which are divided into two major categories: prolamins including gliadins and glutenins and non-prolamins consisting of water-soluble albumins and salt-soluble globulin s (Singh and Skerritt, 2001).

Wheat produced in Ethiopia is used mainly for domestic food consumption, seed and industrial use. For instance, in 2012/13 the household consumption accounted for 58 percent of the total wheat produced. Seed and sales accounted for about 19 percent each, and the remainder is used for animal feed and as in kind payments for labor. Ethiopia imports a large quantity of wheat grain compared to other crops. Approximately 1.74 million tons of wheat is imported annually and consumption is increasing much faster than production due to the increasing rate of the population growth (World Fact Book, 2012). Annual wheat consumption in Ethiopia reached 4.2 million metric tons in 2012/13 from two million metric tons in 1995/96 (USDA, 2013). Wheat consumption growth is higher in urban areas due to higher population growth, changes in life style, and the rising prices for *teff*. In Ethiopia, bread wheat is used for different purpose. Its grain is used to prepare a variety of local food such as *Dabo, Dabokolo, Enjera, Kolo, Genfo, Nifro, Tela* etc. In addition to this the straw of wheat is used for animal feed and for hatching of house (Mathewos *et al*., 2012).

2.3. Constraints of Wheat Production in Ethiopia

Despite the fact that wheat is among the cereal crops widely grown in Ethiopia, the yields have been consistently well below African and World average yields, indicating low productivity of the crop. Recent estimates (CSA, 2017) showed that wheat farmers in Ethiopia produce on average 2.53 t ha^{-1}, which is far from the experimental yield of about 5 t ha^{-1} (MOA, 2012). Wheat is one of Ethiopian main staple crops in terms of both production and consumption. For caloric intake, it is the second most important food in the country behind maize. The yield has consistently lagged behind Africa's and world average yields. In 2012, for instance, Ethiopia's wheat yield was 29 percent Kenyan average, 13 percent below the African average, and 32 percent below the world average yield. There is considerable variation in average wheat yields across regions and zones.

For instance, the average wheat yield in some zones of SNPP (Hadiya and Siltie), and Oromia (Arsi and Bale) where farm sizes are relatively large, and better ranged between 2.8 and 3 t/ha^{-1} than average yield (ranging from 1.7 to 2.2 t/ha^{-1}) report from the most parts of the Tigray and Amhara regions respectively (CSA, 2016).

The relatively low may be partially attributed to several socioeconomic, abiotic and biotic constraints such as poor agronomic practices, low or erratic rainfall, the low level of adoption of improved varieties and improved management techniques like low level of fertilizer usage, plant diseases, weed infestation are major limiting factors in wheat production in Ethiopia**.** In a 2012 national estimate on input, use indicates that only 8.4 percent were planted with improved seed and 48 percent of wheat areas were fertilized (Spielman *et al*., 2011; MOA, 2012). Only about 1 percent wheat areas were cultivated using improved seed-fertilizer package. Fertilizer application rates on fertilized lands are estimated below the average recommended rates although blanket recommendation is common in farmers, only about 39.27 percent of the wheat area was cultivated using improved management and packages (CSA, 2016),which is unfortunate given the high production response for combined use of improved seed and fertilizers in Ethiopia.

The Ministry of Agriculture in the year 2009 has indicated the national recommendation of Urea and DAP (Di-ammonium Phosphate) were 100 kg ha^{-1}, that farmers in most parts of Ethiopia including eastern Ethiopia are using for bread wheat grain production without considering the differences of soil types and fertility status. Similar to other parts of the country, the farmers in eastern Ethiopia are using either the national recommendation rates or different rates of Urea and DAP fertilizers on different bread wheat varieties or local cultivars for grain production (Endale, 2010). But, this fertilizer contain only nitrogen and phosphorus that may not satisfy the nutrient requirements of crops, as a result yield of crop in the country is low. To overcome this Ministry of Agriculture of Ethiopia has been recently introduced a new compound fertilizer (NPS) containing nitrogen, phosphorous and sulfur with the ratio of 19% N, 38% P_2O_5 and 7% S as main source (MoANR, 2013).

The fertilizer used from 1960_s until now is nitrogen and phosphorus fertilizer only irrespective of soil type and fertility status. Nutrient mining due to sub optimal fertilizer use in one hand and Unbalanced fertilizer uses on other hand have favoured the emergence of multi nutrient deficiency in Ethiopian soils (Wassie *et al*., 2011); that in part may contributed to fertilizer factor productivity decline experienced over recent past. The national soil inventory data also revealed that in addition to nitrogen and phosphorus, sulphur, boron and zinc deficiencies are widespread in Ethiopian soils, while some soils are also deficient in potassium, copper, manganese and iron (EthioSIS, 2013/14), which all potentially hold back crop productivity despite continued use of N and P fertilizers as per the blanket recommendation. Improved wheat Varieties are one of the factors which play an important role in producing higher yield of wheat ((Dercon *et al*., 2009; Byerlee *et al*., 2007)). Moreover, the response of wheat plant to application of fertilizer varies with varieties, rainfall, soils, agronomic practices, expected yield. Thus, there is a need to conduct location specific recommendation on the fertilizer rates for major varieties to increase the productivity of bread wheat.

Most Ethiopian soils are deficit in nutrients, especially nitrogen and phosphorus and fertilizer application has significantly increased yields of crops (Tekalign *et al*., 2001). The causes for severe deficiency of most of the major nutrients (nitrogen and phosphorus) in Ethiopian highlands and midlands are the huge loss of soil from agricultural land, which is estimated to be 137 t ha^{-1} per year; approximately an annual loss of 10 mm soil depth (Zeleke *et al*., 2010). Fertilizers, particularly those containing nitrogen and phosphorus, are the major input affecting wheat yield and quality.

As in many other tropical and sub- tropical regions, soils in the high lands of Ethiopia, usually have low levels of essential plant nutrients and organic matter content, specially low availability of N and P has been demonstrated to be a major constraint to wheat production in Ethiopia. This is largely a consequence of the cereal dominated mono-cropping system resulting with the continuous nutrient mining through removal by plants and no consideration for the replenishment through application of either mineral or organic fertilizer sources (Amsal *et al.,* 2000). Apart from the development of high yielding varieties and their use the use of appropriate agronomic practices in wheat production is indispensable for high and sustainable yield.

2.4. Effects of varieties on yield components and yield

Varieties are one of the factors which play an important role in producing higher yield of wheat (Alam and Jahan, 2013). Studies on Assessment of Prevalence and Severity of Wheat rusts in wheat growing areas of Eastern Hararghe and efforts in managing these disease showed that in Jarso District during year 2014 main cropping season varieties of bread wheat Digalu, Danda'a, Mada walabu, Shorima and local were tested using Fertilizer rate of 150 kg ha^{-1} for DAP and 100 kg ha^{-1} urea uniformly to all plots. Urea was applied with DAP all at sowing and Urea half at sowing and half at stem elongation stage respectively. The highest grain yield of 74.33 qt ha^{-1} was record by Digalu followed by Danda'a (71.94 qt ha-1) then Madawelabu (65.02 qt ha-1). The least grain yield (48.38qt ha-1) was recorded by local variety (Samuel *et al;* 2014). However, these varieties are today old and susceptible to disease. Now a day three varieties of bread wheat Ogolcho, Sanate and Jalane are selected based on their adaptability to agro ecological conditions and rut disease resistance such as stem rust and yellow rust. Wise use of fertilizers increase crop yield and production; the reverse will lead to decline in production and ecological imbalance. Efficient use of fertilizers depends on performances of variety. So that cultivar selection plays a very important role in determining grain yield (Brian *et al*., 2007)

2.5. Effect of N Fertilizer on Yield and Yield Components

Nitrogen is the major nutrients affecting wheat yield and quality. Yields of cereals have been reported as being roughly proportional to amount of N applied (Amsal *et al*., 2000). Increased yield of wheat occurs on all soils with increased N rate, but such increases are reported more frequently on heavy clay soils and have also indicated that increased usage of N fertilizer is considered a primary means of increasing wheat grain yield in Ethiopia (Asnakew *et al.,* 1991). It is involved in all major processes of plant development and yield formation. Besides, a good supply of nitrogen to the plant stimulates root growth and development as well as uptake of other nutrients (Brady and Weil, 2002).

Nitrogen is important in determining the final grain yield of wheat during the rapid phase of crop development because it is required for high rates of spikelet initiation, improvement of spikelet fertility, and increasing grains per fertile spikelet and for biomass formation, higher correlation existed between grain yields and the concentration of nitrogen in plants at tillering, jointing and dough stages and they indicated that the amount in plant at jointing gave the best estimate of the grain. Increasing levels of nitrogen under different soils and management conditions increase grain and dry matter yields, number of kernels per head and plant height of wheat (Amsal *et al.,* 2000).

When plants are deficient in N, they become stunted and yellow in appearance. Nitrogen deficiency in cereals is characterized by poor tillering and the number of ears per unit area and also the number of grains per ear are reduced (Mengel and Kirkby, 1996). The grains are small, but often relatively high in protein content, due to a decrease in the import of carbohydrate into grains during the later stages of the grain filling (Mengel and Kirkby, 1996). Several researchers in Ethiopia have reported the role of N in wheat production in the highlands as substantial changes in yield and yield components have been effected with the application of N fertilizer (Amanuel *et al*., 2000; Tilahun *et al*., 2000). The total wheat N up take increased with increasing N 0 to 200 kg N/ha application (Damene, 2003).

Nitrogen application affects the number of seedlings and spikes m^{-2} where the number of plants per meter square was found to increase from the control level of nitrogen to 200kg ha^{-1}. A maximum number of plants per meter square (351.4) were recorded when the N dose was 200 kg ha^{-1} whereas the minimum number of plants per meter square (189.8) was recorded in the control treatment. Similarly, Hussain and Shah (2002) reported that increasing nitrogen application increased the number of productive tillers per unit area. Tilahun *et al*. (2008) found that fertilized plots produced more spikes than the control and adequate nitrogen availability, which might facilitate the tillering ability of the plants, resulting in a greater spike population.

Ali *et al.* (2005) reported significance influence of N fertilizer rates on wheat tiller production. In which N application at the highest rate of 210 kg ha^{-1} produced the highest number of productive tillers (584.31 m^{-2}), which was significantly higher than the number of tillers at the lower nitrogen rates (0, 70 and 140 kg N ha^{-1}). With each increment of the nitrogen, application number of productive/effective tillers increased significantly. They attributed that the increase in number, might occur due to a better response of cultivars to nitrogen application at tillering stage. Similarly, Akram (2000) reported an increase in the number of tillers per plant of wheat because of an increased amount of nitrogen to the soil. Plant height is another parameter that reveals the overall vegetative growth of the crop in response to various management practices (Ali *et al*., 2005). Application of different levels of nitrogen significantly increased the plant height at maturity.

Iqtidar *et al*. (2006) found that increased N application (0 to 200 kg N ha^{-1}) resulted in significantly higher numbers of grains per spike as compared to the control treatment. A maximum number of grains per spike (59.1) were produced when the nitrogen rate was 200 kg ha^{-1}. Iqtidar *et al*. (2006) reported that a number of spikelets per spike and grains per spike depend on florets initiation which is affected by varying N supply at different stages of development. Grain yield per spike was more dependent on the number of productive/effective spikelets per spike and the number of grains per productive spikelets.

Biomass yield is reflected by growth parameters like a total number of plants, tillers per unit area and final plant height (Ali *et al*., 2005). Iqtidar *et al*. (2006) obtained that biological yield increased as the amount of N applied was increased from the control level to 200 kg ha^{-1}. Maximum biological yield (9.6 t ha^{-1}) was recorded at 200 kg N ha^{-1}, which was not significantly different from the recommended dose of nitrogen (100 kg ha^{-1}). The same author indicated that increasing rates of N application increased biological yield in which maximum yield was obtained in plots treated with highest N rate (200 kg ha^{-1}). His reports also indicated N application at the rates of 70, 140 and 210 kg ha^{-1} resulted in significantly higher straw yield than the yields observed under zero N rates.

Khursheed and Mahammad, (2015); Solomon and Anjulo (2017) reported a beneficial effect of N application on wheat. They reported that plant height, numbers of tillers, spike length, number of spikelet's and grains per spike, grain and straw yields of wheat increased with increasing N to the optimum level. Bereket *et al*., (2014) reported that higher application of nitrogen fertilizer significantly increases the seed yield of bread wheat. The level of N fertilization is very important which strongly affects the yield as well as the physical properties of the wheat grain. Solomon and Anjulo, (2017) indicated that N could be an important limiting factor for wheat yield by contributing to the determination of grain number through the development of the spikes. Yield and yield components of high yielding varieties generally increase by increasing level of N fertilization (Behera *et al*., 2000). However, when N fertilizer applied at rates greater than required for maximum yields plant nitrogen use efficiency decreases.

2.6. Effect of Phosphorus on Yield Components and Yield of wheat

The high yield potential of modern wheat cultivars required high supplying phosphorus fertilizer (Clark, 1990) as phosphorus plays a vital role in the storage and transfer of energy within the cells, speeds up root development, and higher grain protein content. Phosphorus 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).

Phosphorus deficiency is a common soil problem in the area having a calcareous nature. It is, therefore, imperative to manage it properly to achieve maximum benefits (Malik *et al*.,1992). However, more than 80% of added P to such soil will be fixed, and only a part of it get dissolved in the soil solution which may be either taken up by plants or precipitates (Leytem and Mikkelsen, 2005). Plants deficient in phosphorus are stunted and in contrast to those lacking nitrogen, are often dark green. Deficiency of P in wheat caused reduced tillering, reduced leaf area and increased susceptibility to number of diseases. Besides,maturity is often delayed in P deficient plants as compared to plants containing abundant phosphate (Marschner, 1995). Minimum number of tillers was due to the deficiency of P that directly altered the normal pattern of tiller emergence by inhibiting the emergence of leaves on the main stem and reducing the rate of tiller emergence (Daniel *et al*., 1998).

There are several reports that signify the role of P application in the enhancement of yield and yield components of wheat. Improvement in total number of tillers with P application might be due to the role of P in emerging radical and seminal roots during seedling establishment in wheat, by increased P application (Daniel *et al.,* 1998). Endalkachew (2006) who 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_2O_5 increased up to 69 kg ha^{-1}.

The research conducted at varies locations in northwestern Ethiopia showed that the highest biological and grain yield produced by the application of the highest P fertilizer rate of 92 kg P_2O_5 ha^{-1} and 184 kg N ha^{-1} (Minale *et al.*,2006). Baraich *et al.* (2012) conducted that application of 90 kg ha^{-1} P fertilizer resulted in maximum values for plant height (84.05 cm), number of tillers (6.36 $plant^{-1}$), spike length (10.85 cm), number of grains (66.33 $spike^{-1}$), seed weight (48.38 g) and grain yield (4504.33 kg ha^{-1}). While analyzing the increase percent in growth and grain yield components in treated plots over control, it was observed that 90 kg P ha^{-1} treatment resulted in an increase of 103.11% in plant height, 97.51% in tillers $plant^{-1}$, 90.01% in spike length, 84.04% in number of grains $spike^{-1}$, 92.82 % in seed index and 115.89% in grain yield ha^{-1} over control. Damene (2003) reported that an increase in the number of spikes was significantly higher due to the application of 40 kg P ha^{-1} than that recorded the application of 20 and 10 kg P ha^{-1} and the control, while no significant differences were observed between 30 and 40 kg P ha^{-1}. Kaleem *et.al*. (2009) who recorded maximum yield of 3557 kg ha^{-1} by the application of 128-128kg ha^{-1} (NP) ratio 1:1 which was indicating importance of phosphorus at its highest dose in achieving maximum wheat productivity.

2.7. Effect of Sulfur Fertilizer on Yield Components and Yield

Sulfur (S) 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 phosphorus(Ali *et al.*, 2008). It is a building block of protein and a key ingredient in the formation of chlorophyll. Without adequate S, crops cannot reach their full potential in terms of yield or protein content. 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 deficiency also decreases grain size and baking quality because of formation of disulfide bonds formed from the sulphydryl groups of cysteine. This affects the visco elasticity of dough. Its fertilization helps enhancing the uptake of N, P, K and Zn in the plant. Due to its synergistic effect, the efficiency of these elements 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). Wheat requires a relatively high amount of supplemental S due to incompatibility of conditions with its period of most rapid growth, when the rate of S release from soil organic matter is quite slow (Johnson, 1999).

Shivran and Yadav (2013) conducted an experiment to study the effect of NP fertilizers, and sulphur on growth, yield attributes, yield and quality of cluster bean and residual effect of NP fertilizers, and sulphur on grain yield of succeeding wheat. The successive increase in sulphur up to 40 kg S ha^{-1} recorded significantly higher seed and straw yields of cluster bean. Saeed *et al.* (2012) conducted an experiment to estimate the effects of sulfur and nitrogen application both as soil as well as foliar fertilization on growth factors and straw yield of wheat cultivars. They stated that the soil and foliar application of nitrogen at 100-120 kg N ha^{-1}and sulfur 20-35 kg ha^{-1} in split doses at various growth stages could be practiced to get appreciable growth and yield of the wheat crop. Tazeh *et al*. (2012) stated that application of compost and sulphur might reduce soil pH, increase phosphorous, and some micro nutrient availability in soil. The increasing of sulfur content up to 100 kg ha^{-1} caused a significant increase in wheat root and shoot growth as well as nutrient uptake.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The experiment was conducted at Afugug kebele (FTC), Jarso district, Eastern Hararghe Zone during main rainy seasons from July 20 up to December 5 of 2019. Jarso district is one of the many districts found in Oromia National Regional State, which is located in eastern part of the Country. It is located at a distance of 561 km eastwards from Addis Ababa and 36 km from the zonal capital, Harar city. Jarso woreda is found at latitude of 55°.36'31" N and longitude of 38°58'91"E at an altitude of 1050-3030m a s l. The district is bordered by the Harari regional state to the south, Kombolcha district to the west, Dire Dawa to the north, and Gursum district to the east. The administrative center of this district is Ejersa Goro. Afugug kebele is just on the South side of the main road to Chenaksen.

The climatic condition of the district is a humid moisture condition, with a relatively shorter growing season. The area receives annual rainfall of 650-950 mm with a bi modal pattern extending from April to November. The mean annual minimum and maximum temperature is 18°C, and 30°C, respectively. As far as the aggro-ecology of the area is concerned, Highland, mid highland and lowland account for 28%, 55% and 17% of the district, respectively. Afugug kebele is found 2 km from Ejersa Goro, and found at a latitude of 09°29, 781' N and longitude of 042°14.867' E at an altitude of (2340 m above sea level) (JWOA, 2019).

3.2. Experimental Materials

The three bread wheat varieties, namely; *Ogolcho, Jalane* and *Sanate* were used for the experiment. The seeds of the varieties were obtained from Haramaya University wheat improvement programme.

Table 1. Descriptions of the bread wheat varieties

No	Varieties	Year of release	Sources of Varieties Institution	Adaptation Zone		Maturity (days)	Yield under research site (t ha^{-1})
				Altitude (masl)	Rain fall (mm)		
1	*Ogolcho*	2012	KARC/EIAR	1500-2100	500-800	102	3.3-5.0
2	*Sanate*	2014	SARC/ OIA R/	2300-2600	750-1500	109-117	3.4-6.7
3	*Jalane*	2017	HU	1790-2200	>650	141	2.7-3.2

Source: MOANR, Crop variety register, 2016; MOANR, Crop variety register, 2017). HU= Haramaya University, KARC/EIAR=Kulumsa Agricultural Research Centre, Ethiopian Institute of Agricultural Research, SARC/OARI=Sinana Agricultural Research Centre, Oromia Institute of Agricultural Research

3.3. Soil Sampling and Analysis

Soil samples were taken in zigzag pattern before planting randomly from the experimental site at a depth of 0-30 cm across the experimental field using auger and was com posited. Then, the composite sample was air-dried at room temperature under shade and the samples were mixed thoroughly to produce 1.0 kg of a representative composite sample. The composite sample was submitted to Haramaya University soil testing laboratory. Then in the laboratory, it was ground to pass through a 2 mm sieve whereas for organic carbon (OC) and nitrogen (N) determination, the soil was ground to pass through a 0.2 mm sieve. The soil sample was analyzed for selected physico-chemical properties mainly for soil texture, soil pH, cation exchange capacity (CEC), total N, and available P and S following standard laboratory procedures at Haramaya University soil testing laboratory.

3. 4. Treatments and Experimental Design

The treatments were arranged in a factorial combination of three bread wheat varieties (*Ogolcho, Jalane, and Sanate*) and five levels of blended NPS fertilizer rates (0, 50, 100, 150 and 200 kg ha^{-1}) and currently recommended 100 kg ha^{-1} Urea fertilizer was applied in split application for all treatments uniformly except control. The experiment was laid out in a randomized complete block design (RCBD) with three replications in factorial arrangement of 3x5=15 treatment combinations. Treatments were assigned to plots by lottery method and each treatment appears only once within a replication. The gross size of each plot was 1.2 m×2.5 m (3 m^2) consisting of six rows and the distance between adjacent plots and blocks was 0.5 m and 1 m apart, respectively. The net plot was 0.8 m ×2 m (1.6 m^2) consisted of four rows of 2 m length. The outermost one row on both sides of each plot and 25 cm of two ends was considered as border plants, and was not used for data collection to avoid border effects.

Table 2.The combination of Varieties and Fertilizer of experimental treatmentsDescription of the treatments

Treatment code			Total Composition of Fertilizer in the treatment		
	Treatment combinations		(kg ha^{-1})		
	Varieties	Fertilizer Treatments (kg ha^{-1})	N	P_2O_5	S
T2	Jalane	50 NPS + 100 Urea	55.5	19	3.5
T3	Jalane	100 NPS + 100 Urea	65	38	7
T4	Jalane	150 NPS + 100 Urea	74.5	57	10.5
T5	Jalane	200 NPS + 100 Urea	84	76	14
T6	Ogolcho	control (no fertilizer)	0	0	0
T7	Ogolcho	50 NPS + 100 Urea	55.5	19	3.5
T8	Ogolcho	100 NPS + 100 Urea	65	38	7
T9	Ogolcho	150 NPS + 100 Urea	74.5	57	10.5
T10	Ogolcho	200 NPS + 100 Urea	84	76	14
T11	Sanate	control (no fertilizer)	0	0	0
T12	Sanate	50 NPS + 100 Urea	55.5	19	3.5
T13	Sanate	100 NPS + 100 Urea	65	38	7
T14	Sanate	150 NPS + 100 Urea	74.5	57	10.5
T15	Sanate	200 NPS + 100 Urea	84	76	14

3.5. Experimental Procedures and Field Management

The experimental field was prepared by using hand implements (local plough 'akafa') according to farmers" conventional farming practices. According to the design, the field layout was prepared; the land was cleaned and leveled, each treatment was assigned randomly to the experimental units within a block. Sowing was done as the experiment has planned 125 kg ha^{-1} in rows of 20 cm spacing manually by drilling on 20 July 2019 and covered lightly with soil (at the depth of 3-5 cm). The whole of NPS and half dose of urea fertilizers were applied at sowing while the remaining half of urea was applied at mid tillering crop stage as top dressing (33 days after sowing). The experimental plots were received other agronomic practices uniformly for all plot treatments.

.

3.6. Data Collection

3.6.1. Phenology and Growth parameters

Days to heading (DTH): days to spike heading was determined as the number of days taken from the date of sowing to the date of 50% heading of the plants from each plot by visual observation.

Days to physiological maturity (DTM): days to physiological maturity was determined as the number of days from sowing to the date when 90% of the peduncle turned to yellow in straw color. It was recorded when no green color remained on glumes and peduncles of the tagged plants, *i.e.* when grains are difficult to break with thumb nail.

Plant height (cm): plant height was measured from the soil surface to the tip of the spike (awns excluded) of 10 randomly tagged plants from the net plot area at physiological maturity.

Spike length (cm): It was measured from the bottom of the spike to the tip of the spike excluding the awns from 10 randomly tagged spikes from the net plot.

Lodging percent: The degree of lodging was assessed just before the time of harvest by visual observation based on the scales of 1-5 where 1(0-15^{o}) indicates no lodging, 2 (15-30^{o}) indicate 25% lodging, 3 (30-45^{o}) indicate 50% lodging, 4 (45-60^{o}) indicate 75% lodging and 5 (60-90^{o}) indicate 100% lodging (Donald, 2004). The scales was determined by measuring the angle of inclination of the main stem from the vertical line to the base of the stem by visual observation

.

3.6.2. Yield Components and Yield

Number of total tillers: Number of total tillers was determined from 0.5 m length of two rows from the net plot and converted to per meter square of net plot at physiological maturity by counting the number of tillers.

Number of productive tillers: Number of productive tillers was determined at maturity by counting all kernel bearing spikes from 0.5 m length of two rows from the net plot and converted to per meter square of net plot at physiological maturity.

Number of kernels per spike: The mean number of kernels per spike were computed as an average of 10 randomly taken spikes from the net plot area.

Thousand Kernels Weight (g): Thousand kernels weight was determined based on the weight of 1000 kernels sampled from the grain yield of each net plot by counting using electronic seed counter and weighed with sensitive balance. Then, the weight was adjusted to 12.5% moisture content.

Above ground dry biomass (kg ha^{-1}): The above ground dry biomass was determined from plants harvested from the net plot area after sun drying to a constant weight and converted to kg per hectare.

Grain yield (kg ha^{-1}): Grain yield was taken by harvesting and threshing the grain yield from net plot area. The grain weight of each plot was recorded in kg and finally, yield per plot was converted to kg ha^{-1}. The yield was adjusted to 12.5% moisture content.

$$\text{Adjusted grain yield} = \frac{(100-MC) \times \text{unadjusted grain yield}}{100-12.5}$$

Straw yield (kg ha^{-1}): Straw yield was obtained as the difference of the total above ground dry biomass and grain yield.

Harvest index (HI): Harvest index was calculated as the ratio of grain yield per plot to the total above ground dry biomass yield per plot.

3.7. Agronomic Efficiency (AE)

The fertilizer agronomic efficiency (kg kg^{-1}): is defined as the economic production obtained per unit of NPS applied. The agronomic efficiency was calculated using the procedure described by Craswell and Godwin (1984) as: $\boldsymbol{AE}(\frac{\boldsymbol{kg}}{\boldsymbol{kg}}) = \frac{\boldsymbol{Gf(kg) - Gu(kg)}}{\boldsymbol{Na(kg)}}$ where; AE stands for agronomic efficiency, Gf and Gu for grain yield in fertilized and unfertilized plots, respectively, and Na for quantity of fertilizer applied.

3.8. Economic Analysis

The economic analysis was carried out by using the methodology described in CIMMYT (1988) in which prevailing market prices for inputs at planting and for outputs at harvesting were used. All costs and benefits were calculated on hectare basis in Birr.
Actual yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield that the farmers could expect from the same treatment.
Adjusted grain yield (AGY) (kg ha^{-1}) the average yield was adjusted downward by a 10% to reflect the difference between the experimental yield and yield of farmers.
Gross field benefit (GFB) (ETB ha^{-1}) was computed by multiplying field/farm gate price that farmers receive for the crop when they sell it as adjusted yield as GFB = AGY×field/farm gate price for the crop.
Total variable cost (TVC) (ETB ha^{-1}) was calculated by summing up the costs that vary, including the cost of NPS, Urea, seed and the application costs.
The **net benefit** (NB) was calculated as the difference between the gross benefit and the total cost that vary (TCV) using the formula NB = (GY x P) – TVC Where GY x P = Gross Field Benefit (GFB), GY = Adjusted Grain yield per hectare and P = Field price per unit of the crop.
Marginal Rate of Return (MRR %): This refers to the net income obtained by incurring a unit cost of seed and fertilizer rates. For each pair of ranked treatments based on net income, marginal rate of return (MRR %) was calculated using the formula

$$\text{MRR (\%)} = \frac{\text{Change in NB } (NB_b - NB_a)}{\text{Change in TVC } (TVC_b - TVC_a)} \times 100$$

; where NBa NB with the immediate lower,

NB_b = NB with the next higher, TCV_a = the immediate lower TVC and TVC_b = the next highest TVC. The dominance analysis procedure as described in CIMMYT (1988) was used to select potentially profitable treatments from the range that was tested. The discarded and selected treatments using this technique were referred to as dominated and un dominated treatments, respectively. Then the treatment with the highest net benefit and marginal rate of more than 100% was considered for the recommendation as described by CIMMYT (1988).

3.9. Statistical Data Analysis

All data collected were subjected to analysis of variance (ANOVA) procedure using Gen Stat 18th edition software (GenStat, 2015). Comparisons among treatment means with significant difference for measured characters was done by using Fisher's protected Least Significant Difference (LSD) test at 5% level of significance.

4. RESULTS AND DISCUSSION

4.1. Soil Physico-chemical Properties of the Experimental Site

The laboratory results of the analysis of the selected physico-chemical properties of the soil before sowing was presented in Table 3. The analytical results of the experimental soil indicated that the soil textural class was clay loam with a particle size distribution of 16% sandy, 36% silt and 48% clay. According to Hailu (1991), soil types used for wheat production vary from well-drained fertile soils to water logged heavy Vertisols. Thus, the soil of experimental site is suitable for the production of wheat. The pH of the soil was 6.9, which is neutral (Tekalign, 1991). FAO (2000) reported that the preferable pH ranges for most crops and productive soils are 4 to 8. Mengel and Kirkby (1996), reported optimum pH range of 4.1 to 7.4 for wheat production. Thus, the pH of the experimental soil was within the range for productive soils for wheat.

The soil of the study site had 1.35% of organic carbon (OC) (Table 3), which is low according to the rating of Tekalign (1991), who rated soils having OC value in the range of 0.5-1.5% as low, indicating low potential of the soil to supply nitrogen to plants through mineralization of organic carbon. The low amount of soil organic carbon might be due to low addition of crop residues as smallholder farmers use the biomass of wheat for animal feed in the study area. Tekalign (1991) has classified soil total N content of <0.05% as very low, 0.05-0.12% as poor, 0.12-0.25% as moderate and > 0.25% as high. According to this classification, the soil samples were found to have moderate level of total N (0.132%) (Table 3), indicates that the nutrient to be a limiting factor for wheat production in the study area.

The analysis revealed that the available P of the soil was 13.64 mg kg^{-1} (Table 3). Indicative ranges of available phosphorus have been established by Olsen *et al*. (1954), as <5 mg kg^{-1} (very low), 5-15 mg kg^{-1} (low), 15-25 mg kg^{-1} (medium), and >25 mg kg^{-1} of soil (high). Thus, the soil of the experimental site was considered as low in available P content. The low available phosphorus in the soil is not satisfactory to get potential yield from the crop. Thus, it is important to apply phosphorus fertilizer from external sources based on the recommended rate. The analysis for available sulfur also indicated that the experimental soil had values of 6.98 mg/kg which is very low according to EthioSIS (2014). Thus, indicating that the sulfur nutrient to be a limiting factor for wheat production in the study area. This might be mainly due to poor sulfur containing parent material of soil, land degradation, crop residue removal, crop uptake, low soil organic matter, use of non-S containing fertilizers (only N and P containing fertilizers used).

Cation exchange capacity (CEC) is 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. According to Landon (1991), top soils having CEC greater than 40 cmol (+) kg^{-1} are rated as very high and 25-40 cmol (+) kg^{-1} as high, and 15-25, 5-15 and < 5 cmol (+) kg^{-1} of soil are classified as medium, low and very low, respectively, in CEC. According to this classification, the soil of the experimental site had high CEC (34.45 cmol (+) kg^{-1} soil), indicating its high capacity to retain cations (Table 3).

Table 3. Selected Physico-Chemical properties of the soil of the experimental site

Parameter	Values	Rating	References
Soil texture			
Clay (%)	48		
Sand (%)	36		
Silt (%)	16		
Textural Class	Clay loam		Hailu (1991)
pH (1 : 2.5 H_2O)	6.9	Neutral	Tekalign (1991)
Total N (%)	0.123	Medium	Tekalign (1991)
Organic Carbon (%	1.345	Low	Tekalign (1991)
CEC[Cmol (+) kg1 soil]	34.45	High	Landon (1991)
Available Phosphorus (mg/kg)	13.641	Low	Olsen (1954)
Available Sulfur (mg /kg)	6.98	Very low	EthioSIS (2014)

4.2. Effects of NPS fertilizer rates on phenology and growth parameters

4.2.1. Days to heading and Days to maturity

Days to heading and days to maturity were highly significantly ($p<0.01$) influenced by the application of blended NPS fertilizer and varieties. However, they were non-significant by the interaction of blended fertilizer rates and varieties (Appendix Table 2). The delayed days to heading and maturity observed in plots that received 200 kg NPS ha^{-1}, but the number of days required for days to heading had not a significant difference with plot that received 0, 50 kg ha^{-1} and 150 and 200 kg ha^{-1} NPS. Similarly, the days to maturity attained in plots that applied with 150 and 200 kg ha^{-1} NPS had not significant difference. *Sanate* and *Jalane varieties* took significantly higher duration to attain days to heading than *Ogolcho*, whereas, *Sanate* had significantly delayed days to maturity than the two varieties. The 8.78 (near 9) and 11.3 days to heading and maturity differences observed between the plants that did not supply fertilizer and which received the highest rate of 200 kg NPS ha^{-1} fertilizer, respectively (Table 4). The result of this study is in agreement with the findings of Tagesse (2017) that indicated the significant influence of blended NPS fertilizer on days to heading and days to physiological maturity of the bread wheat. *Sanate* variety delayed by 7.6 and 35.5 days to heading and maturity, respectively over *Ogolcho* wheat variety, as well as 4.87 and 24.5 days to heading and maturity than *Jalane* variety (Table 4). This indicated either the varieties maturity is the function of a genetic factor or the fertilizer applied.

The delayed days to heading and maturity tend to higher rates of NPS fertilizer though inconsistency and a linear relationship is lacking. This indicated that higher amount of the N content in the NPS fertilizer, which delays days to heading and maturity periods. The inconsistent increasing trend with increased NPS fertilizer might be due to the counteracting effects of P nutrition on N nutrition, because N tends to increase vegetative growth, while P hastens it (Gemechu, 2011). Similarly, Damene, (2003) observed significant differences of plant maturity due to the application of nitrogen on wheat. Woinshet (2007) reported that more application of the N fertilizer delay maturity of barley varieties. Suleiman *et al*. (2014) reported that five wheat varieties showed a significant difference for days to heading and maturity.

Table 4. Effect of varietal difference and rates of blended NPS fertilizer on days to heading and maturity of wheat

Blended NPS Fertilizer rate (kg ha^{-1})	Days to heading	Days to Maturity
0	58.78^{c}	112.4^{d}
50	60.22^{c}	114.8^{c}
100	62.67^{b}	118.0^{b}
150	66.00^{a}	122.0^{a}
200	67.56^{a}	123.7^{a}
LSD (5%)	1.966	1.818
Varieties		
Jalane	62.33^{b}	113.7^{b}
Ogolcho	59.60^{c}	102.7^{c}
Sanate	67.20^{a}	138.2^{a}
LSD (5%)	1.523	1.409
CV (%)	3.2	1.6

Mean values followed by the same letter(s) within a column in each trait and treatments are not significantly different at P<0.05 and LSD (5%) =least significance difference at P<0.05

4.2.2. Effects of blended NPS fertilizer rates on plant height, Spike length and Lodging percent

Plant height and Spike length were highly significantly (p<0.01) influenced by the application of blended NPS fertilizer rates and significant (0.05) effect by variety. But Lodging percent was highly significantly (p<0.01) influenced by the application of blended NPS fertilizer rates and varieties. However, they were non-significant by the interaction of blended fertilizer rates and varieties.

.

Increasing the amount of blended NPS rates significantly increased plant height. The maximum application rate of blended NPS (200 kg ha^{-1}) resulted in the highest plant height (81.38cm). As the NPS fertilizer rates increased from 50 to 200 kg ha^{-1} the plant height increased from 72.04 cm to 81.38cm. While, application of blended NPS fertilizer rates in most of the plots that received 0 and 50 kg ha^{-1} as well as 150 and 200 kg ha^{-1} of fertilizer rates had non-significant differences. The increased plant height in response to increasing rate of blended NPS application might be due to the vital role of N fertilizer in promoting the vegetative growth which resulted in significant increase in plant height. *Sanate* variety had significantly maximum plant height (78.36cm), *Jalane* had the shortest plant height (74.94cm); however, the mean plant height of this variety and *Ogolcho* in most of the plots had not significant differences (Table 5). The differences in plant height among the varieties could be attributed to the difference in their genetic makeup or cell division rate that result in change in plant height of different varieties. Moreover, this result is in line with results of Melesse (2017) who reported that application of N and P fertilizer rates highly significantly ($P<0.01$) increased plant height of bread wheat and recorded the highest height of 94.18 and 90.56 cm at applications of 69 kg N ha^{-1} and 30 kg P ha^{-1}, respectively. Generally, as increasing blended fertilizer plant height increases for all varieties except for some fertilizer level in which increasing trend had not seen to some extent. NPS fertilizer has a great contribution to the vigorous vegetative growth and development. The current study result was also in agreement with the results of Abdul *et al.* (2014) who reported that tallness in wheat plants is mostly associated with the genetic make-up of the variety.

Significantly, maximum mean value of spike length, which ranged from 7.89 to 8.67 cm was recorded due to the application of 100 to 200 kg ha^{-1} NPS fertilizer (Table 5). The treatment that received 150 and 200 kg ha^{-1} NPS fertilizer did not show significant difference. The increase in spike length at the highest NPS rate might have been resulted from improved root growth, increased uptake of nutrients and better growth due to synergetic effect of the three nutrients. NPS fertilizer had ability to increase spike length positively. The highest (8.10 cm) spike length was recorded from *Ogolcho* variety and the lowest (7.46cm) was recorded from the *Jalane* variety (Table 5). This might be due to different varieties which have different yield performing abilities genetically. This result is in agreement with Otteson *et al*. (2007) who reported individual genotypes responded differently to spike length for varying nitrogen rates on wheat.

Lodging is one of crop production factor which determine the yield of crop. The grain yield was negatively correlated with crop lodging which may decline more than 10% of wheat yield (Easson *et al.*, 1993). The lodging percent was highly significantly ($P< 0.01$) affected by the main effects of blended NPS fertilizer rates and varieties. However, the interaction of blended NPS fertilizer and varieties was non-significant (Appendix Table

3). The highest lodging percent (28.89%) was recorded at the application of 200 kg NPS ha^{-1} with no significant differences to 150 kg ha^{-1}. Whereas, the lowest lodging percent (14.22%) was observed at zero blended fertilizer rates (Table 5). As the NPS fertilizer rates increased from 50 to 200 kg ha^{-1} the lodging percent increased. However, application of blended NPS fertilizer rates in most of the plots that received 150 and 200 kg ha^{-1} had non-significant differences. The highest lodging percent recorded at the highest rates of NPS might have resulted from the higher internodes length, tall plant height and weak stalks which are easily affected by wind. Over all, *Sanate* and *Ogolcho* varieties were low in lodging. The highest lodging percent in *Jalane* might be due to the vigorous plant height and weak stalk it possesses.

Table 5. Main effect of blended NPS fertilizer rate and variety on spike length, plant height (cm) and Lodging percent of bread wheat

Blended NPS Fertilizer rates (kg ha^{-1})	Plant height (cm)	Spike length (cm)	Lodging Index (%)
0	70.75^{c}	6.62^{d}	14.22^{d}
50	72.04^{c}	7.29^{c}	17.00^{c}
100	76.54^{b}	7.81^{b}	23.00^{b}
150	80.66^{a}	8.66^{a}	28.00^{a}
200	81.38^{a}	8.67^{a}	28.89^{a}
LSD (5%)	2.32	0.44	1.37
Varieties			
Jalane	74.94^{b}	7.46^{b}	25.00^{a}
Ogolcho	75.52^{b}	8.10^{a}	20.67^{b}
Sanate	78.36^{a}	7.86^{a}	21.00^{b}
LSD (5%)	1.79	0.34	1.06
CV (%)	3.1	5.7	6.4

Mean values followed by the same letter(s) within a column are not significantly different at P<0.05 and LSD (5%)= least significance difference at P<0.05

4.3. Effects of blended NPS fertilizer rates on Yield Components and Yield of bread wheat

4.3.1. Total tillers and Productive tillers

The analysis of variance showed that the number of total tillers and number of productive tillers per m^2 were highly significantly ($P<0.01$) affected by the main effect of NPS fertilizer rates and varieties. However, the interaction effects on Number of total and productive tillers were found significant (0.05) (Appendix 1). The maximum number of total tillers (397.7 m^{-2}) and productive tillers (379.6 m^{-2}) were recorded from the combined application rates of (200 kg NPS ha^{-1}) and (150 kg NPS ha^{-1}) with Sanate variety respectively. Whereas, the minimum number of total tillers (132.7 m^{-2}) and productive tillers (128.1 m^{-2}) were recorded from the combination of (0 kg NPS ha^{-1}) with Jalane variety without significant differences with Ogolcho and Sanate varieties respectively (Table 6).The highest number of tillers at the highest rates of NPS might be due to the rapid conversion of synthesized carbohydrates into protein and consequently the increase in number and size of growing cells, ultimately resulting in increased number of tillers. The highest number of productive tillers at the highest NPS rates might be that increasing NPS fertilizer favored more tillering as result the more number of fertile tillers were obtained.

The number of total tillers and productive tillers increases as NPS fertilizer increase. This is due to nitrogen and phosphorus fertilizer increases total number of tillers and productive tillers per unit area. It agrees with the result obtained by Prystupa *et al*. (2004) showed that a number of productive tillers/plant were affected significantly by NP fertilizer application on barely. Additionally, Maqsood *et.al.* (1999) reported that the increase in the number of fertile tillers with increasing nitrogen levels could attribute to the well-accepted role of nitrogen in accelerating the vegetative growth of wheat.

Accordingly, *Sanate* variety had better performance than *Ogolch*o and *Jalane* vaieties. *Sanate* variety had performed by 18.5% of total number of tillers and 18% of productive tiller than *Ogolcho* and 26% of total number of tillers and 27.25% of productive tiller than *Jalane* variety, respectively. The differences in the number of tillers produced by different responses of different genotypes to various management variable and environments with respect to growth attributes might be the inherent nature of the variety, which would produce different numbers of the productive tiller in the given environmental conditions. Sufficient amount of growth and development of plants owing to the essential elements under blended NPS fertilizer. The present study also agrees with *Wu et al.* (1998) and Lafarge *et al.* (2004) observed that the varietal differences with respect to tillering capacity in rice crop. Similarly, Jemal *et al.* (2015) also reported that significant difference of the bread wheat varieties on number of total tillers and productive tillers. The varieties which had more of the productive number produce more number of grain yield ha^{-1}. This would be due to the number of productive tiller is an important yield component that directly contribute to the final grain yield of the crop.

Table 6. Interaction effects of the NPS fertilizer and variety on total number of tillers / m^2

Blended NPS	Variety		
Fertilizer kg ha^{-1}	*Jalane*	*Ogolcho*	*Sanate*
0	132.7^{f}	147.2^{ef}	153.1^{ef}
50	152.3^{ef}	177.2^{e}	214.0^{d}
100	237.6^{d}	235.7^{d}	289.8^{bc}
150	274.3^{c}	317.3^{b}	389.3^{a}
200	286.5^{bc}	308.3^{bc}	394.7^{a}
LSD		36.30	
CV		8.8	

Means in columns and rows followed by the same letter(s) are not significantly different; LSD=least significant difference at P<0.05

Table 7. Interaction effects of the NPS fertilizer and variety on number of productive tillers

Blended NPS Fertilizer (kg ha^{-1})	Variety		
	Jalane	*Ogolcho*	*Sanate*
0	128.1^{f}	138.1^{f}	141.0^{f}
50	141.0^{f}	163.7^{f}	203.9^{e}
100	224.8^{de}	224.3^{de}	280.1^{bc}
150	258.3^{cd}	299.0^{b}	379.6^{a}
200	271.3^{bc}	301.4^{b}	376.0^{a}
LSD		37.61	
CV		9.6	

Parameters followed by the same letters within a column are not significantly different; LSD=least significant difference at P<0.05.

4.3.2. Kernels per spike and Thousand kernels Weight

The analysis of variance showed that the number of kernels per spike and Thousand kernels weight were highly significantly (P<0.01) affected by the main effect of NPS fertilizer rates and variety. However, the interaction effects blended NPS fertilizer and variety on kernels per spike and thousand kernels weight were found non significant (Appendix 4). Sanate variety had significantly higher (9.6%) and (4%) number of kernels per spike than *Jalane* and *Ogolcho varieties,* respectively (Table 8). Number of kernels per spike is associated with the number of spikelets per spike, number of florets per spikelet as well as efficiency of pollination and seed developing in florets. This can be attributed to varieties that show differences in their performance abilities on the number of kernels per spike. This agree with Abdi (2016) who reported significant difference among wheat varieties on number of kernels per spike.

Application of 200 kg ha^{-1} NPS fertilizer increased number of kernels per spike by 35% than treatment without fertilizer. The plot that received 150 and 200 kg NPS ha^{-1} did not show significant difference. The highest number of kernels per spike at the highest NPS rate might be due to higher uptake of wheat at higher levels that resulted into enhanced number of grains per spike due to its involvement in grain formation and development. The probable reason for increased number of kernels per spike with increased rate of

NPS might be that phosphorus plays an important part in many physiological processes that occur within a developing kernels and involved in enzymatic reactions in the plant and in the development of kernels. This indicated that the NPS fertilizer influence more on yield contributing factors like spike length, number of kernels per spike and thousand kernel weights. Mesfin, and Zemach, (2015) indicated that application of 69/30 NP Kg ha^{-1} fertilizer increase number of seeds per spike up to (42.6) than control (36.3) treatments on barley. In agreement with this result, Nasser and El-Gizawy (2009) reported the highest number of kernels per spike of 69.85 at 90/45 kg N/P_2O_5 ha^{-1} for wheat. Similarly, Yasir *et al*. (2015) reported the maximum number of wheat kernels per spike (56.4) as treated by at 140 kg N ha^{-1} and 20 kg S ha^{-1} at sowing and at anthesis, respectively. Likewise, Workineh *et al***.** (2015) who reported the highest number of kernels per spike (38.83) of wheat from the maximum fertilizer (138/115 N/P_2O_5 kg ha^{-1}).

Application of 200 kg NPS ha^{-1} increased by 15.9% over treatment that did not received fertilizer, without a significant difference with treatment that supplied 150 kg NPS ha^{-1}. The treatment that supplied with 0 to 100 and 150 with 200kg NPS ha^{-1}had not showed significant difference in their mean values (Table 7). As general the result showed that increasing blended NPS fertilizer thousand kernels weight increased significantly. This might be due to the provision of balanced nutrients application have enhanced accumulation of assimilate in the grains and thus resulting in heavier grains of wheat, adequate and better nutrition of the plants resulted in good grain filling and development of better seed size. Similar to this result Alam *et al.* (2003) who reported that besides seed yield and weight of thousand kernel varied significantly due to increasing levels of sulfur and nitrogen fertilizers. This might be because of the contribution of nutrients in the photosynthesis process and movement of its photosynthesis products to storage organs (seeds). Contrasts with the finding of (Tamrat (2006); Ali *et al.* (2007); and Ali *et al.* (2008) who reported that nitrogen and phosphorous fertilizers did not have a significant effect on thousand seed weight.

Jalane variety had significantly the maximum (47.33g) thousand kernels weight than *Ogolcho* and *Sanate* varieties. This might be the genetic nature of the crop may differ in performance during the grain filling period that gives the highest thousand seed weight. This result is related with the findings of Ayoub *et al*. (1994) who reported that the thousand seed weight is an important yield-determining component, which is reported to be a genetic characteristic of cultivars in wheat.

Table 8. Effect of the varietal difference and NPS fertilizer on Number of Kernels per Spike and Thousand Kernels Weight (g) of wheat

Blended NPS Fertilizer rates (kg ha^{-1})	Kernels per Spike (nº)	Thousand Kernels Weight (g)
0	44.56^{d}	40.33^{c}
50	50.67^{c}	41.67^{bc}
100	57.00^{b}	43.33^{b}
150	63.67^{a}	46.11^{a}
200	64.56^{a}	47.33^{a}
LSD (5%)	2.99	1.697
Varieties		
Jalane	53.33^{c}	47.33^{a}
Ogolcho	56.20^{b}	43.73^{b}
Sanate	58.73^{a}	41.93^{c}
LSD (5%)	2.317	1.315
CV (%)	5.5	4

Mean values followed by the same letter(s) within a column are not significantly different at $P<0.05$ and LSD (5%)=least significance difference at $P<0.05$

4.3.3 Above Ground Dry Biomass Yield and Grain Yield

As the analysis of variance revealed; the above ground dry biomass yield and Grain Yield were highly significantly ($p<0.01$) affected by the main effect of variety, NPS fertilizer and Interaction. The highest above ground dry biomass yield (15,132 kg ha^{-1}) was obtained at combination of the highest rates (200 kg ha^{-1} blended NPS fertilizer) with *Sanate* variety. Whereas, the lowest above ground dry biomass yield (7617 kg ha^{-1}) was recorded in response to the application of zero level of blended NPS fertilizer with *Jalane* variety (Table 8). Above ground dry biomass yield had increased with increase in NPS rates from control to the highest fertilizer rates. This means that plot received 200 kg NPS ha^{-1} produced more above ground dry biomass yield by 30% than plot without fertilizer. The increase in above ground dry biomass at the highest rates of blended NPS fertilizer might have resulted from improved root growth and increased uptake of nutrients favoring better growth and delayed senescence of leaves of the crop due to synergetic effect of the three nutrients (NPS). Nitrogen and phosphorus fertilizer application enhance the vegetative growth of the wheat crop, and more tiller number which ultimately increased biological yield with an increase in straw yield. This is due to biomass yield is reflected by growth parameters like; a total number of plants, tillers per unit area and final plant height.

This result agrees with Workine *et al*. (2015) who reported that the highest (11890 kg ha^{-1}) above ground biomass yield of wheat from higher 138/115 kg N/P_2O_5 ha^{-1}. Similarly, Melesse Harfe (2017) who reported that increasing the N/P fertilizer rate from 46/20 kg N/P_2O_5 ha^{-1} to 69/30 kg N/P_2O_5 ha^{-1} for wheat biomass yield was increased from 10417 kg ha^{-1} to 11233 kg ha^{-1}. Likewise, Dawit *et al*. (2015) who reported that increasing N from 0 to 184 kg ha^{-1} and P from 0 to 138 kg ha^{-1} increased the above ground dry biomass yield of wheat by about 70.1% and 40.6%, respectively. Similarly, Yasir *et al*., (2015) also reported the maximum above ground biomass yield of wheat (14,734.5 kg ha^{-1}) from 140 kg N ha^{-1} applied at sowing and 20 kg S ha^{-1} applied at anthesis.

Table 9. Interaction effects of the NPS fertilizer and variety on above ground dry biomass yield of wheat

Blended NPS Fertilizer	Variety		
rates (kg ha^{-1})	*Jalane*	*Ogolcho*	*Sanate*
0	7617^{i}	9005^{gh}	9444^{fg}
50	7922^{i}	9689^{fg}	10384^{ef}
100	7765^{i}	10787^{de}	12226^{c}
150	7806^{i}	11105^{de}	14018^{b}
200	8298^{hi}	11819^{cd}	15132^{a}
LSD		1073.8	
CV		6.3	

Means in columns and rows followed by the same letter(s) are not significantly different; LSD=least significant difference at P<0.05

The highest grain yield (6424 kg ha^{-1}) was obtained by the interaction of 200 kg ha^{-1} NPS with *Sanate* variety without significantly different with plot that received 150 kg ha^{-1}. Whereas, the lowest grain yield (2870 kg ha^{-1}) was recorded at zero level of blended NPS fertilizer with *Jalane* variety (Table 9). The result showed grain yield of wheat increased due to the increasing of blended NPS fertilizer. The highest grain yield at the highest NPS rates might have resulted from improved root growth and increased uptake of nutrients and better growth favored due to the synergistic effect of the three nutrients which enhanced yield components and yield. Many research results also showed highest grain yields obtained from the maximum sulphur applications Nehara *et al*., 2006. Similarly, Baraich *et al*. (2012) stated that grain yield of the improved varieties of wheat increased as increasing level of the phosphorus fertilizers. *Sanate* variety over yielded the yield of *Jalane* and *Ogolcho* varieties by 32.15% and 7.87% kg ha^{-1} respectively (Table 9). This yield difference might be due to high tillering capacity and its genetic potential of the variety *Sanate*. Similarly, Wogene and Agena (2017) reported the significant variation in performance of bread wheat varieties on seed yield.

The current result agrees with the finding of Kaleem *et al*. (2009) who reported maximum yield of wheat (3557 kg ha^{-1}) by the application of 128-128 kg ha^{-1} (NP) ratio 1:1 which indicated the importance of phosphorus at its highest dose in achieving maximum wheat productivity. Similarly, Workineh *et al*. (2015) reported that the highest grain yield (4890 kg ha^{-1}) was recorded at the highest rate of nitrogen and phosphorus fertilization (138/115 kg ha^{-1} N/P_2O_5) while, the lowest grain yield (4270 kg ha^{-1}) was recorded at the lowest rate (46/46 kg ha^{-1} N/P_2O_5). Likewise, Melesse Harfe (2017) reported that increasing the N/P fertilizer from (0/0 N-P kg/ ha) to 69/30 kg N/P_2O_5 ha^{-1} for wheat it was increased the grain yield from 2333 kg ha^{-1} to 4164 kg ha^{-1}. The result is also in line with the result of Yasir *et al*. (2015) who reported the maximum grain yield of wheat (4463.5 kg ha^{-1}) at 140 kg N ha^{-1} and 20 kg S ha^{-1}.

Table 10.Interaction effect of the NPS fertilizer and varieties on grain yield of bread wheat

NPS Fertilizer	Variety		
(kg ha^{-1})	*Jalane*	*Ogolcho*	*Sanate*
0	2701^{h}	3354^{f}	3508^{ef}
50	2870^{h}	3673^{e}	4062^{d}
100	2984^{gh}	4387^{c}	4937^{b}
150	3210^{fg}	4867^{b}	6262^{a}
200	3279^{fg}	4978^{b}	6424^{a}
LSD		318.1	
CV		4.6	

Means in columns and rows followed by the same letter(s) are not significantly different; LSD=least significant difference at P<0.05.

4.3.4. Straw Yield and Harvest Index

Straw yield and Harvest Index were highly significantly ($p<0.01$) affected by the main effect of NPS fertilizer and variety. Interaction effects of blended NPS fertilizer rates and varieties on straw yield and harvest index were significant (0.05) and non-significant, respectively. The highest straw yield (6555 kg ha^{-1}) was obtained from the highest rate (200 kg ha^{-1}) of blended NPS fertilizer, whereas the lowest straw yield (5502 kg ha^{-1}) was recorded in response to the application of zero level of blended NPS fertilizer. Moreover, straw yield increased as blended NPS rates increases for all varieties; but, application of 0 with 50 kg ha^{-1} were non significant difference. Mean straw yield was highest for all varieties at the highest rate of NPS. In general straw yield of *Sanate* was higher than that of *Jalane* and *Ogolcho* varieties. This difference might be attributed to the higher productivity of yield and yield components of varieties. This could help to understand farmers' preference to *Sanate* variety for animal feed.

The significant increase in straw yield in response to the highest application rate of blended NPS fertilizer might have resulted increased uptake of nutrients and better growth favored due to synergistic effect of the three nutrients produced higher plant population which enhanced growth and yield components there by resulting in the highest above ground biomass yield. The current result agrees with the finding of Nasser and El-Gizawy (2009) who reported increased straw yield of wheat with increase in NP fertilizer rates up to 90/45 kg ha^{-1}. Similarly, Bereket *et al.* (2014) reported highest straw yield of bread wheat (6827 kg ha^{-1}) at phosphorus rate of 92 kg P_2O_5 ha^{-1} and nitrogen rate of 138 kg N ha^{-1}.

The highest harvest index (0.43) was obtained from 150 kg ha^{-1} rates of blended NPS fertilizer. Whereas, the lowest harvest index (0.36) was from 0 kg ha^{-1} NPS (control treatment) (Table 10). Plots that received 0 and 50 kg ha^{-1} NPS were non-significant different. The variety *Sanate* had greater mean harvest index (0.41) than *Ogolcho* (0.40) and *Jalane* (0.38) varieties. Harvest index tended to increase with increased application rates of NPS fertilizer until 150 kg ha^{-1}. This might be due to greater photo assimilate production and its ultimate partitioning into grains compared to partitioning in to straw, *i.e.* proportionally higher grain yield than vegetative biomass yield. This result is similar with the findings of Sharer *et al.* (2003) who reported higher harvest index (0.39) under higher level of nitrogen and phosphorus (180/130 kg N/P ha^{-1}) than application of lower levels of the fertilizers. In contrary to this result, Dawit *et.al.* (2015) reported no significant effect of N and P rates on harvest index of bread wheat. Similarly, contrasts with Wogene and Agena (2017) finding who reported that harvest index was insignificantly affected by wheat varieties.

Table 11. Effects of varietal difference and NPS fertilizer on straw and Harvest index of wheat at Jarso 2019

Blended NPS Fertilizer (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index
0	5502^{c}	0.36^{d}
50	5797^{bc}	0.37^{d}
100	6157^{b}	0.39^{c}
150	6197^{b}	0.43^{a}
200	6555^{a}	0.41^{b}
LSD (5%)	477.8	0.0126
Varieties		
Jalane	4873^{c}	0.38^{b}
Ogolcho	6229^{b}	0.40^{a}
Sanate	7202^{a}	0.41^{a}
LSD (5%)	370.1	0.0098
CV (%)	8.1	3.3

Mean values followed by the same letter(s) within a column in each trait and treatment are not significantly different at P<0.05 and LSD (5%) =least significance difference at P<0.05

4.4. Agronomic Efficiency (AE)

As the analysis of variance revealed the Agronomic efficiency was highly significantly (p<0.01) affected by the main effect of NPS fertilizer rates and variety. However, an interaction was significant (0.05). As the NPS level increased from 50 to 150 kg ha^{-1}, the agronomic efficiency increased from 3.69 to 11.04 kg grain per kg NPS in *Sanate*, from 2.13 to 6.05 in *Ogolcho* and from 1.13 to 2.04 in *Jalane*; but, decreased at application of 200 kg ha^{-1}.

The highest agronomic efficiencies were obtained at 150 kg ha^{-1} blended NPS by the three varieties; in Sanate (11.04), *Ogolcho* (6.05) and *Jalane* (2.04). In contrast to Mellese, (2017) who reported that as the P level increased from 23 to 69 kg P/ha, the agronomic efficiency decreased from 30.66 to 18.36. There was low agronomic efficiency (1.13 kg grain per kg NPS) observed at *Jalane* cultivar; which indicated that it produced low grain yield per unit of NPS supply. The study showed that agronomic efficiency increases up to 150 kg/ha NPS application levels then beyond this levels it decreased. According to this study increment of NPS above 150 kg/ha is not economical and it leads to environmental pollution and it is in line with Wogene and Agena (2017) who reported supplying wheat plant by 46 kg/ha produced the maximum grain yield per nitrogen unit increase; the greatest agronomic efficiency which reached 34.47 kg grain per kg nitrogen, whereas low agronomic efficiency 22.44 kg grain per kg N was observed at high nitrogen levels i.e. 69 kg/ha. According to Craswell and Godwin (1984), high agronomic efficiency would be obtained if the yield increment per unit applied is high (Table 11).

Table 12**.** Interaction effect of the blended NPS fertilizer and variety on agronomic efficiency (AE) of bread wheat at Jarso 2019

NPS Fertilizer	variety		
rates (kg ha^{-1})	*Jalane*	*Ogolcho*	*Sanate*
50	1.13^{fg}	2.13^{ef}	3.69^{c}
100	1.42^{fg}	5.17^{cd}	7.14^{b}
150	2.04^{ef}	6.05^{bc}	11.04^{a}
200	1.93^{f}	5.77^{bc}	9.72^{a}
LSD (5%)		1.95	
CV (%)		24.2.	

Means in columns and rows followed by the same letter(s) are not significantly different; LSD=least significant difference at P<0.05.

4.5. Partial Budget Analysis

Partial budget analysis of the net benefits, total costs that vary and marginal rate of returns are presented in Table 10.The yield of bread wheat was adjusted down ward by 10% to reflect experimental yield and expected yield of farmers from the same treatments. The actual price of seed was used to convert the adjusted yield into gross yield benefits (15 Birr kg^{-1}), the cost of fertilizer NPS (15.0623 Birr kg^{-1}) and Urea (13.7878 Birr kg^{-1}).

The result of the economic analysis showed that the highest net benefit of ETB (82710 ha^{-1}) and the marginal rate of return (2305.8%) was obtained through the planting of *Sanate* variety with the application rate of 150 kg ha^{-1} blended NPS fertilizer. The net economic benefit of ETB (63118.4 ha^{-1}) was achieved by *Ogolcho* planted with 150 kg ha^{-1} and the marginal rate of return (749.7%) and the net benefit of ETB (39937.9 ha^{-1}) and the marginal rate of return (315.7%) was obtained from *Jalane* variety with application 150 kg ha^{-1} (Table10).

According to CIMMYT (1988) suggestion, the minimum acceptable marginal rate of return should be more than 100%. In this study, even an application of 200 kg NPS ha^{-1} gave the maximum net benefit (Birr 84629.5 ha^{-1}) and the marginal rate of return was (254.9%) from Sanate but, economically compared with the application of 150 kg ha^{-1} NPS not acceptable. Similarly, The net benefit of ETB (64173.9 ha^{-1}) and the marginal rate of return (140.2%) was obtained from *Ogolcho* variety (Table 10). Therefore, on economic grounds, application of 150 kg ha^{-1} rate of NPS would be best and economical for production of bread wheat in the study area and other areas with similar aggro-ecological conditions.

Table 13. Summary of partial budget and marginal rate of return analysis for bread wheat to blended NPS fertilizer rates in Jarso District, Eastern Ethiopia.

Treatments		Wheat yield (kg ha^{-1})			Income (ETB ha^{-1})		GFB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	MRR (%)
NPS rate	Varieties	AVGY	AdGY	SY	Grain	SY				
0	Ogolcho	3353.8	3018.4	5651.6	45276	2825.7	48101.4	2062.5	46038.9	0
50	Ogolcho	3672.9	3305.6	6015.8	49584	3007.9	52592.3	4194.4	48397.9	110.7
100	Ogolcho	4386.7	3948	6400.3	59220	3200.2	62420.2	4947.5	57472.7	1204..9
150	Ogolcho	4866.7	4380	6238	65700	3119	68819	5700.6	63118.4	749.7
200	Ogolcho	4978.3	4480.5	6840.3	67207.5	3420.2	70627.6	6453.7	64173.9	140.2
0	Jalane	2700.7	2430.6	4916.7	36459	2458.3	38917.3	2062.5	35377.3	655.8
50	Jalane	2869.7	2582.7	5052.7	38740.5	2526.4	40933.8	4194.4	36739.4	D
100	Jalane	2984.3	2685.9	4780.7	40288.5	2390.4	42507.9	4947.5	37560.4	109
150	Jalane	3210.4	2889.4	4595.9	43341	2297.9	45638.6	5700.6	39937.9	315.7
200	Jalane	3279.2	2951.3	5018.5	44269.5	2509.3	46778	6453.7	40324.3	D
0	Sanate	3508.1	3157.3	5936.3	47359.5	2968.2	50327.2	2062.5	48264.7	180.8
50	Sanate	4062.5	3656.3	6321.5	54844.5	3160.8	58004.5	4194.4	53810.1	260.1
100	Sanate	4936.8	4443.1	7289.5	66646.5	3644.8	70291.9	4947.5	65344.4	1531.6
150	Sanate	6261.7	5635.5	7756.3	84532.5	3878.2	88410.7	5700.6	82710	2305.8
200	Sanate	6424.4	5781.9	8707.3	86728.5	4353.6	91083.3	6453.7	84629.5	254.9

Where, GFB=gross field benefit, TVC = total variable costs; NB = net benefit, MRR = marginal rate of return; ETB ha^{-1}=Ethiopian ETB ha^{-1}, AVGY=average grain yield, AdGY= adjusted grain yield, SY= straw yield, D=dominated treatments. At sowing the Cost of bread wheat seed= Birr 16.50 kg^{-1}, NPS cost=15.0623 Birr kg^{-1}, Urea cost= 13.7878 Birr kg^{-1}. The labour cost for application of NPS 10 persons ha^{-1}, each 70 ETB day^{-1}), and Urea (12 persons ha^{-1}, each 70 ETB day^{-1}), Market price of bread wheat grain =15 Birr kg^{-1} and straw=0.5 Birr kg^{-1} in Ejersa Goro town at harvesting time in December 2019.

5. SUMMARY AND CONCLUSION

Bread wheat is one of the major staple and strategic food security crop in Ethiopia. However, wheat yield in Ethiopia and the study zone are low as compared to the attainable yield because wheat production is constrained by low soil fertility, cultivation of unimproved low yielding varieties, use of inappropriate fertilizer type and rate, disease, insect pests, poor management practices and moisture stress. Moreover, the effects of blended NPS fertilizer rates on yield components and yield has not been studied in Jarso district. Therefore, this research was initiated to evaluate the effects of blended NPS fertilizer rates on yield components and yield of bread wheat varieties and to identify economically feasible rate of blended NPS fertilizer in Jarso district during the main cropping season in 2019.

The experiment was conducted at Afugug FTC in Jarso District, East Hararghe Zone, Oromia Region. The experiment was laid out by a factorial combination of the five NPS fertilizer levels (0, 50, 100, 150 and 200 kg ha^{-1}) with three bread wheat (*Jalane, Ogolcho* and *Sanate*) varieties and currently recommended 100 kg ha^{-1} Urea. The experiment was tested in factorial arrangement in randomized complete block design with three replications.

Analysis of the results showed that parameters like 50% days to heading, 90% physiological maturity, number of total tillers, number of productive tillers, lodging percent, number of kernels per spike, thousand kernels weight, above ground biomass, grain yield, straw yield and harvest index were highly affected by the main effect of NPS fertilizer rates and varieties. While, plant height and spike length were highly affected by the main effect of NPS fertilizer rates and significant effect by varieties. However, all parameters were not significantly affected by the interactions of blended NPS fertilizer rates and variety except above ground biomass and grain yield which were highly affected by the interactions. But, number of total tillers, number of productive tillers and straw yield were significantly affected by the interaction of both factors.

The highest and the lowest mean values of the days to heading (67.56 and 58.78), days to maturity (123.7 and 112.4), plant height (81.38cm and 70.75cm), spike length (8.67cm and 6.62cm), kernels per spike (64.56 and 44.56), lodging percent (28.89% and 14.22%), thousand kernels weight (47.33 and 40.33) were recorded due to the application of 200 kg ha^{-1} and from the control treatments, respectively. While, the highest and the lowest value of harvest index (0.43 and 0.41) was recorded from 150 kg ha^{-1}. Moreover, the highest and the lowest mean value of plant height (78.36cm and 74.94cm), kernels per spike (58.73 and 53.33) Straw yield (7202 and 4873) and harvest index (0.41 and 0.38) were recorded on *Sanate* and *Jalane* varieties. Furthermore, the interaction of NPS with variety the highest and the lowest (379.6 and 128.1) mean values of productive tillers was recorded from the combination of *Sanate* variety with 150kg ha^{-1} and *Jalane* variety with zero kg ha^{-1} NPS, respectively. Similarly, the highest and the lowest (11.04 and 1.13) agronomic efficiency was obtained from the combined application rate of 150 kg ha^{-1} with *Sanate* variety and 50 kg ha^{-1} fertilizer rates with *Jalane* variety, respectively. However, the highest and the lowest (6424 and 2701 kg ha^{-1}) mean of grain yield was recorded from the combined application rate of 200 and 0 kg ha^{-1} NPS fertilizer rates with *Sanate* and *Jalane* varieties, respectively.

The research results indicated that the variety as well as rates of blended fertilizer had significant influence on yield and yield components. The application of 200 kg NPS ha^{-1} and *Sanate* variety produced highest grain yield with higher mean values for most of the yield parameters without significant difference to 150 kg NPS ha^{-1}. The growing of *Sanate* variety with the application of 150 kg NPS ha^{-1} had highest marginal rate of return in percent (2305.8%) and net benefit (82710 Birr ha^{-1}) than any other treatment combinations (as compared economically). Therefore, it can be concluded that the application of 150 kg NPS ha^{-1} in addition to 100 kg ha^{-1} Urea and the growing of *Sanate* variety could be better choice of the farmers of the study area to obtain high yield with higher rate of return. However, since the experiment was conducted for one season at one location, it is suggested that the experiment has to be repeated over seasons and locations using this and other improved bread wheat varieties in order to give a comprehensive recommendation.

6. REFERENCES

Abdi Ahmed. 2016. Response of Bread Wheat (Triticum aestivum L.) Varieties to the Application of Mineral NP Fertilizers and Farmyard Manure in Jigjiga Plain, Eastern Ethiopia. PhD Dissertation in Agriculture. Haramaya University, Haramaya Ethiopia.

Abu, T. 2012. Grain and feed annual report. Grain report number: ET1201, Addis Ababa, Ethiopia (*Triticum aestivum* L.*). Research in Plant Biology*, 3 (1): 33-36.

Akram, M.A. 2000. Effect of Irrigation and Nitrogen levels on The Growth, Yield and Grain Quality of Wheat, Bangladesh. *Journal of Agri*, 8:108-114.

Alam, M. S. and Jahan, I. 2013. Yield and yield components of wheat as affected by phosphorus fertilization. *Rajshahi University Journal of Life and Earth and Agricultural Sciences,* 41:21-27.

Alam, M.M., Islam, Md.N., Rahman, M.S, Halaluddin, Md. and Hoque. M. Md. 2003. Effect of Sulfur and Nitrogen on the yield and seed quality of maize (cv. Barnali). *Online journal of biological sciences,* 3(7):643-654.

Ali, H., Shakeel, A., Hina, A. and Hassan, F.H. 2005. Impact of Nitrogen Application on Growth and Productivity of Wheat (*Triticum aestivum* L.). *Journals of Agricultural Science,* 3:216-218.

Ali, M.K., Alam, M.F., Alam, M.N., Islam, M.S. and Khandaker, S.M. 2007. Effect of nitrogen and potassium level on yield and quality seed production of onion. *J. Appl. Sci. Res*,*3*(12):1889-1899.

Ali, R., Khan, M.J. and Khattak, R.A. 2008. Response of rice to different sources of Sulfur (S) at various levels and its residual effect on wheat in rice-wheat cropping system. *Soil Environment,* 27(1): 131-137.

Amanuel Gorfu, Kefyalew Girma, Tanner D.G., Assefa Tamam, and Shambel, M. 2000. Effect of crop rotation and fertilizer application on wheat yield performance across five years at two locations in South Eastern Ethiopia; In: The Seventh Regional Wheat Workshop for Eastern, Central and Southen Africa, Addis Ababa, Ethiopia.

Amare Aleminew, Adane Legas, and Mekonen Misganaw. 2015. Yield Response of Bread Wheat to Timing of Urea Fertilizer Application in Eastern Amhara Region. Sirinka Agricultural Research Center, Woldia, Ethiopia. *Journal of Biology, Agriculture, and Healthcare,* 5 (3):180-183.

Amsal Tarekegn, Tanner, D.G. and Chanyalew Mandefro.2000. Agronomic and economic evaluation of the on-farm N and P response of bread wheat grown on two contrasting soil types in Central Ethiopia. Regional Wheat Workshop for Eastern, Central and Southern Africa, Addis Ababa, Ethiopia, 18-22 Sep 2000.

Asnakew Woldeab, Tekalign Mamo, Mengesha Bekele and Tefera Ajema. 1991. Soil fertility management studies on wheat in Ethiopia. Pp. 137-170.

Ayoub, M.,Guertin, S., Lussier, S. and Smith, D.L.1994. Timing and level of nitrogen fertility effects on spring wheat yield in eastern Canada. *Crop science*, *34*(3):748-756.

Baraich, A.A., Baraich, A.H., Chattha, S.H. and Salarzi, A.U.2012. Impact of the phosphorus and potassium on the growth and yield of wheat cv. mehran-89. *Pakistan J. Agri.*

Behera, U.K., Chougule, B.A., Thakur, R.S., Ruwali, K.N., Bhawsar, R.C. and Pandey, H.N. 2000. Influence of planting dates and nitrogen levels on yield and quality of durum wheat (*Triticum durum*). *Indian Journal of Agricultural Sciences*, *70*(7):434-436.

Bekele Hunde, Kotu, H. Varkuijl, W. Mwangi, M. and Tanner, D.G. 2000. Adaptation of improved wheat technologies in Adaba and Dodola woredas of the Bale highlands, Ethiopia. Mexico D.F:International Maize and Wheat Improvement Centre

Bereket Haileselassie, Dawit Habte, Mehretab Haileselassie, Gebremedhin Gebremes kel.2014. Effects of mineral nitrogen and phosphorus fertilizers on yield and nutrient utilization of bread wheat *(Triticum aestivum*) on the sandy soils of Hawzen District, northern Ethiopia. *Agriculture, Forestry and Fisheries*, 3(3):189–198.

Brady, N.C. and Weil, R.R. 2002. The nature and properties of soils, 13th. *Pearson educat (Singapore) Pte. Ltd. Indian Branch*, 482:621-624.

Brian N. Otteson, Mohamed Mergoum and J. K. R. 2007. Seeding rate and nitrogen management effects on spring wheat yield and yield components. Agronomy Journal, 99(6):1615-1621.

Byerlee D., Spielman, Alemu Dawit and Gautam, Madhur.2007. Policies to promote cereal intensification in Ethiopia: *a Review of Evidence and Experience*, IFPRI discussion papers 00707, Washington DC: International Food Policy Research Institute.

CIMMYT (Centro International de Mejoramiento de Maize y Trigo/ International Maize and Wheat Improvement Center). 1988. From Agronomic data to Farmer Recommendations: An Economic work Book. Mexico, D.F.: CIMMYT.

Clark, R.B. 1990. Physiology of cereals for mineral nutrient uptake, use and efficiency. In Crops as enhancers of nutrient use. (Eds.):V.C. Baligar and R.R. Dunean. Academic Press Inc.,pp. 131-183.

Cooke, R.J, Law, JR. 1998. Seed storage protein diversity in wheat varieties. *Plant Var Seeds,* 11: 159–167

Craswell ET, Godwin DC (1984). *In:* Mengel, K. and E.A. Kirkby, 1996. Principles of plant nutrition. Panima Publishing Corporation, New Delhi, India

CSA (Central Statistical Agency). 2017. Agricultural sample survey Report on area and production for major crops, 1: 1-122

CSA (Central Statistical Authority). 2016. Agricultural sample survey 2015/16. Volume I.Report on area and production of major crops for private peasant holdings, meher season. *Statistical bulletin* 584. Central Statistical Agency, Addis Ababa, Ethiopia.

Damene Darota. 2003. Yield Response of Bread Wheat (*Triticum aestivum* L.) to Applied Levels of N and P Fertilizers on Nitisol of Dawro Zone, Southwestern Ethiopia. MSc. Thesis. Haramaya University, Haramaya Ethiopia.

Daniel, T.C., Sharpley, A.N. and Lemunyon, J.L. 1998. Agricultural phosphorus and eutropication: a symposium overview. *J. Environ. Qual*, 27: 251-257.

Dercon S, Gilligan, D. Hoddinott, J. and Tassew Woldehanna. 2009. The Impact of Ro ads and Agricultural Extension on Consumption Growth and Poverty in Fifteen Ethiopian Villages. *American Journal of Agricultural Economics,*91(4):1007-1021.

Doberman, A. and Fairhurst T. 2000. *Rice: Nutrient Disorder and Nutrient Management. Handbook Series.* Potash and Phosphate Institute of Canada and International Rice Research Institute. 191p.

Donald, L.S. 2004. Understanding and reducing lodging in cereals. Advances in Agronomy, 84:217–271.

Easson, D.L., White, E.M. and Pickles, S.J. 1993. The effects of weather, seed rate and cultivar on lodging and yield in winter wheat. J. *Agric. Sci.,* 121(2): 145-156.

Emam, Y., Ranjbaran, A.M. and Baharani, M.J. 2007 Evaluation of Yield and Yield Components in Wheat Genotypes under Post-Anthesis Drought Stress. JWSSI s fahan University of Technology, 11; 317-328.

Endale Kefyale. 2010. Fertilizer consumption and agricultural productivity in Ethiopia. Addis Ababa, Ethiopia: Ethiopian Development Research Institute (EDRI).

Endalkachew Kissi. 2006. Effects of rates and methods of phosphorus placement on residual soil phosphorus, yield and phosphorus uptake of wheat in *Nitosols* of Kulumsa area, Arsi Zone. An MSc Thesis, Alemaya University, Ethiopia.

EthioSIS (Ethiopian Soil Information System). 2014. Soil analysis report. Tentative list of fertilizers required in Oromia Region for 124 surveyed Woredas. Addis Ababa, Ethiopia.

Eyob Bezabeh, Tesfay Haregewoin, Dejene Hailegiorgis, Fitsum Daniel and Baye Belay. 2015. Change and growth rate analysis in the area, yield and production of wheat in Ethiopia. Ethiopian Institute of Agricultural Research. *Research Journal of Agriculture and Environmental Management*, 4(4):189-191

FAO (Food and Agriculture Organization of the United Nation). 2000. Fertilizers and their use.4th ed. International Fertilizer Industry Association. Food and Agricultural organization of the United Nations. Rome Italy.

FAO (Food and Agriculture Organization). 2014. Food Balance Sheets. Rome: FAO. Athttp://faostat.fao.org/site/368/Desktop Default. aspx? Page ID=368#ancor. Accessed on 20 May, 2017

FAOSTAT (Food and Agriculture Organization of the United Nations). 2013. World crop production data. Available at: (http://www.faostat.fao.org/site. Accessed on February 20, 2018.

Gemechu Gerba. 2011. Influence of Nitrogen and Phosphorus Fertilizers on Seed Yield and Quality of Maize (*Zea mays* L.) at Bedele, Southwestern Ethiopia. MSc Thesis. Haramaya University, Haramaya Ethiopia.

GenStat, 2015. *GenStat Procedure Library Release. 18th edition*. VSN International Ltd.

Greenwood, D.J. 1981. Fertilizer use and food production: World scene. *Fertilizer Research*, 2: 33-51

Hailu Gebremariam. 1991. Wheat production and research in Ethiopia. pp. 1-15. In: Hailu G.M., Tanner, D.G., Mengistu, H. (eds.). Wheat Research in Ethiopia: A Historical Perspective. IAR/CIMMYT, Addis Ababa, Ethiopia.

Howard, J., Crawford, E., Kelly, V., Mulat Demeke, and Jeje, J.J.2003. Promoting high-input maize technologies in Africa: the Sasakawa-Global 2000 experience in Ethiopia and Mozambique. *Food Policy*, 28(4):335-348.

Hussain, M.I., Shah, S.H. 2002. Growth, yield and quality response of three wheat (*Triticum aestivum* L.) varieties to different levels of N, P and K fertilizers. *International Journal of Agriculture and Biology,*4 (3):362-364.

Iqtidar, H., Muhammad, A. K., Ejaz, A. K. 2006. Bread wheat varieties as influenced by different nitrogen levels. *Journal of Zhejiang Univ. Science,* 7 (1):70-78.

Jarso woreda Office of Agriculture and Natural Resources Main Coordinate, 2019.E/Goro.

Jemal Abdulkerim, Tamado Tana and Firdissa Eticha. 2015. Response of Bread Wheat (Triticum aestivum L.) Varieties to Seeding Rates at Kulumsa, South Eastern Ethiopia. *Asian Journal of Plant Sciences*,14(2):50–58.

Johnson, J.W. 1999. Most asked agronomic questions. In Ohio State University Extension, J.W. Johnson and C. Hudak (eds.), Extension Bulletin E-760-88.Columbus,OH: The Ohio State University, USA.

Kaleem S., Ansarm.,Ali M., Sher A. and Rashid M. 2009. Effect of Phosphorus on the Yield and Yield Components of Wheat Variety Inqlab-91 Under Rainfed Conditions Sarhad *Journal of Agriculture*, 25(1):1989–1992.

Khursheed MQ, Mahammad MQ.2015. Effect of different nitrogen fertilizers on growth and yield of wheat. *Zanco J. Pure Appl. Sci*. 27(5):19-28.

Kumar, R., Nanwal, R.K. and Agarwal, S.K. 2006. NPK content and uptake as affected by planting systems, seed rates and N levels in wheat (*Triticum aestivum* L.). Haryana University *Journal of Agricultural Research*, 36 (2) : 93-96.

Lafarge, T., Tubana B. and Pasuquin E. 2004. Yield advantage of hybrid rice induced by its higher control in tiller emergence. *Proceedings of the 4th International Crop Science Congress*, 26 September-October1,2004, Brisbane, Australia.

Landon, J.R. 1991. Booker Tropical Soil Manual: a handbook for soil survey and agricultural land evaluation in the tropics and subtropics. (eds.). John Wiley & Sons Inc., New York.

Leytem, A.B. and Mikkelsen, R.L. 2005. The nature of phosphorus in calcareous soil. *Better Crops*, 89:11-13.

Malik, D.M., Chaudhry, R.A. and Sherazi, S.J.A. 1992. Management of phosphorus for wheat production in Punjab.In:Proc. Symp. On the Role of Phosphorus in Crop Production. NFDC, Islamabad. Pakistan. pp. 175- 195.

Maqsood, M., Akbar, M., Yousaf, N., Mehmood, M.T. and Ahmad, S. 1999. Effect of different rate of N, P and K combinations on yield and components of yield of wheat.*Int.J.Agri.Biol*,1(4):359-361

Marschener, K. 1995. *Mineral nutrition of higher plants. 2nd ed*. Academic press, London.398p.

Mathewos, A., Tewodros, M. and Yasin, G. 2012. Participatory on-farm evaluation of improved bread wheat technologies in some districts of southern Ethiopia. Journal of Biology, Agriculture and Healthcare, 2 (4): 85-91.

Melesse Harfe. 2017. Response of Bread Wheat (*Triticum Aestivum L.)* Varieties to N and P Fertilizer Rates in Ofla District, Southern Tigray, Ethiopia. *African Journal of AgriculturalResearch*,12(19):1646–1660.

Mengel, K. and Kirkby, E.A. 1996. *Principles of Plant Nutrition*. Panimo Publishing Corporation, New Delhi, India.

Mesfin Kassa and Zemach Sorsa. 2015. Effect of Nitrogen and Phosphorus Fertilizer Rates on Yield and Yield Components of Barley *(Hordeum Vugarae* L.) Varieties at Damot Gale District, Wolaita Zone Ethiopia. *American Journal of Agriculture and Forestry*, 3(6):271–275.

Minale Liben, Alemayehu Assefa, Tilahun Tadesse and Abreham Mariye. 2006. Effect of Nitrogen and phosphorus fertilizers on the yield of bread wheat (*Triticum aestivum* L.) in major wheat growing areas of northwestern Ethiopia. *Proceedings of the 1st Annual Regional Conference on Completed Crop Research Activities*. Amhara Regional Agricultural Research Institute, Bahir Dar, Ethiopia, pp 84-90.

Ministry of Agriculture and Natural Resource. 2013. Ethiopia is transitioning into the implementation of soil test based fertilizer use system. www. moa. gov. et / documents/93087/.../ be8d5386-e5fb-4ca3-8ff0-d295bc603e70

MoA (Ministry of Agriculture). 2012. Animal and Plant Health Regulatory Directorate. *Crop Variety register, Issue No. 15*. Addis Ababa, Ethiopia.

MoALR (Ministry Of Agriculture and Livestock Resource). Plant Variety Release, Protection and Seed Quality Control Directorate. Crop Variety Register. June, 2017. Addis Abeba, Ethiopia.

MoANR (Ministry of Agriculture and Natural Resources). Plant variety release protection and seed quality control directorate. Crop variety register. June, 2016. ISSUE No. 19.Addis Abeba, Ethiopia.

Mollasadeghi V, Shahryari, R. 2011. Important morphological markers for improvement of yield in bread wheat. *Advances. Environmental Biology*, 5 (3): 538 – 542.

Nasser, K.h. El-Gizawy, B. 2009. Effect of Planting Date and Fertilizer Application on Yield of Wheat under No till System. *World Journal of Agricultural Sciences*, 5 (6): 777-783.

Nehara, K. C. Kumawat, B. Singh, P. 2006. Response of Fenugreek (*Trigonella foenumgraecum* L.) to phosphorus, sulphur and plant-growth regulators under semi-arid eastern plains zone of Rajasthan. *Indian Journal of Agronomy*, 51(1):73-76.

Olsen, S.R., Cole, V., Walambe, C.V. and Dean, L.A. 1954. Estimation of Available P in Solis by Extraction with Sodium Bicarbonate. USDA Circ. No. 939, Washington DC.

Ortiz-Monasterio, J.I., R.J. Pena, K.D. Sayre, and S. Rajaram. 1997a. CIMMYT's genetic progress in wheat grain quality under four nitrogen rates. *Crop Sci*. 37(3): 892-898.

Otteson, B.N., Mergoum, M. and Ransom, J.K. 2007. Seeding rate and nitrogen management effects on spring wheat yield and yield components. *Agronomy journal*, 99(6):16151621.

Prystupa, P.,Slafer, G.A. and Savin, R. 2004. Leaf appearance, tillering and their coordination in response to NxP fertilization in Barley. *Plant and Soil*,255(2):587-594.

Saeed, B., Gul, H., Khan, A.Z. and Parveen, L. 2012. Growth factors and straw yield of wheat cultivars in relation to nitrogen and sulfur fertilization. *ARPN J. Agri. Biol. Sci.,* 7(1):13-22.

Samuel Tegene, Fuad Abdusalam, Zeleke Legesse.2014. Assessment of Prevalence and Severity of Wheat Rusts in the Wheat Growing Areas of Eastern Hararghe and Efforts in Managing These Diseases. *ARPN. Journal of science and technology,* 4(3).ISSN 2225-7217.

Schulthess, Urs., Boy Feil and Jutzi, S. C. 1997. Yield independent variation in grain nitrogen and phosphorus concentration among Ethiopian wheat. *Agronomy*, 89 (3): 497-506.

Sharer, M.S., Ayub, M., Nadeem , M.A. and Ahmad, N. 2003. Effect of Different Nitrogen and Phosphorus on Growth and Grain Yield of Maize. *Asian Journal of Plant Sciences,* 2 (3): 347-349.

Shivran, A.C., and Yadav, B.L. 2013. Effect of NP fertilizers, vermicompost, and sulphur on growth, yield, and quality of cluster Bean (*cymopsiste tragonoloba* L.)) and their residual effect on grain yield of succeeding wheat (*Triticum aestivum* L.)). *Legume Research: An International Journal,* 36(1).

Singh, J. Skerritt, J.H. 2001. Chromosomal control of albumins and globulins in wheat grain assessed using different fractionation procedures. *Journal of Cereal Science,* 33: 163–181

Spielman D. J. Dawit Kelem work, and Dawit Alemu. 2011. *Seed, fertilizer, and agricultural extension in Ethiopia*. ESSP II Working Paper 020. International Food Policy Research Institute (IFPRI). Washington, DC, USA.

Suleiman A. A., Nganya J.F.and Ashraf M.A. 2014. Effect of Cultivar and Sowing Dateon Growth and Yield of Wheat (*Triticum aestivum* L.) in Khartoum, Sudan: *Journal of Forest Products & Industries*,3(4):198-203.

Tagesse Abera. 2017. Effect of Blended NPS Fertilizer Supplemented with Nitrogen on Yield Component and Yield of Bread Wheat (*Triticum aestivum* L.) In Soro District, Hadiya Zone Southern Ethiopia. Msc.Thesis. Haramaya University, Haramaya Ethiopia.

Tamrat Tesema. 2006. Effect of nitrogen and phosphorous application on seed yield and nutrient uptake of onion (*Allium cepa* var. cepa). M.Sc. Thesis, Haramaya University, Ethiopia.

Tanner, D.G., Amanuel Gorfu, and Kasahun Zewde. 1993. Wheat agronomy research in Ethiopia. pp 95-136. In: Haillu Geber-mariam, D.G. Tanner and Mengsitu Huluka (Eds.). Wheat research in Ethiopia; a historical perspective, Addis Ababa, IAR/CIMMYT.

Tazeh, E.S., Aliasgharzadeh, N., Rameshknia, Y., Rad, S.N. and Tahmasebpoor, B. 2012. Effect of Microbial sulfur Municipal Compost for Wheat Plant. *Universal J. Environ. Res. and Tech*., 2(6):551-559.

Tekalign Mammo, Teklu Erkossa and Balesh Tulema. 2001. Soil Fertility and Plant Nutrition Research on Tef in Ethiopia. pp. 199-200. In: Hailu Tefera, Getachew Belay and Mark Sorrels (eds.) Narrowing the Rift. *Tef* Research and Development, *Proceedings of the International Workshop* on *Tef* Genetics and Improvement, 16-19 October, 2000. Addis Ababa, Ethiopia, pp 167-176.

Tekalign Tadesse. 1991. Soil, plant, water, fertilizer, animal manure and compost analysis. Working Document No. 13. International Livestock Research Center for Africa, Addis Ababa

Tilahun Gelato, Feyissa Tadesse, Kedir Nero, Genene Gezu, Habtamu Seboka, Ashinie Bogale and Abdo Woyema. 2008. Recommendations of production management practices.pp.39-46. *In:* Kedir, N., Tilahun Gelato, G. and Allo Aman. (eds.). *Fifteen years achievements*. Oromia Agricultural Research Institute, Sinana Agricultural Research Center, Bale Robe, Ethiopia.

Tilahun Geleto, Kedir Nefo and Feyissa Tadesse, 2000. Crop rotation effects on grain yield, and yield components of bread wheat in Bale highlands of southeastern Ethiopia. pp.316-330. In: The Eleventh Regional Wheat Workshop for Eastern, Central and Southern Africa. CIMMYT, Addis Ababa, Ethiopia

Tisdale, S.L., Nelson, W.L., Beaton, J.D. and Havlin, J.L. 1993. Soil Fertility and Fertilizers. 5th edn. MacMilln Company, New York. pp. 634.

USDA (United States Department of Agriculture). 2013. Grain: world markets and trade. Accessed at http://www.fas.usda.gov/data/grain-world-market-and-trade. Accessed on May 10, 2017

Wakene Tigre, Walelign Worku and Wassie Haile. 2014. Effects of nitrogen and phosphorus fertilizer levels on growth and development of barley (*Hordeum vulgare* L.) at Bore District, Southern Oromia, Ethiopia. *American Journal of Life Sciences,* 2(5): 260-266.

Wassie Hailu and Shiferaw Boke. 2011.Response of Irish Potato (Solanum tuberosum) to the Application of Potassium at Acidic Soils of Chencha, Southern Ethiopia. *International Journal of Agricultural Biology* 13: 595–598.

Wogene Solomon and Agena Anjulo. 2017. Response of Bread Wheat Varieties to Different Levels of Nitrogen at Doyogena, Southern Ethiopia. *International Journal of Scientific and Research Publications*, 7(2):452–59.

Woinshet Tariku. 2007. Effect of nitrogen fertilizer levels on grain yield and malt quality of different malt barley (*Hordeum vulgare* L.) varieties in Shashemane woreda. MSc. Thesis. Hawassa University, Hawassa Ethiopia.

Workineh Assefa, Yemane Nega and Dawit Hapte. 2015. Planting density, and nitrogen and phosphorus fertilization effect on different bread wheat (*Triticum aestivum* L.) genotypes in Southern Tigray, Ethiopia. *World Journals Agricultural Science*, 3 (2): 020-028.

World Fact book. 2012. https://www.cia.gov /library/ publications / the world fact book / fields /2012. Html. Accessed on March 19, 2018.

Wu, G., Wilson, L.T. and McClung, A.M.1998. Contribution of rice tillers to dry matter accumulation and yield. *Agronomy Journal*, 90(3):317-323.

Yasir, H., Zahid, H., Shad, K.K., Zafar, H.K., Ikramullah, M.A., Tariq, S. and Farooq, S. 2015. Effects of Nitrogen and Foliar Sulphur Applications on the Growth and Yield of Two Wheat Varieties Grown in Northern Pakistan. ARPN *Journal of Agricultural and Biological Science*, 10(4):139 – 145.

Zeleke, G., Agegnehu, G., Abera, D. and Rashid, S. 2010. Fertilizer and soil fertility potential in Ethiopia: Constraints and opportunities for enhancing the system. IFPRI, Addis Ababa, Ethiopia, 63p.

Zhang, Z.Y., Sun, K.G., Luli, A.Y. and Zhang, X.B. 1999. Study on the effect of S fertilizer application on crops and the balance of S in soil. *Journal of Agricultural Science,* 5: 25- 27.

7. APPENDICES

Appendix Table 1. Mean monthly annual total rainfall and minimum and maximum temperatures of ten years (2010-2019); mean monthly minimum and maximum temperatures and total rainfall recorded in the experimental area during the experimental year of the test crop (January 2019 – November 2019)

2010-2019 Meteorological Data				2019 Meteorological Data			
Months	Total rainfall (mm)	Min. Temp. (ºC)	Max. Temp. (ºC)	Total rain fall (mm)	Maximu Temp. (ºC)	Minimu Temp. (ºC)	Average Temp. (ºC)
January	66.73	1.76	11.92	60.798	12.16	1.041	6.60
February	63.22	1.77	13.71	62.224	13.25	1.83	7.54
March	68.51	4.73	17.10	69.482	16.98	5.11	11.045
April	69.01	8.41	20.72	75.78	20.53	8.58	14.555
May	65.20	11.53	23.34	74.602	23.28	11.45	17.365
June	75.36	13.96	25.67	74.643	25.94	13.99	19.965
July	87.33	15.14	26.67	76.841	26.94	15.16	21.05
August	89.89	14.65	26.19	89.53	26.37	14.63	20.5
September	71.89	12.68	24.13	91	24.57	12.85	18.71
October	67.49	9.49	20.51	75.612	20.86	9.67	15.265
November	64.27	5.09	16.16	69.433	16.08	5.04	10.56
December	60.27	2.03	13.29	55.62	13.46	2.13	7.795
Total	849.17			875.565			
Average		8. 5	19.93		20.035	8.46	14.25

Source: National Meteorological Agency, Ejersa Goro Branch

Appendix Table 2. Mean square values of ANOVA for days to heading, maturity, plant height and spike length of bread wheat as affected by blended NPS and variety at Jarso during 2019 main cropping season.

Source of variation	DF	Mean squares			
		DH	DPM	PH	SL
Replication	2	28.289	36.689	28.074	0.7048
Blended NPS	4	124.644**	200.700**	211.018**	7.0940**
Variety	2	222.289**	4963.756**	50.195*	1.5660*
NPS X Variety	8	1.011ns	1.950ns	5.015ns	0.2950ns
Error	28	4.146	3.546	5.755	0.2055
CV(%)		3.2	1.6	3.1	5.8

Where, D.F= degree of freedom, DH= Days to heading, DPM= Days to physiological maturity, PH= plant height, SL=spike length; ANOVA =Analysis of variance; CV=coefficient of variation, NS=non-significant difference; ** and * significant at 1% and 5% level of significant, respectively.

Appendix Table 3. Mean square values of ANOVA for lodging percent, Number of total tillers and Number of productive tiller of bread wheat as affected by blended NPS and variety at Jarso during 2019 main cropping season

Source of variation	DF	Mean squares		
		LP	NTT	NPT
Replication	2	9.489	2950.0	3366.4
Blended NPS	4	381.833**	63429.9**	60255.6**
Variety	2	87.222**	20347.0**	20261.4**
NPS X Variety	8	4.083ns	1417.3*	1537.0*
Error	28	2.013	470.9	505.6
CV(%)		6.4	8.8	9.6

Where, D.F= degree of freedom, LP= lodging percent, NTT= Number of total tillers, NPT= Number of productive tiller ANOVA =Analysis of variance; CV = coefficient of variation, NS, * and ** = non-significant, significant at 5% level of significant and significantly different at level of 1%, respectively.

Appendix Table 4. Mean square values of ANOVA for number of kernels per spike, thousand kernels weight y and above ground dry biomass of bread wheat as affected by blended NPS and variety at Jarso during 2019 main cropping season

		Mean squares		
Source of variation	DF	NKPS	TKW	AGDB
Replication	2	57.622	38.422	111146
Blended NPS	4	657.800^{**}	77.856^{**}	13598500^{**}
Variety	2	109.489^{**}	50.422^{**}	72137844^{**}
NPS X Variety	8	9.433^{ns}	1.589^{ns}	3747584^{**}
Error	28	9.598	3.089	412194
CV(%)		5.5	4.0	6.3

Where, D.F= degree of freedom, NKPS= Number of kernels per spike; TKW= thousand kernels weight, AGDB= above ground dry biomass; ANOVA =Analysis of variance; CV = coefficient of variation, NS, * and ** = non-significant, significantly different at 5% and 1%, respectively.

Appendix Table 5. Mean square values of ANOVA for yield, straw yield and harvest index of bread wheat as affected by blended NPS and variety at Jarso during 2019 main cropping season

Source of variation	DF	Mean squares		
		SY	YLD	HI
Replication	2	144521	11881	0.0002454
Blended NPS	4	2325108^{**}	5049184^{**}	0.0063076^{**}
Variety	2	20529550^{**}	15710764^{**}	0.0029578^{**}
NPS X Variety	8	1042757^{*}	856535^{**}	0.0000663^{ns}
Error	28	244834	36181	0.0001709
CV(%)		8.1	4.6	3.3