EFFECTS OF BLENDED (NPSB) FERTILIZER RATES ON YIELD AND YIELD COMPONENTS OF BREAD WHEAT (*Triticum aestivum* L.) VARIETIES IN HULBAREG DISTRICT, SOUTHERN ETHIOPIA

MSc THESIS

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DECEMBER 2020

HARAMAYA UNIVERSITY, HARAMAYA

Effects of Blended (NPSB) Fertilizer Rates on Yield and Yield Components of Bread Wheat (*Triticum aestivum* L.) Varieties in Hulbareg District, Southern Ethiopia

A Thesis Submitted to School of Plant Sciences, Postgraduate Program Directorate
HARAMAYA UNIVERSITY

In Partial Fulfillment of the Requirements for the Degree of MASTER OF SCIENCE IN AGRICULTURE (AGRONOMY)

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December 2020

Haramaya University, Haramaya

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I hereby certify that I have read and evaluated this thesis entitled **'Effects of Blended (NPSB) Fertilizer Rates on Yield and Yield Components of Bread Wheat (*Triticum aestivum* L.) Varieties in Hulbareg District, Southern Ethiopia'** Prepared under my guidance by Muzayin Kamil. I recommend that it be submitted as fulfilling the thesis requirement.

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DEDICATION

Dedicated to my beloved wife Medina Duna and my mother Shega Ashebo for the all-rounded and unconditional support rendered to me for the betterment of my life.

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm 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.

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BIOGRAPHICAL SKETCH

Mr. Muzayin Kamil was born on the 19th of July 1990 at a small village called Shurmo Kebele in Lemo District in Hadya, Zone of Southern Nation, Nationalities and Peoples' Regional State (SNNPRS), Ethiopia, from his father Kamil Haji and his mother Shega Ashebo. He attended his elementary education at Shurmo Primary School from 1996 to 2003 and Senior Secondary and Preparatory High School from 2004 to 2007 at Wachemo Secondary and Preparatory School. After passing the Ethiopian Higher Education Entrance Certificate Examination (EHEECE) in 2008, he joined Dilla University College of Agriculture and Rural development and graduated with Bachelor of Science (BSc) degree in Plant Science in July 2011.

After graduation, he was employed as an agronomist in Silte Zone, Hulbareg Woreda Agricultural and Rural Development Office in September 2012 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.

ACKNOWLEDGEMENTS

I express my heartfelt and sincere gratitude to my major advisor Dr Yibekal Alemayehu and co advisor Dr Jemal Abdulahi for their interest in the work, frequent supervision with genuine comments, and reviewing, their guidance, encouragement, support and advices starting from proposal development to Thesis write up.

My special thanks go to the Kulumsa Agricultural Research Center for providing me the seed of the bread wheat varieties I used for the experiment. My sincere thanks also go to Mr. Sefan Shifa head of Angamo Yede kebele agriculture office for his notable support during the research from arranging the farmer training center to facilitating works, materials, follow up and field management. I am deeply indebted to my beloved wife: Medina Duna and my mother Shega Ashebo for their encouragement during my study and in the time of hardships.

I would also like to Thank Hulbareg Woreda Adminstration Office for giving me the opportunity of study.

LIST OF ABBREVIATIONS AND ACRONYMS

ATA	Agricultural Transformation Agency
CSA	Central Statistical Agency
DZARC	Debre Zeit Agricultural Research Center
ETB	Ethiopian Birr
EthioSIS	Ethiopian Soil Information System
HWOA	Hulbareg Woreda Office of Agriculture
KARC	Kulumsa Agricultural Research Center
LSD	Least Significance Difference
MRR	Marginal Rate of Return
NPSB	Nitrogen, Phosphorus, Sulfur and Boron

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Abstract

Low soil fertility and poor crop management practices are among the major constraints limiting the productivity of bread wheat in Ethiopia in general and Hulbareg District in particular. Therefore, a field experiment was conducted in Hulbareg District during the 2019 main cropping season to evaluate the effect of blended NPSB fertilizer rates on yield and yield components and to determine the economically feasible rates for bread wheat production. Factorial combination of three improved bread wheat varieties (Ogolcho,Kekeba and Kingbird) and five rates of NPSB fertilizers (0,50,100,150 and 200) were laid out in randomized complete block design with three replications. The results revealed that the spike length, plant height, thousand kernels weight, above ground dry biomass, grain yield and straw yield were significantly ($P < 0.01$) affected by the main effects of NPSB and variety. The maximum spike length (8.11 cm) and total dry biomass yield (15389 kg ha^{-1}) were obtained at the NPSB rate of 200 kg ha^{-1}. The interaction of fertilizer and variety also significantly affected grain yield, days to physiological maturity and above ground dry biomass yield. The maximum grain yield (6500 kg ha-1), above ground dry biomass kg ha^{-1} (15389), were recorded at combination of the highest rates of NPSB i.e 200 kg NPSB with variety Ogolcho. In general, the economic feasibility of the fertilizer over varieties combination indicated that application of 200 kg NPSB ha^{-1} to Kekeba variety resulted in maximum marginal rates of return of 4202 % . The partial budget analysis revealed that the highest net return (72495 Birr ha^{-1}) with MRR 2711.9% was obtained for Ogolcho from application of 200 kg NPSB ha^{-1}. Based on the result of this study, it can be tentatively concluded that bread wheat variety Ogolcho and NPSB rate of 200 kg ha^{-1} to be appropriate for bread wheat production in the study area.

Keywords: Blended fertilizer; biomass; bread wheat; economic benefit; grain yield; main effect;; partial budget

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) belongs to the family Poaceae, subfamily Pooideae and tribe Triticeae (Clayton *et al*., 2015). Synonyms include Triticum vulgare and there are also many synonyms for subspecies and cultivars (Clayton *et al*., 2015). Wheat (*Triticum aestivum* L.) is the world's leading cereal grain where more than one-third of the population of the world uses as a staple food (Curtis, 2002). Bread wheat is the most widely grown food crop in the world. Wheat Production in 2018 was 731.46 million tons. This year's (2019) production of 764.49 million tons could represent an increase of 33.03 million tons or 4.52% in wheat production around the globe. It ranks first in the world cereal crops accounting for 30% of all cereal food worldwide (USDA, 2020).

Wheat is an important staple food crop all over the world (Mathpal *et al*., 2015). It is one of the most important cereals cultivated in Ethiopia (Jemal *et al*., 2015). Ethiopia is one of the largest wheat producers in the Sub-Saharan Africa, with yearly estimated production of 4.5 million tons on 1.69 million hectares of land in 2018/19 (CSA, 2019) with 2.66 ton yield per hectares (CSA, 2019). Durum and bread wheat are the two major wheat species produced in the country. However, bread wheat surpasses durum wheat in recent years (Eshetu and Zerihun, 2003) due to its wide agro-ecological adaptation and better productivity. Wheat is a leading source of protein in human food (Yong *et al*., 2011). It is one of the daily diets of the Ethiopian population that contributes significantly to the calorie and protein intake. In terms of caloric intake, it is the second most important food in the country next to maize (FAO, 2014).

Wheat is one of the most important cereals cultivated in Silte zone and ranks first in area coverage and total production. The total wheat area and production in the Silte zone is

55,063.25 ha and 132,151.8 tons respectively with the productivity of 2.4 tons ha^{-1} in 2018/19 cropping season (CSA, 2019) which is lower than the national average 2.66 tons ha^{-1} (CSA,2019) and the world 2.8 tons ha^{-1} (USDA, 2019).

There are several factors that lowered the wheat productivity in Ethiopia and in the experiment area such as lack of knowledge about improved wheat production technologies by farmers, poor extension support, biotic stress, low soil fertility, and lack of improved management practices, high cost and inadequate supply of agri-inputs (Demeke and Di Marcantonio, 2013). The yield gap of Silte zone suggests the potential for increasing production through improved soil and crop management practices, particularly increased use of fertilizers and adequate soil fertility maintenance program with the appropriate varieties for the area. Continuous cropping and inadequate replacement of nutrients, nutrients removed in crop harvest or lose through erosion and leaching are the major causes of soil fertility decline in Ethiopia (Hillette *et al*., 2015).

Among the above constraints, low soil fertility and slow progress in developing wheat cultivars with durable resistance to diseases are considered the most important constraints limiting wheat production in Ethiopia (Teklu and Teklawold, 2009). Crop growth requires sufficient, but not excessive supply of essential mineral elements for optimal productivity. An insufficient supply of mineral elements may limit plant growth and development (Nadian *et al*., 2010). Thus, addition of nutrients such as N, P, S and B to less fertile soil is important to increase wheat yield.

For the last four to five decades, Ethiopian agriculture depended solely on urea and Di-ammonium phosphate (DAP), as sources of N and P, respectively. However, recently it is perceived that the production of such high protein cereals like wheat can be limited by the deficiency of S and other nutrients (Assefa *et al*., 2015). It is true that farmers and extensionists can aim at increasing crop yields only in quantity by applying significantly higher amounts of N from urea and DAP. But, in such conditions, failure to supplement S in balanced-fertilizer programmes can rapidly deplete available soil reserve leading to hidden S deficiency (Assefa *et al*., 2015).

Nitrogen is considered as the most deficient nutrients in soils of Ethiopia (Asnakew *et al*., 1991). Nitrogen fertilizer may not be fully utilized if S is deficient and correct S fertilization improves quality of grains. The capabilities of nitrogen fertilizer is to increase protein content, while sulfur fertilizer affects protein composition (Luo *et al*., 2000). Further, Boron is essential for cell division and elongation in meristematic tissues, floral organs and for flower male fertility, pollen tube germination along with its and seed/fruit formation. Boron deficiency impairs grain setting in wheat, resulting in increased number of open spikelet's and decreased number of grains per spike (Marschner, 1995).

Varieties are one of the factors which play an important role in producing higher yield of wheat (Alam and Jahan, 2013). Efficient use of fertilizers depends on performances of variety. So that cultivar selection that optimally utilizes the applied fertilzers plays a very important role in determining grain yield and quality (Brian *et al*., 2007). A study was conducted to know the response of three wheat cultivars (Ogolcho, Kekeba and Kingbird) and five NPSB rates (0, 50, 100, 150 and 200 kg NPSB ha^{-1}) at Hulbareg. The result showed that variety Ogolcho out smart variety Kekeba and Kingbird in grain yield at fertilizer rate of 200 kg NPSB ha^{-1}.

Recent studies have indicated that elements like N, P, K, S and Zn levels as well as B and Cu are becoming depleted and deficiency symptoms are being observed on major crops in different areas of the country (ATA, 2013). Further studies showed that most Ethiopian soils are deficit in macronutrients (N, P, K and S) and micronutrients (Cu, B, and Zn) (EthioSIS, 2014). Macro-nutrients as well as micronutrients are of primary importance in our agriculture system but due to unawareness of the farmers about importance of applying micronutrients and unavailability, the soils are becoming deficient in micronutrients (Muhammad *et al*., 2009). Micronutrients are essential for plant growth and play a vital role in increasing crop yields as they develop plant nutrition and increase soil efficiency (Hamzeh and Florin, 2013). The increases in crop yields from application of B, Cu, Fe, Mn, Mo, and Zn occur in many parts of the world (Martens and Westermann, 1991).

Therefore, this study was undertaken with the following objectives:

- To assess the effect of blended (NPSB) fertilizer rates on yield and yield components of bread wheat varieties, and
- To estimate the economic feasibility of the blended (NPSB) fertilizer rates for wheat production.

2. LITERATURE REVIEW

2.1. Description of Wheat

Wheat evolved from wild grasses, probably somewhere in the Near East. The first cultivation of wheat occurred about 10,000 years ago, as part of the 'Neolithic Revolution', which saw a transition from hunting and gathering of food to settled agriculture. These earliest cultivated forms were einkorn and emmer wheat and their genetic relationships indicate that they originated from the south-eastern part of Turkey (Dubcovsky and Dvorak, 2007). Cultivation spread to the Near East by about 9000 years ago when bread wheat made its first appearance (Feldman, 2001). The main route into Europe was via Anatolia to Greece (8000 BP) and then both northwards through the Balkan to the Danube (7000 BP) and across to Italy, France and Spain (7000 BP), finally reaching the UK and Scandinavia by about 5000 BP. Similarly, wheat spread via Iran into central Asia reaching China by about 3000 BP and to Africa via Egypt.

It is, a self-pollinating annual plant in the true grass family Gramineae (Poaceae), is extensively grown as staple food sources in the world (Mollasadeghi and Shahryari, 2011). It is exclusively produced under rain fed conditions, meher and belg (long and short rainy seasons), respectively. The species of Triticum and their close relatives can be divided into diploid, tetraploid and hexaploid 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 (m.a.s.l), between 6-16° N latitude and 35- 42° E longitude. The most suitable agro- ecological zones, however, fall between 1900 and 2700 m.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 400-1200 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. Growth and Development of Wheat

Plant growth and development are influenced by both environmental and genetic factors (Evans, 1987; Fageria, 1992; Slafer and Rawson, 1994; Arisnabarreta and Miralles, 2008). A good understanding of growth and development can help producers implement appropriate management practices and obtain higher yields. Attention to plant phenology can help guide the timing of N top dressing to stimulate growth and reduce fertilizer N losses. In addition, irrigation can be scheduled at critical growth stages to improve water-use efficiency. Further, an understanding of the crop growth cycle in a given agro-ecological region can help the producer schedule planting to avoid drought and possible adverse effects of low and high temperatures. Knowledge of growth stages is also useful in scheduling tissue sampling at different locations. In addition to visual morphological observations (Haun, 1973; Zadoks *et al.,* 1974; Hay and Kirby, 1991; Kirbyet *et al.,* 1994; Jamieson *et al.,* 1995; Jamieson and Munro, 1999), models of phenological development of cereals, including wheat and barley, have been developed (Laurie *et al.,* 2004; Jamieson *et al.,* 2006).

Plant growth and development are complex processes, depending on many factors both internal and external. They can be considered to begin with germination, followed by a large complex series of morphological and physiological events that are called growth and development (Ting, 1982; Fageria, 1992; Fageria *et al.,* 2006). These two terms are sometimes confused and used interchangeably, but they are different. Growth is an irreversible increase in size or volume accompanied by the biosynthesis of new protoplasmic constituents. Development is a combination of both growth and cellular differentiation, a higher order of change that involves anatomical and physiological specialization and organization. According to Salisbury and Ross (1985), the process by which cells become specialized is called differentiation, and the processes of growth and differentiation of individual cells into tissues and organs are often called development.

According to the above definition, growth is a quantitative aspect of development, representing an increase in the number and size of cells, and differentiation is the qualitative aspect of development (Ting, 1982; Fageria *et al.,* 2006). Growth is usually measured in terms of increase in volume or weight of the crop plant or its organ. In field crops, productivity is the main objective of cultivation; in this situation, dry weight of the plant or plant parts is the preferred measurement of growth. Root and shoot growth,were slow in the beginning, increased until 60 days, and then remained more or less constant. But shoot growth increased significantly after 35 days and continued to increase until maturity. The slow early growth of the shoot may be attributed to the relatively small number of cells that can divide, the small leaf area available for light interception and photosynthesis, and the relatively large percentage of photosynthetic translocated to the roots (Brown, 1984; Fageria *et al.,* 2006).

The root system is a very important organ of the plant which provides mechanical support and absorbs nutrients and water. The root systems of wheat and barley consist of three to six primary or seminal roots growing from the seed and the secondary roots (also called nodal, crown, or adventitious roots) that arise from nodes at the base of the main stem and tillers. Each tiller develops its own roots and can thus become independent of other shoots (Hoad *et al.,* 2001).

In wheat, the culm usually has six nodes, although culms with five or seven are not uncommon (Peterson, 1956; Briggle, 1967). Genetypic differences in tiller formation exist among cultivars due to inherent genetic factors (Hucl and Baker, 1989). As a result, cultivars vary significantly in the number of tillers produced, with many producing only one or two tillers (Otteson *et al.,* 2008). Donald (1968) proposed that auni-culm plant of wheat could be more appropriate than freely tillering cultivars for well-watered crops with high nutrient inputs. Visual quantification of wheat development is provided by Haun (1973). Bauer *et al*. (1987) studied dry matter distribution in wheat and showed that the leaves constitute 100% of shoot dry matter after emergence, about 50% at the flag-leaf stage, and 20% at anthesis. According to Waldren and Flowerday (1979), dry matter accumulation in winter wheat increases rapidly from the jointing growth stage through grain in the stiff dough stage. Translocation of dry matter from leaves to grain begins at flowering, and translocation from culms and head to grain begins at grain filling. Kemanian *et al.* (2007a) reported that the supply of dry matter depends on current photosynthesis and pre-stored reserves. Plant growth occurs through cell division and cell elongation. Areas where cells are actively dividing are called meristem regions. The plant embryo contains only meristem tissue, so all 8 plant parts such as roots, stems, leaves, and flowers are derived from the meristem (Stoskopf, 1981). A detailed description of growth and development of wheat is given by Simmons (1987).

2.3. Production and Importance of Wheat in Ethiopia

Bread wheat (*Triticum aestivum* L.) is one of the most important cereals cultivated in Ethiopia. In 2019, 1.69 million ha of land was covered with production of 4.5 million tons. It ranks fourth after teff, maize and sorghum in area coverage and total production (CSA, 2018); the area coverage in the same year was 2.8, 2.1, and 1.9 million hectares respectively, and with total production of 47.5, 72.2, and 46.3 million quintals respectively. The national average yield of wheat in the country is 2600 kg ha $^{-1}$ (CSA, 2020).

The crop is produced almost in all highland parts of the country with major wheat belt areas of Arsi and Bale areas of Oromia; the other major areas of wheat production include the Shoa, Gojam, and Gonder areas of the country; with minor production found almost in all parts of the highlands (Hailu *et al.,* 1989).

Wheat is one of the important cereal crops in the world and it has the widest distribution among cereal crops. Cereal grains are major contributors to human nutrition throughout much of the world and comprise about 86.68% of total crop production in Ethiopia (CSA, 2016). From the earliest times, wheat has played an important role in the development of civilization. Substantial amounts of wheat are produced in tropical and subtropical environments, although the crop is the number one cereal of the temperate regions. Nutritionally, wheat provides an optimum amount of energy (339 kcal of energy), protein (10.3 g of protein), calcium (49 mg of calcium) and iron (1.5 mg of iron) per 100 g of whole 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 globulins (Singh and Skerritt, 2001).

Wheat produced in Ethiopia is used mainly for domestic food consumption, seed and industrial use. For instance, in 2012/13 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 kind payments for labor. Of the total wheat sold, about 50 percent is commercialized within farmers' district to local retailers and consumers. On average, households in Ethiopia spend 9 percent of their total per capita food expenditure on wheat, second only to maize. Wheat accounts for about 10-15 percent of all the calories consumed in country (Berhane *et al.,* 2011; FAO, 2014). Moreover, estimated total wheat consumption (for food, seed and industrial use) is rapidly increasing at the national level.

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 Tef. In Ethiopia, bread wheat is used for different purpose. The grain of bread wheat is used for bread, biscuits and cookies are some of the industrial products. It is mainly used to prepare traditional recipes such as 'dabo' (Ethiopian bread), 'injera' (thin, flattened bread), 'kolo' (roasted grain), 'nifro' (boiled whole grain, sometimes mixed with pulses) and 'kinche' (crushed kernels, cooked with water and mixed with spiced butter), 'ganfo' (wheat flour cooked with water and mixed with spiced butter) and other food types and beverages in Ethiopia. The straw is a good source of animal feed and it is also used for roof thatching.

Currently with the emerging agro-industries using wheat as a raw material, good quality of bread wheat grain for processing has become increasingly important and the import of wheat. There is a high demand by both commercial and small-scale peasant farmers for wheat varieties with higher grain yield and better end-use quality.

2.4. Wheat Production Constraints 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 showed that wheat farmers in Ethiopia produce on average 2.53 t ha^{-1}, which is far below the experimental yield of above 5.0 t ha^{-1} (Hailu, 1991; MOA, 2012). The yield has consistently lagged behind Africa's and world average wheat yields. In 2012, for instance, Ethiopia's wheat yield was 29 percent below the Kenyan average, 13 percent below the African average, and 32 percent below the world average yield (FAO, 2014b).

Several socio-economic, abiotic and biotic constraint such as poor agronomic practices, poor soil fertility, diseases and pest, lack of improved varieties, weed and low/erratic rainfall are the factors that contribute for these yield gaps. The use of modern production enhancing inputs like improved seeds and fertilizers among wheat farmers in Ethiopia is remarkably low. For example, the 2012 national estimates on input use indicated that only 8.4 percent of wheat was planted with improved seed and 48 percent of wheat areas were fertilized. Fertilizer application rates on fertilized lands are estimated below the average recommended rates although blanket recommendation is common in farmers (Endale, 2010; Spielman *et al.,* 2011; MOA, 2012) only about 39.27 percent of the wheat area was cultivated using improved managements and packages (CSA, 2016), which is unfortunate given the high production response for combined use of improved seeds and fertilizers in Ethiopia (Dercon *et al.,* 2009; Byerlee *et al.,* 2007).

The fertilizer used from 1960s 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 favored the emergence of multi nutrient deficiency in Ethiopian soils (Wassie *et al*., 2011); that in part might have contributed to fertilizer factor productivity decline experienced over recent past. The national soil inventory data also revealed that in addition to nitrogen and phosphorus, sulfur deficiencies are widespread in Ethiopian soils, while some soils are also deficient in potassium, copper, Boron, manganese and iron (EthioSIS, 2013), which all potentially hold back crop productivity despite continued use of N and P fertilizer as per the blanket recommendation. Thus, future gains in food grain production will be more difficult and expensive considering the increasing problem of multi nutrient deficiencies. Other constraints of medium importance include poor seedbed preparation due to lack of oxen, weak oxen, dry season feed shortage, and poor performing plows; water logging problems on Vertisols which forces farmers to plant late, leach of nutrients and yield reduction. Among socioeconomic constraints unavailability of improved inputs like seeds, fertilizers, and herbicides; seasonal shortage of labor mostly in highlands where most crops are planted at the same time which results in shortage of labor during the peak seasons of weeding and harvesting.

Other socioeconomic factors included draft power shortage, land shortages, low prices, and lack of credit facilities (Hailu *et al.,* 1989).

As in many other tropical and sub-tropical regions (Sanchez, 2002), soils in the highlands of Ethiopia usually have low levels of essential plant nutrients and organic matter content. Basically, low availability of N and P has been demonstrated to be a major constraint to wheat production in Ethiopia (Tekalign *et al.,* 1988). This is largely because the cereal dominated mono-cropping system results in continuous nutrient mining through removal by plants with no consideration for replenishment through application of either mineral or organic fertilizer sources (Amsal *et al.,* 1999). 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 (Asefa *et al.,* 1996). Soil nutrient management, as one of the agronomic practices, is essential for obtaining high and sustainable wheat yield.

2.5. Response of Wheat Varieties to Fertilizer Application

In sustainable wheat production the efficiency of fertilization, could be increased by using variety-specific fertilization (Filipov and Dachev, 1999). Different works done on Nitrogen use and genetic variation showed that efficient use of N in crop plant requires adequate genetic variability for traits that determines N use efficiency (Sherrard *et al.,* 1984). Heitholt *et al.,*(1990) suggested that, because of a negative correlation, the possibility of selecting varieties that exhibit high yielding and high grain N concentration is narrow. Comparative study of Arega *et al.,* (2013) on varietal difference and N fertilization on bread wheat grain yield and quality showed significant variations among the varieties for all the agronomic traits, except for grain yield. Mosalem (1993) and Khattab (1994) reported that wheat varieties (Giza 164, Sakha 69 and Giza 163) were superior to the rest of the studied genotypes in most major characters which affected grain yield such as flag leaf area, number of spikelet and grains/spike, grain Weight/spike and 1000 grain weight. In other study, Sharshar and Ei-Said (2000) noted that wheat varieties significantly differed in grain yield and most of yield related traits.

2.6. Effect of Fertilizers on Yield Components and Yield of Bread Wheat

Recent studies have indicated that elements like N, P, K, S and Zn levels as well as B and Cu are becoming depleted and deficiency symptoms are being observed on major crops in different areas of the country (ATA, 2013). Further studies showed that most Ethiopian soils are deficit in macronutrients (N, P, K and S) and micronutrients (Cu, B, and Zn) (EthioSIS, 2014). Macro-nutrients as well as micronutrients are of primary importance in our agriculture system but due to unawareness of the farmers about importance of applying micronutrients and unavailability, the soils are becoming deficient in micronutrients (Muhammad *et al*., 2009). Micronutrients are essential for plant growth and play a vital role in increasing crop yields as they develop plant nutrition and increase soil efficiency (Hamzeh and Florin, 2013). The increases in crop yields from application of B, Cu, Fe, Mn, Mo, and Zn occur in many parts of the world (Martens and Westermann, 1991).

2.6.1. Effect of nitrogen fertilizer application

Nitrogen is one of the important factors that affect the yield and quality of wheat (Dandan and Yan, 2013). Nitrogen is one of the key nutrients that limit crop growth of cereals in many production systems (Fatma *et al*., 2014). Its application is an important input for wheat production (Ejaz *et al*., 2010). Nitrogen is the most important nutrient which affects the assimilate production and distribution and also affecting directly and indirectly the source-sink relation (Aynehband *et al*., 2010).

Nitrogen is a constituent of proteins, enzymes, coenzymes, nucleic acids, phytochromes and chlorophyll; so that it plays an important role in the biochemical processes of the plant (Benin *et al*., 2012). Grains are the most active sink for carbon and N assimilates in cereal after flowering (Aynehband *et al*., 2010). Studies have shown that grain N in wheat mainly represents N accumulated in the vegetative parts until anthesis and translocated to kernel during the reproductive phase. This is mainly due to a reduction in available N when soil N mineralization is not enough to fulfill the crop demand (Fernando *et al*., 2009). The number of spikes per unit area is set before stem elongation (Li *et al*., 2001). So, N fertilization in tillering stage has a significant impact. Wheat is highly responsive to N fertilization, with significant amounts of supplemental N required to maximize grain yields (Tamado *et al*., 2015); application of N fertilizers has been the most direct and effective approach to increase wheat production. In Ethiopia, erratic seasonal rainfall, inadequate availability of other nutrients, nitrate leaching during the short but heavy rainy seasons, ammonia volatilization and continuous removal in the cereal monocropping systems of the highlands may be the major factors that result in inefficient use of N fertilizer (Haile *et al*., 2012).

In Ethiopia, wheat is grown during the high rainfall season and losses of applied N through leaching may be decreased through proper rate and timing of N application (Haile *et al*., 2012). The bread-making quality of bread wheat was primarily dependent on mineral N fertilization; necessary values for bread wheat were predominantly obtained only when mineral N-fertilization rates of 110-160 kg ha^{-1} were applied (Osman *et al*., 2005). Application of 105 kg N ha^{-1} gave the highest mean values of all yield and its components compared as control treatment such increments might be attributed to the favorable role of nitrogen in encouraging in catabolic processes in wheat plants (Goma *et al*., 2015). Actually, fertilizer rate depends on variety, soil, environmental and associated management practices. Grain yield was affected by annual weather conditions in the first place, followed by mineral N fertilization and organic fertilization, respectively (Osman *et al*., 2005). At higher N application rates, top-dressing of N fertilizer significantly increased grain yield, improved grain protein content, and grain N uptake. The increase in grain N uptake and protein content led to an improvement in wheat grain quality (Mohammed *et al*., 2013).

High nitrogen supply favours the conversion of carbohydrates into proteins, which in turn promotes the formation of protoplasm (Arnon, 1972). The increase in the level of applied N increased grain protein percentage. Protein value reached 11.29% (300 kg ha^{-1} N rate) and was higher than 10.32% (250 kg ha^{-1} N rate). Grain yield increased by 1.4 t ha^{-1} in response to N fertilizer applications up to 250 kg N ha^{-1} (De Ruiter and Martin, 2001). Nitrogen increased grain yield primarily by increasing the number of mature spikes (Campbell and Davidson, 1979). With the increasing amount of nitrogen fertilizer, the wheat quality gradually improved and the percentage of weight gain in grain filling stage in kernel increased and got higher kernel yield; the wheat with nitrogen fertilizer rate in 300 kg ha^{-1} gained the best quality and decreasing percentage of wheat gain in grain filling stage in kernel and lower yield (Dandan and Yan, 2013).

Highest values of plant height, effective tillers per m^2, spike length, seeds per spike and biomass yield were obtained from the maximum fertilizer (138/115 N/P_2O_5 kg ha^{-1}) (Assefa *et al*., 2015). (Ejaz *et al*., 2010) reported that increasing levels of nitrogen fertilizer improved grain yield, which seems to be the result of enhanced tiller production and increased kernel number per spike. However, N rate beyond the optimum prolongs the vegetative stage and thereby reducing yield and quality. Nitrogen fertilizer applications that exceed crop N requirements lead to environmental pollution including nitrate N leaching and gaseous N emissions (Tayebeh *et al*., 2011).

2.6.2. Effect of phosphorus fertilizer application

Phosphorus is an important nutrient element on crop production. An adequate quantity from available source of phosphorus is vital for the growth, reproduction, yield and quality of wheat (Alam and Jahan, 2013). It is critical in the metabolism of plants, playing a role in cellular energy transfer, respiration, and photosynthesis. It is also a structural component of the nucleic acids of genes and chromosomes and of many coenzymes, phosphoproteins and phospholipids (Muhammad *et al*., 2010). Phosphorus is also essential for cellular respiration, metabolism of starch and fats which has been investigated by many researchers (Kaleem *et al*., 2009).

Application of adequate amount of phosphorus improves wheat grain yield (Alam and Jahan, 2013). Thus, there is a need to apply the adequate level of phosphorus for obtaining higher yield with good quality product of wheat. Wheat is very responsive to phosphorus fertilizer application on soils that do not provide adequate amounts of this essential nutrient (Mudassar *et al*., 2012). Phosphorus is the second to nitrogen as the nutrient that most commonly limits wheat growth and development. Maximum grain yield was obtained at 128 kg P ha^{-1} indicating importance of phosphorus at its highest dose in achieving maximum wheat productivity (Alam and Jahan, 2013). Maximum phosphorus dose contributed in achieving highest 1000 grain weight and finally resulted in significantly higher grain yield ha^{-1}. The phosphorus fertilizer use can help to reduce the adverse effect of drought under rain fed conditions (Muhammad *et al*., 2010). The Potash and Phosphate Institute, PPI (1999) reported that phosphorus, in balanced soil fertility program, increase water use efficiency and helps crop to achieve optimal performance under limited moisture conditions.

Due to deficiency of phosphorus, growth of root and shoot is restricted, plants become thin and spindly, premature shedding of leaves and flowering occur, yields are consequently decreased (Alam and Jahan, 2013). An application of 60 kg P_2O_5 ha^{-1} to each crop would be desirable for cost effective, optimum production of the soybean-wheat system (Milkha *et al*., 2003). Wheat has high phosphorus requirement, especially during the early growth stages, as phosphorus affects rooting and tillering (Rastija *et al*., 2010). Application of the highest dose of phosphorus contributed to maximum dry matter and physiological attributes towards the yield attributes in wheat and therefore, helped in achieving highest number of grains per spike, 1000 grain weight and ultimately yield of wheat (Alam and Jahan, 2013). In many parts of Northwestern and Northern Ethiopia, applying P fertilizer at the highest rate has significantly enhanced yield and yield components of wheat, maize, barley and teff (Hagos and Hailemariam, 2016).

2.6.3. Effect of sulfur fertilizer application

Sulfur is an essential plant nutrient in crop production required for protein and enzyme synthesis as well as it is a constituent of some of the amino acids (Scherer, 2001). Sulphur, an essential secondary plant nutrient, plays a vital role in biosynthesis of primary metabolities for improving yield and quality of oil seed crops and for accruing better yield under balanced fertilization (Anwar *et al*., 2002). Oil concentration in seed increased with S fertilization (Malhi *et al*., 2007). So an insufficient S supply can affect both yield and quality of the crops (Inal *et al*., 2003). Plants can take up sulfur (S) from the soil as sulfate (SO_4^{-2}) ions and from the atmosphere in a gaseous form as SO_2 through the stomata in leaves (Inal *et al*., 2003). It is an essential constituent of amino acids like cysteine and methionine, several co-enzymes, thioredoxins, sulfolipids, and all proteins containing cysteine and methionine (Anwar *et al*., 2002; Inal *et al*., 2003). Sulfur fertilization increased the amino acids content in the protein of winter wheat in field trials on average of cysteine by 24.5%, methionine by 35.3%, threonine by 14.4% and lysine by 7.7% (Järvan *et al*., 2008). Some of the most important functions of S include its role in specialized peptides, such as glutathione and thioredoxins, in redox reactions, and the role of disulfide bond (S-S) formation in the stabilization of protein structure (Inal *et al*., 2003).

Deficiency of S has been recognized as a limiting factor for crop production in many regions of the world (Inal *et al*., 2003). Sulfur deficiency had a significant influence on the yield and yield components of wheat (Järvan *et al*., 2012). It is clear that protein rich cereals like wheat are likely to suffer from hidden S deficiency (Assefa *et al*., 2016). In addition to its effects on wheat yields, the S status of grain is an important parameter for the quality of wheat products (Hoel, 2011). Reproductive growth of wheat appears to be more sensitive to sulfur deficiency than vegetative growth, with decreased grain size under sulfur-limiting conditions (Järvan *et al*., 2008). The primary form of plant-available S is sulfate (SO_4^{-2}), which is very mobile and readily leached from the rooting zone, if not adsorbed by soil particles (Mascagni and Harrison, 2008). In S deficient environments, it is expected that a higher N uptake will enhance NUE when S is added (Mascagni and Harrison, 2008). The increase in grain yield in response to S addition was associated with a higher N uptake rate before anthesis confirming the positive interaction between both nutrients (Mascagni and Harrison, 2008). Sulfur (S) is another essential nutrient for successful rape seed growth (Butkute, 2013). Nevertheless, this element received little attention for many years, because fertilizers and atmospheric inputs supplied the soils with adequate amounts of the nutrient (Scherer, 2001). Nowadays, in many regions of the world, including most European countries, the incidence of S deficiency has been increasingly reported (Scherer, 2001). It also plays an important role in synthesis of certain vitamins and proteins in the formation of flavoured compounds (Anwar *et al*., 2002).

Decreased inputs of S have increased the incidence of S-deficiency in crops, resulting in decreased yields and quality (Malcolm, 2000). Responses of the bread making quality of wheat to sulfur are more common than responses in terms of grain yield. Sulfur application did not affect grain protein concentration directly, but tended to increase gel protein weight in flour and the proportion of polymeric proteins. Due to sulfur fertilization all major parameters of winter wheat's baking quality improved: stability and quality number of dough, loaf volume and specific volume and round loaf's height-to-diameter ratio. Without adequate sulfur, crops cannot reach their full potential in terms of yield (Järvan *et al*., 2008); the most important role in such an increase of grain yield was performed by the number of grains per ear as one of the yield components. Addition of S to a calcareous soil may result in a decline in soil pH and consequently may increase availability of micronutrients like B (Nadian *et al*., 2010). At Gora Silingo, since wheat showed significant response to the applied sulfur, and the pre-soil tests showed low/medium, applying sulfur at a rate of 20 kg ha^{-1} with recommended dose of NP is advisable.

2.7. Effect of Boron Fertilizer on Yield Components and yield of Wheat

Boron (B) is an essential micronutrient for plants, and plant requirements for this nutrient are lower than the requirements for all other nutrients except molybdenum and copper. It is the only non-metal among the micronutrients and also the only micronutrient present over a wide pH range as a neutral molecule rather than an ion (Epstein and Bloom, 2005). Boron is required for normal development of reproductive tissues and deficiency results in low grain set and poor seed quality. Even the cereals (like wheat and rice) with small B requirement can suffer from impaired seed set due to Boron shortage at a critical growth stage (Shorrocks, 1997).

Boron is involved in N and P metabolism, in plants poorly supplied with Boron, NO_3–N accumulated in the roots, leaves, and stems, showing that NO_3 reduction and amino acid synthesis were inhibited. Boron is mainly associated with cell wall pectin, and physical Characteristics of the growing cell wall were altered under Boron deficiency (Brown and Hu, 1997).

Boron uptake by plants is controlled by the Boron level in soil solution rather than the total Boron content in soil (Yermiyahu *et al.,* 2001). Plants absorb boron in the form H_3BO_3, and it moves to plant root mainly by mass flow and diffusion. Uptake of Boron in crop plants is mainly determined by yield level. Variation in Boron uptake was about 99% in rice and 97% in dry bean with increasing plant age. This variation in Boron uptake may be associated with increasing dry matter of shoot in both crop species (Fageria and Barbosa filho, 2006).

The decrease in Boron uptake at harvest was associated with translocation of this element to grain. Boron recovery under field conditions by annual crops is generally in the range of 5 to 15% the year of application, and for most annual crops, uptake of 100 to 200 g Boron ha^{-1} of applied B could be expected to be sufficient (Shorrocks, 1997). In Boron deficient soils, use of appropriate source is fundamental to improve crop yields and Boron use efficiency. Principal Boron carriers are boric acid, borax, or sodium tetra borates are commonly used fertilizers for correcting B deficiency in crop plants. Boron fertilizers can be applied as broadcast, band, or foliar (Fageria, 2009). Fageria (2001) determined adequate and toxic rates of Boron for five annual crops grown on Brazilian Oxisol. Adequate Boron rates were 2 kg ha^{-1} for dry bean, 4.7 kg ha^{-1} for corn, and 3.4 kg ha^{-1} for soybean applied to a Brazilian Oxisol in a greenhouse experiment. The toxic rates were 4.4 kg Boron ha^{-1} for upland rice and dry bean, 8.7 kg Boron ha^{-1} for corn, 6.8 kg Boron ha^{-1} for soybean, and 7.4 kg Boron ha^{-1} for wheat.

Macro-nutrients as well micronutrients are of primary importance in our agriculture system but due to unawareness of our farmers about importance of applying micronutrients to soils which are becoming deficient in micronutrients. Boron is one of those micronutrients which are rapidly being deficient in soils. Boron deficiency impairs grain setting in wheat, resulting in increased number of open spikelets and decreased number of grains per spike. The difference in the number of open spikelets under normal and Boron deficient soil conditions has been used to compare wheat genotypes for boron efficiency (Rerkasem *et al.,* 1993).

Boron deficiency in crops is more pervasive than the deficiency of any other micronutrient (Gupta, 1993). Visual symptoms of Boron deficiency generally become evident in dicots, corn and wheat at tissue concentrations of less than 20-30, 10-20 and 10 mg kg^{-1} weight, respectively. Nutritional disorders attributed to Boron deficiency are also prevalent among vegetables, fruit and nut trees. Marschner (1995) reported that Boron is essential for cell division and elongation in meristimatic tissues, floral organs and for flower male fertility, pollen tube germination along with its elongation and seed/fruit formation. In addition, in Boron deficient soils seeds generate abnormal seedlings.

(Dell *et al.,* 1997) stated that deficiency of Boron inhibits root elongation through limiting cell enlargement and cell division in the growing zone of root tips. Deficiency of Boron causes inhibition of leaf expansion and reduction in photosynthesis, though exact role of Boron in photosynthesis remain to be explored. In the field, sexual reproduction is often more affected by low Boron and significant grain yield reductions may occur without visual symptoms expressed during vegetative growth.

The sterility problem in wheat as a consequence of Boron deficiency has been reported in different parts of the world (Subedi *et al.,* 1997a, 1997b). Boron deficiency causes the poor development of anthers and pollen, and the failure of pollen germination in wheat has been identified as male sterility, resulting in grain set failure (Rerkasem *et al.,* 1997; Rerkasem and Jamjod, 1997), with losses of grain yield and quality. As a result of the general immobility of B in plants that is characteristic of most species, plants require a constant supply of Boron during all phases of plant growth. Even a short period of limitation in Boron availability can depress plant growth. If Boron deficiency occurs during critical reproductive stages, significant yield losses can be expected (Brown and Shelp, 1997).

3. MATERIALS AND METHODS

3.1. Description of the Study Site

The field experiment was conducted at Angamo Yede Farmers Training Center (FTC) in Hulbareg District from July to November 2019 under rainfed conditions. Hulbareg District is located in the Southern Nations Nationalities and Peoples Region (SNNPR). The District is located at 7º 45' 42.00''S latitude and 38º 46' 41''S longitude. The elevation at study area is 2100 m above sea level. The District has two Agro-ecological Zones; 95% Weina Dega and 5% Kolla climatic type. The soil of the experimental site is classified as sandy loam in texture with pH of 5.1. The mean annual rainfall of the area ranges between 800 and 1200 mm and the annual average minimum and maximum air temperatures are 9.84°C and 23.57°C,respectively (HWOA, 2019).

3.2. Soil Sampling and Analysis

Soil samples were taken in zigzag pattern before planting from the experimental site at a depth of 0 - 30 cm across the experimental field from 10 spots using auger before planting and was composited. 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 sample. The composite sample was submitted to Soddo soil testing laboratory and Areka Agricultural Research Center. Then in the laboratory, it was ground to pass through a 2 mm sieve for soil analysis 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, organic carbon, cation exchange capacity (CEC), total N, and available P following standard laboratory procedures at Wolaita Soddo soil testing laboratory and the available S and B was analyzed at Areka Agricultural Research Center soil testing laboratory.

Organic carbon was determined by Walkley and Black oxidation method (Walkley and Black, 1934). Total nitrogen was analyzed by Kjeldhal method (Dewis and Freitas, 1975). The pH of the soil was determined by potentiometric test method on 1:2.5 (weight/volume) soils to water ratio using a pH meter (Motsara and Roy, 2008). The cation exchange capacity (CEC) was measured after saturating the soil with 1N ammonium acetate (NH_4OAc) and displacing it with 1N NaOAc (Chapman, 1965). Available phosphorus was determined by the Olsen method

(Olsen et al., 1954). Available sulfur (mg/kg SO_4^{-2}) was determined by ammonium acetate method (Chapman, 1965). Available B were done by dilute HCl methods and azomethine reducing agent (Havlin *et al*., 1999).

3.3. Experimental Materials

3.3.1. Plant material

Seeds of three bread wheat varieties, which were adapted to the agro-ecology of the area were used as test/experimental material. The varieties where released by Kulumsa Agricultural Research Center (KARC) and their detail description is provided in Table 1.

Table 1. Description of bread wheat varieties used in the experiment

Variety	Year of release	Rainfall	Maturity (days)	Adaptation (m.a.s.l.)	Yield (t ha^{-1})
Ogolcho	2012	400-500	102	1600-2100	3.3-5.0
Kekeba	2010	500-800	90-120	1500-2200	3.3-5.2
Kingbird	2015	500-800	90-120	1500 -2200	3.3-5.2

Source: (MOA, 2012) and KARC (2016)

3.3.2. Fertilizer materials

The blended NPSB fertilizer (18.9% of N, 37.7% of P_2O_5, 6.95% of S and 0.1% of B) and urea (46% N) as N sources were used for the experiment.

3.4. Treatments and Experimental Design

The experimental treatments consisted of factorial combination of three bread wheat varieties (Ogolcho, Kekeba, and Kingbird), and five levels of blended NPSB (0, 50,100, 150, 200 kg ha^{-1}) fertilizer in which treatments arranged in a randomized complete block design (RCBD) with three replications (Table 2). The experimental field was ploughed with oxen to a fine tilth four times and the plots were leveled manually. Then, a field layout was made and each treatment was assigned randomly to the experimental units within a block. Bread wheat seed was sown at the recommended seed rate of 150 kg ha^{-1} in rows of 20 cm spacing manually by drilling. The currently recommended 100 kg ha^{-1} of urea was applied for all treatments equally except for the control. The gross plot size was 10 rows of three -meter length (3 m×2 m =6 m^2) and the net plot/ harvestable rows consist of 8 with 2.8 m length (2.8 m×1.6 m=4.48 m^2). The spacing between rows, plots and blocks were 0.20, 0.5 and 1 m, respectively. The whole amount of blended (NPSB) and 1/2 of the urea were applied at sowing, and the remaining 1/2 urea top-dressed at tillering. Weeding was done as needed; and harvesting and threshing was done manually.

Table 2. Rates of fertilizer treatment used with their nutrient contents in kg ha^{-1} for the experiment

No	Treatments	Total composition of the respective nutrients in the treatment (kg ha^{-1})			
	fertilizer rates	N	P_2O_5	S	B
1	0 kg NPSB ha^{-1} + 0 kg urea ha^{-1}	0	0	0	0
2	50 kg NPSB ha^{-1} + 100 kg urea ha^{-1}	55.45	18.85	3.475	0.05
3	100 kg NPSB ha^{-1} + 100 kg urea ha^{-1}	64.9	37.7	6.95	0.1
4	150 kg NPSB ha^{-1} + 100 kg urea ha^{-1}	74.35	56.55	10.425	0.15
5	200 kg NPSB ha^{-1} + 100 kg urea ha^{-1}	83.8	75.4	13.9	0.2

3.5. Crop Data Collected

3.5.1. Crop 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 panicles turned to yellow straw color. It was recorded when no green color remained on glumes and panicles of the plants, i.e. when grains are difficult to break with thumb nail.

Plant height (PH): 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 (SL): It was measured from the bottom of the spike to the tip of the spike excluding the awns from 10 randomly tagged plants from the net plot.

Lodging percent (LP): 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) indicates 25% lodging, 3(30-45^o) indicate 50% lodging, 4(45-60^o) indicates 75% lodging and 5(60-90^o) indicates 100% lodging (Donald, 2004). The scales were determined by measuring the angle of inclination of the main stem from the vertical line to the base of the stem by visual observation. Data were normalized using Arcsine transformation.

3.5.2. Yield components and yield

Number of total tillers (NTT): 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 (NPT): 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 (NKPS): Ten main plants were taken randomly from the net plot area of each plot and number of kernels per spike was counted carefully and then the mean was determined.

Thousand kernels weight (TKW): The TKW was determined by weighing 1000 kernels sampled from the net plot yield of wheat after moisture content is measured using grain moisture meter and weighed using a sensitive balance and the seed mass was adjusted to 12.5% moisture content.

Aboveground dry biomass (AGB): The above ground dry biomass was determined from plants harvested from the net plot area after sun drying and converted to kg ha^{-1}.

Grain yield (GY): Grain yield was taken by harvesting and threshing the grain yield from net plot area. The grain yield was adjusted to 12.5% moisture content as:

$$\text{Adjusted grain yield} = \frac{\text{Grain yield obtained (kg ha}^{-1}\text{) x (100 - MC)}}{100 - 12.5}$$

Where MC- is the moisture content of bread wheat grains at the time of measurement and 12.5 is the standard moisture content of bread wheat in percent. Finally, yield per plot was converted to kg ha^{-1}

Straw yield (SY): Straw yield was obtained by subtracting grain yield from the total above ground dry biomass yield for respective treatment and expressed in kg ha^{-1}.

Harvest index (HI): Harvest index was calculated as ratio of grain yield per plot to total aboveground dry biomass yield per plot expressed as percent.

3.6. Statistical Data Analysis

All data collected were subjected to analysis of variance (ANOVA) procedure using GenStat 18th edition software (GenStat, 2013). Comparisons among treatment means with significant difference for measured characters were done by using Fisher's protected Least Significant Difference (LSD) test at 5% level of significance.

3.7. Partial Budget 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}) was the average yield 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 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 NPSB, Urea and the application costs. The cost of each variable was as folows; NPSB (Birr 12.20 kg^{-1})), urea (Birr 10.42 kg^{-1}) and bread wheat seed (Birr 16 kg^{-1}) during sowing time (July 22, 2019). The labour cost for application of NPSB was 7 persons ha^{-1}, each 60 ETB day^{-1}, and two split of urea application was 8 persons ha^{-1}, each 60 ETB day^{-1}). The costs of other inputs and production practices such as the cost of seed, labour cost for land preparation, planting, weeding, harvesting and threshing were considered the same for all treatments or plots. The average open price of bread wheat grain at Hulbareg market was Birr12.50 kg^{-1} and straw price was Birr 0.50 kg^{-1} in December 2019 during harvesting time.

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) – TCV

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 refers to net income obtained by incurring a unit cost of fertilizer. For each pair of ranked treatments based on net income, % marginal rate of return (MRR) was calculated using the formula

$$\mathrm{MRR}\ (\%) = \frac{\text{Change in NB (NBb} - \text{NBa)}}{\text{Change in TCV (TCVb} - \text{TCVa)}} \times 100$$

Where NB_a is NB with the immediate lower, NB_b is NB with the next higher, TCV_a - is the immediate lower TCV and TCVb is the next highest TCV.

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 undominated 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).

4. RESULTS AND DISCUSSION

4.1. Soil Physico-chemical Properties of the Experimental Site

Soil physico-chemical properties analysis indicated that the soil textural class was sandy loam with a particle size distribution of 60% sandy, 23% silt and 17% clay (Table 3). According to Hailu (1991), soil types used for wheat production vary from well-drained fertile soils to waterlogged heavy vertisols. Thus, the soil of experimental site is suitable for the production of wheat. The pH of the soil was 5.1, which is highly acidic (Ethiosis, 2013). 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 2.16% 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 0.86 to 2.59% 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 (0.13%) (Table 3), indicating 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 13.73 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 medium 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 value of the study area was 19.16 mg kg^{-1} (Table 3). Based on EthioSIS soil classification for S values lies on low range. The classification is < 9 very low, 10-20 low, 20-80 optimum, and > 80 mg kg^{-1} high. So, addition of fertilizer which contains S is relevant. This low in sulfur content of the soil may be due to loss of OM and lacking of using S source mineral fertilizer. It was also related to continuous cultivation which result intensive mining of S from the soil. 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). The results of the analysis also indicated that the soil has medium available Boron (0.67 mg kg^{-1}) according to the rating of Horneck *et al*. (2011).

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 low CEC (8 cmol kg^{-1} soil), indicating its low capacity to retain cations.

Table 3. Selected physico-chemical properties of the soil of the experimental site

Parameter	Values	Rating	Reference
Soil texture			
Clay (%)	17		
Sand (%)	60		
Silt (%)	23		
Textural Class	sandy loam		
pH (1 : 2.5 H_2O)	5.1	highly acidic	Tekalign (1991)
Total N (%)	0.13	moderate	Tekalign (1991)
Organic Carbon (%)	2.16	low	Tekalign (1991)
CEC[Cmolkg^{-1} soil]	8	low	Landon (1991)
Available Phosphorus (mg kg^{-1})	13.73	low	Olsen (1954)
Available Sulfur (mg kg^{-1})	19.16	low	Ethiosis (2014)
Available Boron (mg kg^{-1})	0.67	medium	Horneck *et al*. (2011).

4.2. Crop Phenology and Growth Parameters

4.2.1. Days to heading

The analysis of variance revealed that blended (NPSB) fertilizer,varieties as well as the interaction of the two factors had no significant effect on days to 50% heading (Appendix Table 2). Even though days to 50% heading is statistically non-significant, relatively prolonged duration to reach 50% heading was observed in response to the combined application of the highest rates of the fertilizers (200 kg NPSB) with the variety Ogolchoand relatively lower duration to 50% heading was observed in the (0 kg NPSB) with the variety Kingbird.

4.2.2. Days to physiological maturity

The main effect of varieties as well as the interaction effect of fertilizer treatments and varieties (Appendix Table 2) showed significant ($p<0.01$) effect on days to physiological maturity and main effect of NPSB fertilizer did not show significant effect on days to physiological maturity. The longest days to physiological maturity (108 days) was recorded at the NPSB rate of 150 kg ha^{-1}) whereas the shortest (103 days) was obtained from 50 kg NPSB ha^{-1}. The number of days required to 90% physiological maturity varied between 103.0 for variety Kingbird to 108.00 for variety Ogolcho (Table 4). The significant difference between varieties might be due to genetic difference among the varieties coupled with the favourable environmental condition and as a result there is difference on enhancing or delaying the physiological maturity of wheat varieties. Beena *et al*. (2012) reported significance effect of physiological maturity among wheat varieties.

Generally, the number of days to physiological maturity recorded at the highest rate of NPSB was significantly higher than that of unfertilized plot and lower rate of NPSB fertilizer. The increase in days to maturity of wheat at the highest rate of NPSB might be due to the three nutrients interaction and synergetic effect of them, especially N and S. Nitrogen 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 (FAO, 2000; Brady and Weil, 2002). An adequate supply of N is associated with high photosynthetic activity, vigorous vegetative growth, and dark green colour as result it delayed the crop maturity. On the other hand sulfur is an essential element best known for its role in the synthesis of proteins, oils, vitamins and flavored compounds and it is essential not only for plant growth and quality produce, but also enhances other nutrients use efficiency. The current result is in line with the study by Melesse Harfe (2017) who reported that increasing the N/P fertilizer from zero level to 69/30 kg N/P_2O_5 ha-1 for wheat, prolonged the physiological maturity from 124.87 to 127 days. Similarly, Manna et al. (2005) reported that combined application of NP and organic fertilizers promoted vegetative growth, leading to prolonged days to maturity. Legesse (2004) have also reported that N fertilization delayed the physiological maturity of tef due to extended vegetative growth instead of reproductive growth.

Table 4. Days to physiological maturity (days) of bread wheat as influenced by the interaction of blended NPSB fertilizer and bread wheat variety

Blended NPSB (kg ha^{-1})	Variety		
	Ogolcho	Kekeba	Kingbird
0	103.33^{de}	104.67^{bcde}	105.33^{bc}
50	104.33^{cde}	103.00^{e}	104.00^{cde}
100	106.33^{ab}	103.67^{cde}	103.33^{de}
150	108.00^{a}	104.00^{cde}	103.33^{de}
200	104.67^{bcde}	105.00^{bcd}	104.00^{cde}
LSD (0.05)	1.92		
CV (%)	1.1		

Means in columns and rows followed by the same letters are not significantly different at 5% level of significance; LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of variation;

4.2.3. Plant height

The result showed that, the main effect of fertilizer and variety had significant ($p<0.01$) effect on plant height (Appendix Table 2). The interaction effect of variety and fertilizer rates was not significant. Variety Ogolcho had the tallest plant height of 92.75 cm, whereas, variety kekeba had the shortest plant height of 81.88 cm (Table 5). In case of fertilizer rates, plant height was reduced at the lowest fertilizer rates. Whereas the highest plant height 89.74cm) was recorded from 150 kg NPSB ha^{-1} fertilizer rate. This could be due to the adequate soil fertility resources in the soil required by the wheat crop for growth and development. These results supported by the findings of Khan *et al*. (2000) who reported that increasing the level of nitrogen increased the plant height. Application of the highest dose of phosphorus contributed to maximum dry matter and physiological attributes towards the yield attributes in wheat and therefore, helped in achieving highest number of grains per spike, 1000 grain weight and ultimately yield of wheat (Alam and Jahan, 2013). Non-significant variation for plant height among bread wheat varieties was reported by (Fano and Tadeos, 2017).

4.2.4. Spike length (cm)

The main effect of NPSB and variety had highly significant ($P < 0.01$) effect on the spike length of bread wheat, while the interaction did not have significant influence on this parameter (Appendix Table 2). The result showed that increasing the rate of NPSB increased spike length. Thus, the longest spike length (8.11 cm) were obtained at the rate of 200 kg NPSB ha^{-1}, while the shortest spike length (7.02 cm) were recorded at the rate of 0 kg NPSB ha^{-1}. The increase in spike length at the highest NPSB rate might have been resulted from improved root growth and increased uptake of nutrients, better growth and activate cell division favored due to synergetic effect of the four nutrients and availability of adequate crop nutrients at the highest rate. This result agrees with the findings of Firehiwot (2014) who reported the maximum spike length (8.29 cm) at combined application of 64 kg P_2O_5 + 46 kg N ha^{-1}. Generally, spike length recorded over all the treated plots was significantly higher than the unfertilized plot/control. In contrast with this result, Khan *et al*, (2000) reported that spike length is genetic characters of a variety, which is less influenced by agronomic practices.

4.2.5. Lodging percentage

The result indicated that the main effects of fertilizer and varieties as well as the interaction of the two factors were not significant on the lodging percentage (Appendix Table 3). The maximum lodging percentage 38% was recorded for variety Ogolcho while the lowest lodging percent (21%) was recorded for variety Kingbird (Table 5). This might be due to varieties differ in number of leaves, internodes and tillers. Large differences amongst wheat varieties were observed for lodging tendency (Berry *et al*. 2003). Regarding the effect of fertilizers, the highest lodging percentage (41%) was recorded in the plot treated with NPSB fertilizer rate of 200 kg ha^{-1} whereas the lowest lodging percentage (17%) was recorded from fertilizer rate of 0 kg ha^{-1} (Table 4). The highest lodging percent at the highest rate of NPSB could be due to highest N fertilizer application which indicated vital role of N in vegetative growth and resulted for increment of number of tillers and leaves. Many of previous studies have shown that high N application leads to thinner stems and significant increases in lodging of wheat (Kong *et al*., 2014) and rice (Yang *et al*., 2009). Moreover, over supply of N may cause lodging, disease incidence and lower grain quality (Beuerlein *et al*., 1992). It is commonly perceived that high rates of N increase lodging by making plants taller (Laghari *et al*., 2010). Lodging causes decreases in yield and quality by reducing photosynthesis in the canopy, damages vascular bundles by bending or breaking stem, and causes problem associated with mechanical harvesting (Kono *et al*., 1995).

Table 5. Main effects of variety and blended NPSB fertilizer on days to panicle heading, plant height, spike length and lodging percentage of bread wheat

Treatments	Days to 50% panicle Heading	Plant height (cm)	Spike length (cm)	Lodging percentage
Variety				
Ogolcho	60.67[a]	92.75[a]	8.91[a]	16.62
Kekeba	59.93[ab]	86.21[b]	7.92[b]	17.5
Kingbird	59.73[b]	81.88[c]	6.56[c]	15.83
LSD (0.05)	0.76	2.36	0.28	NS
Fertilizer ($kg\ ha^{-1}$)				
0	59.44	80.22[b]	7.02[b]	18.0
50NPSB	60.22	87.1[a]	7.89[a]	12.5
100NPSB	60.56	89.16[a]	7.97[a]	20.8
150NPSB	60.11	89.74[a]	8.00[a]	15.2
200NPSB	60.22	88.46[a]	8.11[a]	16.6
LSD (0.05)	NS	3.05	0.36	NS
CV (%)	1.7	3.6	4.9	13.2

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation; NS= non-significant. Means in columns followed by the same letter are not significantly different at 5% level of significance.

4.3 Yield Components and Yield

4.3.1. Number of total tillers and productive tillers

The analysis of variance indicated that the main effect of fertilizer rate had highly significant ($p<0.01$) effects on the number of total and effective tillers per plant. However, main effect of variety and the interaction effect of variety and fertilizer rates was not significant (Appendix Table 3.4). Application of 200 kg NPSB ha^{-1} resulted into maximum number of total and effective tillers of 476.1 and 451.7 per m^2, respectively and no fertilized treatment resulted into minimum number of total and effective tillers of 240 and 218.9 per m^2, respectively (Table 6). In line with this result, Hameed *et al*. (2003) observed that increasing nitrogen application significantly increased the number of tillers m^{-2}. Pasha (2005) also found a significant increase in the number of total tillers per plant with the increase of NPK level from 0 to150kg ha^{-1}. Muhammad *et al*., (2010) reported that the significant variations on number of tillers per plant with the increased level of phosphorus application and the maximum numbers of tillers per plant (6.67) were found in the 80 kg P ha^{-1}.

4.3.2. Number of kernels per spike

The result revealed that fertilizer rates showed highly significant ($p<0.01$) effect with respect to the number of kernels per spike. While, the main effect of varieties and the interaction between the two factors were not significant to the number of kernels per spike (Appendix Table 4). Variety Ogolcho had the highest number of kernels per spike (47.28) while lowest number of kernels per spike (41.97) recorded from variety kingbird (Table 6). The difference among varieties might be due genetic differences among the varieties. In agreement with this result Knezevic *et al*., (2012) reported that highly significant differences among the tested cultivars for number of kernels per spike with largest impact belongs to the genetic variability (63.92%). Similarly, Akmal *et al*., (2000) observed significant differences among the wheat varieties for number of grains per spike. In contrast to this result, Hussain *et al*., (2002) reported non-significant difference among wheat cultivars for number of grains per spike in response to NPK fertilizer treatments which on an average varied only from 43.9 to 44.25. The effect of fertilizer also showed that the highest number of kernels per spike (50.43) was recorded from NPSB fertilizer rate of 150 kg ha^{-1} (Table 5). Such response can be attributed to the adequate nitrogen availability which might facilitate the tillering ability of the plants, resulting in a greater spike population. These results agreed with the study by Jan and Khan (2000) who observed significant effects of nitrogen application on grain number per spike. Similarly, Rehman *et al*., (2008) observed that number of grains per spike was significantly increased with each increment of NPK fertilizer. Geleto *et al*., (1995) also reported higher number of spikes per unit area at 120 kg N ha^{-1} fertilized plots than the control.

4.3.3. Thousand kernels weight (TKW)

The result revealed that fertilizer rate and the varieties showed highly significant ($p<0.01$) effect on the thousand kernels weight and the interaction effect was not significant (Appendix Table 4). Variety Kekeba had the highest thousand kernels weight (40.28g) whereas variety Kingbird had the lowest thousand kernels weight (37.91 g) (Table 6). This might be due to good grain filling period and favorable environmental condition increases the thousand seed weights differ among the varieties. The reason is due to genetic variability in the parameter among the varieties. In line with this result the significant variation with the highest 42.96 g and lowest 39.58 g thousand seed weight among the varieties was reported by Shirinzadeh *et al*., (2017). The effect of fertilizer rate showed that the highest thousand kernels weight (40.7 g) was recorded from NPSB fertilizer rate of 150 kg ha^{-1} while the lowest thousand kernels weight (36.97g) was obtained with no fertilizer application (Table 5). This may 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. This could also be due to adequate and better nutrition of the plants resulted in good grain filling and development of better seed size. The fact that higher amount of nitrogen application resulted in higher percentage of weight gain in grain filling stage in kernels and there by thousand kernel weight increased (Kauser *et al*., 1993). Makowska *et al*., (2008) also reported that 1000 kernels weight increased with the increase in nitrogen rate up to 100 kg ha^{-1}. In similar to this result, Bereket *et al*., (2014) also reported that increasing N rate from 92 kg N ha^{-1} to 138 kg N ha^{-1} decreased thousand kernels weight of bread wheat by about 3.7%.

Table 6. Main effects of variety and blended fertilizer on number of total and productive tillers, Number of kernels per spike and thousand kernels weight of bread wheat

Treatments	Number of total tillers/m^2	Number of productive tillers/m^2	Number of kernels per spike	Thousand kernel weight (g)
Variety				
Ogolcho	329	302	47.28	38.76^b
Kekeba	315	297.7	45.66	40.28 ^{a}
Kingbird	355.3	329	41.97	37.91^b
LSD (0.05)	NS	NS	NS	1.29
Fertilizer (kgha^{-1})				
0	240^d	218.9^c	32.46^c	36.97^c
50NPSB	277.2^{cd}	250.6^c	43.52^b	39.03^{ab}
100NPSB	340^b	310.6^b	48.81^{ab}	38.68^b
150NPSB	332.2^{bc}	316.1^b	50.43^a	40.7^a
200NPSB	476.1^a	451.7^a	49.62^a	39.53^{ab}
LSD (0.05)	58.19	54.38	2.88	1.67
CV (%)	5.8	8.0	13.6	4.4

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation; NS= non-significant, means in column followed by the same letter are not significantly different at 5% levels of Significance.

4.3.4. Grain yield (kg ha^{-1})

The analysis of variance showed that the main effects of blended NPSB fertilizer and variety and their interactions significantly ($P < 0.01$) affected the grain yield of bread wheat (Appendix Table 5). Thus, the highest grain yield (6500 kg ha^{-1}) was obtained at the rates of 200kg NPSB ha^{-1} for Ogolcho whereas, the lowest grain yield (2330 kg ha^{-1}) was recorded at 0 fertilizer application in combination with Kekeba(Table 7). The increase in grain yield at increasing NPSB rate might have resulted from improved root growth and increased uptake of nutrients and better growth favored due to the synergetic effects of both nutrients which enhanced yield components and yield. In agreement with this result, Haile *et al*., (2012) found that increasing N rate from 0 to 120 kg N ha^{-1} increased grain yield of bread wheat. Bereket *et al*., (2014) also reported that increasing P rate from 46 to 69 kg P_2O_5 ha^{-1} increased grain yield of bread wheat by about 6.8%. Similarly, Mulugeta Eshetu *et al*., (2017) reported that application of nutrients like K, S, Zn, Mg and B used in experiments significantly increased grain yield and yield component of bread wheat as compare to the control (no fertilizer)

Table 7. Mean grain yield (kg ha^{-1}) of bread wheat as influenced by the interaction of blended NPSB fertilizer and variety

Blended NPSB (kg ha^{-1})		Variety	
	Ogolcho	Kekeba	Kingbird
0	2444^{g}	2330^{g}	3078^{fg}
50	2650^{g}	4444de	4039^{e}
100	4167de	4178de	5833^{abc}
150	5000^{cd}	3889^{ef}	5556^{bc}
200	6500^{a}	6222^{ab}	5944^{ab}
LSD (0.05)	915		
CV (%)	12.4		

Means in columns and rows followed by the same letters are not significantly different at 5% level of significance; LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of variation;

4.3.5. Straw yield

The result showed highly significant ($P<0.01$) difference among the varieties of wheat and the fertilizer rate and the interaction between the two factors were not significant (Appendix Table 5). Variety Kingbird had the highest straw yield (8056 kg ha^{-1}) whereas variety Kekeba had the lowest straw yield (2611 kg ha^{-1}) (Table 9). This might be due to differences in genetic make-up of the varieties. Similarly, Ghafari *et al*., (2017); and Gul *et al*., (2012) found that straw yield of wheat significantly varied among the varieties. The result showed that an increase in straw yield when fertilizer rate increased from the lowest to the highest rate. The highest straw yield of 7222 kg ha^{-1} was obtained at the highest NPSB rate of 200 kg ha^{-1} whereas the lowest straw yields of 3033 kg ha^{-1} was from the control (Table 6). The significant increase in straw yield in response to the highest rate of blended NPSB might be attributed to the synergistic roles of the nutrients that enhanced growth and development of the crop. The result is consistent with that of Nasser

(2009) who reported increased straw yield of wheat with increase in NP fertilizers rates up to 90/45 kg ha^{-1}. Bereket *et al*., (2014) also reported that the highest straw yield was recorded at the highest nitrogen rate of 69 kg N ha^{-1}. Similarly, Gul *et al*., (2012) reported that higher nitrogen application (160 kg ha^{-1}) has more contribution in higher straw yield production (9098.65 kg ha^{-1}) as compared to control treatment (5302.97 kg ha^{-1}).

4.3.6. Aboveground biomass yield (kg ha^{-1})

Analysis of variance showed that the main effects of variety, fertilizer rates and the interaction effect of variety and fertilizers had a highly significant effect ($p<0.01$) on aboveground dry biomass yield (Appendix Table 8). Variety Ogolcho produced the highest aboveground dry biomass yield (15389 kg ha^{-1}) treated with 200 kg ha^{-1} NPSB while the lowest aboveground dry biomass yield (5056 kg ha^{-1}) was produced from variety Kekeba at 0 level application of the fertilizer (Table 8). This result agrees with that of 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 aboveground dry biomass yield of wheat by about 70.1% and 40.6%, respectively. Similarly, Workineh *et al*., (2015) reported that the highest biomass yield (11890 kg ha^{-1}) of wheat was observed with 138/115 kg N/P_2O_5 ha^{-1} while the lowest (9780 kg ha^{-1}) was recorded with 46/46 kg N/P_2O_5 ha^{-1}. Likewise, Melesse Harfe (2017) 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}. The increase in aboveground dry biomass at the highest rates of NPSB 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 nutrients. In conformity with this result, Jasemi *et al*., (2014) reported vegetative growth and biological yield has much dependence to consumption of chemical fertilizers, application of the fertilizers led to increasing biological yield of wheat. Similarly, Bekalu and Mamo, (2016) also reported that increasing N rates from 23 to 69 kg ha^{-1} increased aboveground dry biomass of wheat by about 22.6%. Likewise, Wakene *et al*., (2014) stated that supply of P_2O_5 at rate of 69 kg ha^{-1} in wheat found to be adequate to produce maximum aboveground dry biomass. Yasir *et al*., (2015) also reported the maximum aboveground dry biomass of wheat have obtained with application of 140 kg N ha^{-1} at sowing and 20 kg S ha^{-1} at anthesis.

Table 8. Mean Above ground biomass (kg ha^{-1}) of bread wheat as influenced by the interaction of blended NPSB fertilizer and variety

Blended NPSB (kg ha^{-1})	Variety		
	Ogolcho	Kekeba	Kingbird
0	5208^{ij}	5056^{j}	6689^{hij}
50	7122^{ghi}	8611^{fg}	8206g^{h}
100	8669^{fg}	10844de	13611^{abc}
150	11944^{cde}	10278^{ef}	13611^{abc}
200	15389^{a}	12611^{bcd}	14278^{ab}
LSD (0.05)	1919.3		
CV (%)	11.3		

Means in columns and rows followed by the same letters are not significantly different at 5% level of significance; LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of variation;

4.3.7. Harvest index (HI)

Harvest Index (HI) were insignificantly affected by varieties, fertilizer rates and the interaction between the two factors (Appendix Table 5). Harvest indices of the varieties, averaged across all treatments, varied (White and Wilson, 2006). In agreement with the present result, a non-significant effect of N supply on harvest index has been reported for wheat (Ibrahim *et al*., 2014).

Table 9. Main effects of variety and blended fertilizer on g straw yield and harvest index of bread wheat

Treatments	Harvest index (%)	Straw yield (kg ha^{-1})
Variety		
Ogolcho	42.87	5259^{b}
Kekeba	45.57	5244^{b}
Kingbird	44.9	6264^{a}
LSD (0.05)	NS	872.6
Fertilizer (kgha^{-1})		
0	46.15	3033^{c}
50NPSB	46.64	4269^{b}
100NPSB	43.16	6293^{a}
150NPSB	41.98	7130^{a}
200NPSB	44.46	7222^{a}
LSD (0.05)	NS	1126.6
CV (%)	14.4	20.9

LSD (0.05) = Least Significant Difference at 5% level; CV = Coefficient of Variation; NS= non-significant, means in column followed by the same letter are not significantly different at 5% levels of Significance.

4.4. Partial Budget Analysis

The partial budget analysis showed that highest net benefit of (72495) Birr ha^{-1} was obtained for variety Ogolcho that received 200 kg NPSB ha^{-1}(Table 10). However, the lowest net benefits of (27651) Birr ha^{-1} was obtained from the unfertilized treatment with the variety Kekeba. The variety Ogolcho gave economic benefit of (72495 ha^{-1}) with marginal rate of return (2711.9%) at 200 kg NPSB ha^{-1} fertilizer rate. Therefore, on economic grounds, application of 200 kg NPSB ha^{-1} with variety Ogolcho would be best and economical for production of bread wheat in the study area and other areas with similar agro-ecological conditions.

In line with this result, (Bekalu and Mamo, 2016) reported that N application at 69 kg ha^{-1} is effective in attaining higher grain yield and economic benefit of wheat in southern part of Ethiopia.

Table 10. Summary of partial budget and marginal rate of return analysis for response of bread wheat varieties to blended NPSB fertilizers in Hulbareg District, Southern Ethiopia

Treatments		Wheat Yield (Kg ha^{-1})			Income (ETB ha^{-1})					
varieties	Fertilizer NPSB ha^{-1}	UGY	AGY (Kg ha^{-1})	SY	Grain (ETB ha^{-1})	Straw (ETB ha^{-1})	GFB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	MRR (%)
Ogolcho	0	2444	2199.6	2611	27495	1305.5	28800.5	0	28800.5	
Ogolcho	50	2650	2385	4472	29812.5	2236	32048.5	2550	29498.5	72.45
Ogolcho	100	4167	3750.3	4502	46878.75	2251	49129.75	3160	45969.75	2700
Ogolcho	150	5000	4500	6944	56250	3472	59722	3770	55952	1636.4
Ogolcho	200	6500	5850	7500	73125	3750	76875	4380	72495	2711.9
Kekeba	0	2330	2097	2878	26212	1439	27651.5	0	27651.5	D
Kekeba	50	4444	3999	4167	49995	2083.5	52078.5	2550	49528.5	812.9
Kekeba	100	4178	3760	6667	47002.5	3333.5	50336	31	47176	D
Kekeba	150	3889	3500.1	6389	43751.25	3194.5	46945.75	3770	43175.75	D
Kekeba	200	6222	5599.8	6389	69997.5	3194.5	73192	4380	68812	4202
Kingbird	0	3078	2770.2	3611	34627.5	1805.5	36433	0	36433	D
Kingbird	50	4039	3635.1	4167	45438.75	2083.5	47522.25	2550	44972.25	334.9
Kingbird	100	5833	5249.7	7711	65621.25	3855.5	69476.75	3160	66316.75	3499
Kingbird	150	5556	5000.4	8056	62505	4028	66533	3770	62763	D
Kingbird	200	5944	5349.6	7778	66870	3889	70759	4380	66379	592.8

Where AGY= adjusted grain yield; SY = Straw yield; GFB = gross field benefit;TVC= total variable costs; NB = net benefit, MRR = marginal rate of return; ETB ha^{-1} = Ethiopian Birr per hectare; D = dominated treatments. Cost of bread wheat seed= 16.00 ETB $kg^{-1;}$ Cost of NPSB= 12.20 kg^{-1}; Cost of Urea =10.40 ETB kg $^{-1}$; Labour cost for NPSB application = 7 persons ha^{-1}, each 60 ETB day^{-1}; Labour cost for urea top dress fertilizer application at tillering = 8 person ha^{-1}, each 60 ETB day^{-1}. Market price of bread wheat grain =12.5 Birr kg ha^{-1} and straw=0.5 Birr kg $^{-1}$ in Hulbareg town at harvesting time in December 2019.

5. SUMMARY AND CONCLUSIONS

Bread wheat is one of the major staples and strategic food security crop in Ethiopia. However, wheat yield in Ethiopia and the study woreda is low as compared to the attainable yield because wheat production is constrained by both biotic and abiotic factors such as diseases, insect pests, poor management practices, moisture stress, low soil fertility etc. Thus, addition of nutrients such N, P, S and B and use of appropriate variety are important to increase the productivity of wheat. Ethiopia is one of the largest wheat producers in the Sub-Saharan Africa. For the last four to five decades, Ethiopian agriculture depended solely on imported fertilizer products; only urea and Di-ammonium phosphate (DAP), as sources of N and P, respectively. However, recently it is perceived that the production of such high protein cereals like wheat can be limited by the deficiency of S and other nutrients. Thus, addition of nutrients such N, P, S and B to low fertile soil is important to increase yield, yield components and quality of wheat whether it is for consumption or industrial purpose. Thus, the experiment was conducted to determine the effect of blended NPSB fertilizer rates on yield components and yield of bread wheat varieties; and to know economically feasible rates of blended NPSB for bread wheat production in Hulbareg District, Southern Ethiopia. Three improved bread wheat varieties (Ogolcho, Kekeba and Kingbird) and five rates of NPSB fertilizers [0, 50,100,150 and 200] were tested in factorial combination in randomized complete block design (RCBD) with three replications.

The results obtained revealed that spike length, plant height, total dry biomass yield and straw yield were significantly ($P < 0.01$) affected by main effect of NPSB as well as main effect of variety while grain yield and thousand kernels weight were affected by main effects of blended NPSB fertilizer and variety and days to heading and days to physiological maturity is affected by main effect of variety. The highest number of total tiller (476.1), productive tiller (451.7) per meter square, number of kernels per spike (49.62) were obtained at the NPSB rate of 200 kg ha^{-1}. On the other hand, the lowest number of total tiller (240), number of productive tiller (218.9), and number of kernels per spike (32.46) were recorded at zero level of NPSB rate. With regards to the effect of variety, the maximum days to heading (60.67) and days to physiological maturity (108) were recorded for the variety Ogolcho while the minimum days to heading (59.93) and days to physiological maturity (103) recorded for the variety kekeba.

The interaction of the two NPSB and variety also significantly affected above ground biomass, grain yield and days to physiological maturity. The highest grain yield (6500 kg ha^{-1}), spike length (8.11cm), plant height (92.75cm), straw yield (7222 kg ha^{-1}), thousand kernels weight (40.7g) and above ground dry biomass(15389 kg ha^{-1}) were recorded at combination of the highest rates of 200 kg NPSB fertilizer with variety Ogolcho. In contrast, the minimum grain yield (2330 kg ha^{-1}), spike length (6.56cm), plant height (81.88cm), straw yield (3033 kg ha^{-1}), thousand kernels weight (36.97g) and above ground dry biomass (5056 kg ha^{-1}) were recorded at combination of the zero level of NPSB ha^{-1} fertilizer rate with variety Kekeba.

The partial budget analysis revealed that combined applications of 200 kg ha^{-1} blended NPSB fertilizer rate with variety Ogolcho gave higher net benefit of 72495 Birr ha^{-1} with MRR of 2711.9% which is above the acceptable minimum range of MRR 100%, while the lowest net returns (27651 ETB $ha^{-1)}$ was recorded with zero blended NPSB rate and variety Kekeba. In general, this study provided evidence that yield and economic returns of bread wheat could be improved by appropriate application of blended NPSB and variety.

Therefore, from the result of present study that the application of the 200 kg ha^{-1} blended NPSB fertilizer in addition to 46 kg N ha^{-1} with variety Ogolcho can be tentatively recommended to farmers for production of wheat in the study area and other areas with similar agro-ecology. 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.

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7. APPENDICES

Appendix Table 1. Mean monthly annual total rainfall and minimum and maximum temperatures of ten years (2009-2018); 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

2009-2018 Metreological Data				2019 Metreological Data			
Months	Total rainfall (mm)	Min.Temp (ºC)	Max.Temp (ºC)	Total rainfall (mm)	Min.Tem (ºC)	Max.Temp (ºC)	Average Temp (ºC)
January	10.53	8.25	23.2	0.0	7.5	24.7	16.1
February	25.4	9.5	24.2	52.3	10	25	17.5
March	85.2	11.2	25.3	80.5	10.8	25.6	18.2
April	116.2	10.9	25.4	95.5	11.3	24.8	18.05
May	155.8	10.3	24.8	175.3	11	23.5	17.25
June	165.1	10.1	25	155	10.7	24	17.35
July	175.3	9.8	23.7	135.2	9.5	22.5	16
August	160.6	10.12	23.9	197	11	23	17
September	152.44	10.2	24.5	94.2	9.7	21.8	15.75
October	49.7	10.3	24.2	33	9.4	22.5	15.95
November	32	11	25.5	5.5	9	23.4	16.2
December	6.4	11.2	25.7	-	8.2	22	
Total	1134.67			1023.5			
Average		10.24	24.62		9.84	23.57	16.7

Source: National Meteorological Agency, Hawassa Branch.

Appendix Table 2. Mean squares of ANOVA for day to heading, day to physiological maturity and plant height of bread wheat as affected by blended NPSB fertilizer rates and varieties

Source of variation	D.F	Mean squares		
		DH	DPM	PH (cm)
Replication	2	0.556	0.156	93.187
Fertilizer (F)	4	1.500^{NS}	1.722^{NS}	135.563**
Varieties (V)	2	3.622*	8.956**	449.447**
F×V	8	1.067^{NS}	6.372**	14.392^{NS}
Error	28	1.056	1.322	9.951
CV (%)		1.7	1.1	3.6

Where, D.F= degree of freedom, DH= Days to heading, DPM= Days to physiological maturity, PH= plant height, 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 squares of ANOVA for spike length, lodging percent and number of total tillers of bread wheat as affected by blended NPSB and variety

Source of variation	D.F	Mean squares		
		SL(cm)	LP (%)	NTT
Replication	2	0.1216	0.4667	5557
Fertilizer (F)	4	1.7491**	0.5556^{NS}	72654**
Varieties (V)	2	20.9362 **	0.0667^{NS}	6291^{NS}
F×V	8	0.2501^{NS}	0.2889^{NS}	3804^{NS}
Error	28	0.1449	0.2286	363
CV (%)		4.9	13.2	5.8

Where, D.F = degrees of freedom, SL= spike length, LP= lodging percent, NTT= Number of total tillers, ANOVA =Analysis of variance; CV = coefficient of variation, NS= non-significant difference; ** and * significant at 1% and 5% level of significant, respectively

Appendix 4. Mean squares of ANOVA for productive tillers, number of kernels per spike and thousand kernels weight of bread wheat as affected by blended NPSB and varieties

		Mean squares		
Source of variation	D.F	NPT	NKPS	TKW
Replication	2	9151	24.82	10.110
Fertilizer (F)	4	71867**	506.14**	16.678*
Varieties (V)	2	4324^{NS}	111.24^{NS}	21.678*
F×V	8	3028^{NS}	16.03^{NS}	4.542^{NS}
Error	28	3171	37.50	2.999
CV(%)		8.0	13.6	4.4

Where, D.F = degree of freedom, NPT= Number of productive tiller; NKPS= Number of kernels per spike; TKW= thousand kernels weight; ANOVA =Analysis of variance; CV = coefficient of variation, NS= non-significant difference; ** and * significant at 1% and 5% level of significant, respectively.

Appendix Table 5. Mean squares of ANOVA for aboveground dry biomass (AGB), grain yield (GY), straw yield (SY) and harvest index (HI) of bread wheat as affected by blended NPSB fertilizer and varieties.

			Mean squares		
Source of variation	D.F	AGB	GY	SY	HI
Replication	2	458631	279496	1030312	25.87
Fertilizer (F)	4	100152743**	16310939**	31077325**	34.76^{NS}
Varieties (V)	2	14676820**	2545494*	5127170**	30.27^{NS}
F×V	8	5536739*	1437325**	1896956^{NS}	77.01^{NS}
Error	28	1316881.	299293	1361136	41.02
CV(%)		11.3	12.4	4.7	14.4

Where, D.F = degree of freedom, AGB=aboveground dry biomass, GY=grain yield, SY= straw yield and HI=harvest index ANOVA =Analysis of variance; CV = coefficient of variation, NS= non-significant difference; ** and * significant at 1% and 5% level of significant, respectively.

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Number of Pages: 70

Number of Words: 21,700 (approx.)

Number of Characters: 123,691 (approx.)