EFFECTS OF BLENDED NPSB FERTILIZER RATES ON GROWTH, YIELD COMPONENTS AND YIELD OF BREAD WHEAT (*Triticum asetivum.L*) VARIETIES AT DEGAM DISTRICT, CENTRAL ETHIOPIA

MSc THESIS

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Effects of Blended NPSB Fertilizer Rates on Growth, Yield Components and Yield of Bread Wheat (*Triticum asetivum.L*) Varieties at Degam District, Central Ethiopia

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

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POSTGRADUATE PROGRAM DIRECTORATE

I hereby certify that I have read and evaluated this thesis entitled '**Effects of Blended NPSB Fertilizer Rates on Growth, Yield Components and Yield of Bread Wheat (*Triticum asetivum.*L) Varieties in Degam District, Central Ethiopia'** prepared under my guidance by Abreham Feyisa**.** We recommend that it be accepted as fulfilling the thesis requirements.

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As member of the Board of Examiners of the MSc Thesis Open Defense Examination, I certify that I have read and evaluated the thesis prepared by **Abreham Feyisa** and examined the candidate. I recommend that the thesis be accepted as it fulfilling the Thesis requirements for the Degree of Master of Science in Agriculture (Agronomy).

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Final approval and acceptance of the thesis is contingent upon the submission of the final copy to the Council of Graduate Studies (CGS) through the candidate's School Graduate Committee (SGC).

DEDICATION

This thesis work is dedicated to my father Mr. Feyisa Bededa, my mother Mrs. Felaku Negawo, my sister Birki Feyisa and my brother Habtamu Feyisa and Tesfaye Feyisa for their unreserved and consistent care in the success 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

The author was born on June 17, 1991 at Gebra Guracha town in North Shewa Zone, Oromia National Regional State, Ethiopia. He attended his elementary school at Gebra Guracha Number two (Kera) from 1999 to 2006. He completed his junior and high school at Gebra Guracha Secondary and Comprehensive preparatory School in Kuyu district, Gebra Guracha town from 2007 to 2010.

After passing the Ethiopian Higher Education Entrance Examination, he joined Mada Walabu University, School of Plant Sciences in 2011 and graduated with B.Sc. degree in Plant Science on June 29, 2013. Starting from February 2014, he was employed by Oromia Agricultural Research Institute as a junior researcher at Fitche Soil Research Center (now Fitche Agricultural Research Center) in Soil Fertility Improvement Research Team and served at different positions as an Agronomist in soil fertility improvement at the center.

In October 2018, the author joined the Postgraduate Program Directorate of Haramaya University to pursue his MSc study in Agronomy.

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LIST OF ABBREVIATIONS AND ACRONYMS

AGBM	Above ground Biomass
ATA	Agricultural Transformation Agency
CEC	Cation Exchange Capacity
CSA	Central Statistical Agency
CIMMYT	International Centre for Wheat and Maize Improvement
DAP	Di-Ammonium Phosphate
ETB	Ethiopian Birr
EthioSIS	Ethiopian Soil Information System
FAO	Food and Agricultural Organization
FiARC	Fitche Agricultural Research Center
IFIDC	International Fertilizer Development Center
IFPRI	International Food Policy Research Center
KARC	Kulumsa Agricultural Research Center
MoA	Ministry of Agriculture
MRR	Marginal Rate of Return
NKS	Number of Kernel per Spike
NPS	Nitrogen, Phosphorus and Sulfur
NPSB	Nitrogen, Phosphorus, Sulfur and Boron
OARI	Oromia Agricultural Research Institute
RCBD	Randomized Complete Block Design
SARD-SC	Support to Agricultural Research for Development of Strategic Crops
TVC	Total Variable Cost
USDA	United States Department of Agriculture

TABLE OF CONTENTS

Continues…

LIST OF TABLES

Tables **Page**

LIST OF FIGURE

LIST OF TABLES IN APPENDICES

Effects of Blended NPSB Fertilizer Rates on Growth, Yield Components and Yield of Bread Wheat (*Triticum asetivum.L*) Varieties at Degam District, Central Ethiopia

ABSTRACT

Bread wheat (Triticum aestivum L.) is an important food crop and source of income for farmers at Degam district in central highland of Ethiopia. However, its productivity is mainly constrained by poor soil fertility and lack of site specific fertilizer (NPSB) recommendation in general and in the study area in particular. Thus, field experiment was conducted at Degam district on farmer's field in 2019 main cropping season to investigate the response of bread wheat varieties to blended NPSB fertilizer rates and identify its economic benefit. Factorial combination of three improved bread wheat varieties (Danda'a, Hidase and Kakaba) and six fertilizer rates [Control, 50 kg NPSB, 100 kg NPSB, 150 kg NPSB, 200 kg NPSB each supplemented with 92 kg N ha^{-1} and 64/20 kg NP ha^{-1} (Blanket recommendation)] were laid out in randomized complete block design with three replications. Analysis of the results revealed that number of total tillers (NTT), spike length (SL), number of kernels per spike (NKS), above ground biomass (AGBM), straw yield (SY) and grain yield (GY) were significantly affected by the main effect of fertilizers; similarly, number of total tillers (NTT), number of kernels per spike (NKS), thousand kernels weight (TKW) and grain yield (GY) were significantly affected by the main effect of varieties. While days to 50% heading (DH), days to maturity (DM), plant height (PH) and number of productive tillers (NPT) were affected by interaction effects of fertilizer and varieties. The highest NKS (54.9), AGBM (13.8 tons ha^{-1}), SY (9.4 tons ha^{-1}) and GY (4549kg ha^{-1}) were recorded from 200 kg NPSB fertilizer. Among the varieties the highest NKS (54.3) from Danda'a, TKW (49.3 g) and GY (3351kg ha^{-1}) were recorded from Hidase variety. Variety Kakaba score the highest PH (102.5 cm) and PNT (5 per plant) with combination of 200 kg and 150 kg NPSB fertilizer respectively and reached days to heading and maturity earlier than Danda'a and Hidase. In general, the economic feasibility of the fertilizer over varieties combination indicated that application of 200 kg NPSB ha^{-1}to all varieties Hidase, Danda'a and Kakaba resulted in maximum marginal rates of return 640.14 %, 604.81% and 481.47%, with a net benefit of 97993, 88596, and 82996 ETB respectively. On the other hand, application of 200 kg NPSB ha^{-1} led to the highest MRR for the Hidase variety as compared to all other treatments and with about a total of 9397 ETB net benefit increment. Therefore, application of 200 kg blended NPSB in supplement of 92 kg N ha^{-1} fertilizer with Hidase variety was temporarily the best producing alternatives and economically profitable grain yield with acceptable grain yield of bread wheat production at the study area.

Keywords: Blended NPSB, Bread wheat varieties, Economic benefit and Yield

1. INTRODUCTION

Wheat is a staple food that provides around 20% of protein and calories consumed worldwide (FAOSTAT, 2015). The demand for wheat is expected to grow by 34 to 60% in 2050 in developing countries (Valin, 2014). The FAO estimates that global commercial production of all types of wheat was 650.9 million metric tons in 2016, harvested from 217.0 million hectares; it is grown on around 4% of the planet's agricultural land (FAO, 2017).

Ethiopia is one of the largest wheat producers in the Sub-Saharan Africa with yearly estimated production of 4.6 million tons on 1.69 million hectares of land in 2017/18 with productivity of 2.74 tons per hectare (CSA, 2018).Wheat is mainly grown in the highlands of Ethiopia, which lie between 6-16° N and 35-42° E, at altitudes ranging from 1500 to 2800 meters above sea level and with mean minimum temperatures of 6°C to 11°C exclusively under rainfed conditions (Engida , 2001; MoA, 2012). Mean wheat yield increased from 1.3 tons ha^{-1} in 1994 (CSA, 1995) to 2.74 tons ha^{-1} in 2017/18 (CSA, 2018), far below experimental yields of over 5 tons ha^{-1} (Gete et *al.*, 2010; Mann and Warner, 2015). The average wheat productivity in SSA is 1.7 tons ha^{-1} (FAOSTAT, 2014), nearly 50% below the world average. The national wheat productivity in SSA varies across countries. It ranges from 0.7 tons ha^{-1} in Burundi to 3.4 tons ha^{-1} in Mali. But, some of the world highest spring wheat yields are obtained in Africa. For instance, Egypt's average productivity is 7 tons ha^{-1}, Ethiopia farmers have obtained more than 8 tons ha^{-1} in very few areas of the country and new varieties introduced through SARD-SC in Nigeria yield up to 7 tons ha^{-1}, but these achievements were recorded still by very few farmers (Harlod and Tabo, 2015).

The main wheat growing areas of Ethiopia are the highlands of the central, south-eastern and northwest parts of the country. However, Ethiopia's current wheat production is insufficient to meet domestic needs, forcing the country to import 30 to 50% of its wheat demand to fill the gap (Minot *et al.,* 2015). There are several factors that hindered the production and productivity of wheat crops such as low soil fertility, lack of improved wheat varieties and lack of improved management practices. The low yield is primarily associated with the depletion of soil fertility due to continuous nutrient uptake of crops, low fertilizer use and insufficient organic matter application (Kidane, 2015). Continuous cropping and inadequate replacement of nutrients removed in crop harvest or lose through erosion and leaching has been the major causes of soil fertility decline (Hillette et *al.*, 2015; Van Beek *et al.,* 2016). This is particularly evident in the intensively cultivated high potential areas that are mainly concentrated in the highlands of Ethiopia (Hillette *et al.,* 2015).Nutrient balances in the highlands of Ethiopia, typically the high potential areas for agricultural productions are currently exposed to severe soil fertility depletion (Van Beek *et al.,* 2016). In addition, several factors such as improved varieties, adequate cultural practices like balanced fertilization and management of other biotic and abiotic factors are very important for higher productivity of wheat (Alam and Jahan, 2013).

Studies on nutrient cycles in the Central highlands of Ethiopia revealed that the nutrient balance in different soil fertility classes varied from -20 to -185 kg N, from +11 to -83 kg P and from +23 to -245 kg K ha^{-1} yr^{-1} (Balesh, 2005), and the average annual soil loss from agricultural land is estimated to be 137 tons $ha^{-1}yr^{-1}$, which is approximately an annual soil depth loss of 10 mm (Gete *et al.,* 2010). These indicate that major nutrients outflows far exceed inflows in a range of soil types which results negative nutrient balances. Thus, addition of nutrients such N, P, S and B to less fertile soil is important to increase wheat yield, yield components and to improve the quality of crops. 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).

Yet, agricultural production is increasing which benefits farmers' livelihoods and contributes to food security of the country as a whole, but at the expense of the natural resource base (Van Beek *et al.,* 2016). The yield gap of over 3 tons ha^{-1}, suggests the potential for increasing production through improved soil and crop management practices, particularly increased use of fertilizers and adequate soil fertility maintenance program.

Varieties are one of the other major factors which play an important role in producing higher yield of wheat (Alam and Jahan, 2013). Wise use of fertilizers increases crop yield and production; the reverse will lead to decline in production and ecological imbalance. Efficient use of fertilizers depends on performances of variety. So that cultivar selection plays a very important role in determining grain yield and quality (Brian *et al*., 2007). Wogene and Agena (2017) also reported that different varieties respond differently to nutrient with respect to their genetic makeup and physiological life processes.

In most of the nutrient studies in Ethiopia, more emphasis was given to macronutrients, especially N and P, and micronutrients investigations had received little attention. Studies related to the micronutrients status of Ethiopian soils on the other hand are scarce, although the role of micronutrients plays in agriculture maybe equally important (Yifru and Mesfin, 2013). Beginning from 1960’s, 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 (Assefa *et al*., 2015).

However, Ethiopia is moving from blanket recommendations for fertilizer application rates to recommendations that are customized based on soil type and crop (Nicholas *et al*., 2015). This is a move towards diversification and inclusion of blended fertilizers apart from DAP and urea, which have long been the only types of fertilizer imported for grain crops.

Different recent studies have showed 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). Most Ethiopian soils are deficit in macronutrients (N, P, K and S) and micronutrients (Cu, B, and Zn) (EthioSIS, 2014).

Macronutrients 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).

Even though different types of blended are suggested by EthioSIS, farmers in most parts of the country have limited information on the impact of different types and rates of fertilizers except that of blanket recommendation which is nitrogen at a rate of 41 kg N ha^{-1} and phosphorus at a rate of 46 kg P_2O_5 ha^{-1}. This translates to the use of50 kg Urea and 100 kg DAP ha^{-1} for wheat while according to the soil fertility map made over 150 districts most of the Ethiopian soils lack about seven nutrients (N, P, K, S, Cu, Zn and B) (EthioSIS, 2013). The effect of blended fertilizers types and rates on yield components and yield of bread wheat are unknown, even though a new blended fertilizer such as NPS, NPSB etc, are currently introduced to the country.

Similarly, farmers of the study area have been using this blended fertilizer in similar trends and equivalent ratio with that of their previous information they have used and awareness in the last four to five decades on blanket recommendation of DAP and Urea fertilizers, which is 100 kg of DAP and 100 kg of urea per ha. Therefore, due to lacking of such information particularly on effects of blended NPSB fertilizer rate on the production of bread wheat along with varieties in the district, this study was initiated with the following objectives:

- To investigate the effect of blended NPSB fertilizer rates on different yield components and yield of bread wheat varieties.
- To identify the most profitable blended fertilizer rates for the different bread wheat varieties for wheat crop production in the study area.

2. LITRATURES RIVIEW

2.1. Ecological Adaptation and Distribution of Wheat

Wheat (*Triticum* spp.) is an annual plant that belongs to the grass family Poaceae, tribe Triticeae and sub tribe Triticineae (Temesgen, 2015). 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).

Wheat (*Triticum aestivum* L.) is one of the important cereal crops in the world and it has the widest distribution among cereal crops. Substantial amount of wheat is produced in tropical and subtropical environments, although the crop is more produced cereal in the temperate regions. Wheat is the most important among all cereals used as a food grain in the world. It ranks first in the world cereal production and is a staple food of about one third of the world's population (Anonymous, 2001). Ethiopia is the second largest producer of wheat in Sub-Saharan Africa following South Africa and about 1.69 million hectare of land is cultivated in 2017/2018 cropping season for both bread and durum wheat production (CSA, 2018). In area of production, wheat ranks 4th after tef, maize, and sorghum and 3rd in total grain production after maize and tef and 2nd in yield to maize. It is cultivated by 4.212 million farmers and accounts for more than 15.17% of the total cereal production and 4.54 million tons of wheat was produced on an area of 1.69 million ha in 2016/2017 cropping season (CSA, 2018).

2.2. Economic Importance of Bread Wheat

Wheat is the world's most important food grain (Katina, 2005). It is a crop of global importance that supplies carbohydrates to more than half of the worlds' population (Tataw *et al*., 2016). The nutritional value of wheat is extremely important as it takes an important place among the few crop species being extensively grown as staple food sources. Bread wheat is a globally important crop, accounting for 20 per cent of the calories consumed by humans (Brenchley *et al*., 2012). In addition 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. 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 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. Its grain is used to prepare a variety of local food such as '*Dabo' (*Ethiopian bread), *'Enjera'* (thin, flattened bread), *'Kolo'* (roasted grain), *'Genfo'* (wheat flour cooked with water and mixed with spiced butter), *'Kinche'* (crushed kernels, cooked with water and mixed with spiced butter), *'Nifro'* (boiled whole grain, sometimes mixed with pulses), *'Tela'* (beverage drink) etc. In addition to this the straw of wheat is used for animal feed and for roof thatching.

2.3. Major Constraints of Wheat Crop Production

One major problem that Ethiopia faced pertinent to the agricultural soils was the lack of soil fertility database and absence of area and crop specific fertilizer recommendation. The IFDC (2015) report showed that as the mean fertilizer consumption in Ethiopia has risen from 132,522 MT (1995/96) to 858,825 MT (2014/15) period. Even though the amount of fertilizer imported increases every year, Ethiopian farmers still lag far behind other developing countries in fertilizer use. The average intensity of fertilizer use in the country (which is roughly less than 40 kg ha^{-1}) remains much lower than elsewhere (e.g., 54 kg ha^{-1} in Latin America, 80 kg/ha in South Asia, and 87 kg ha^{-1} in South East Asia).

The scenario fairly suggests that there was no much effort to improve the fertilizer use in the country that has a variable agro-ecology and soil conditions. The unbalanced use of fertilizer in the sense of soil fertility (which is assessed according to the gap between recommended dose and type of fertilizer and its actual use in fields) became evident in recent years. The significant gap between the recommended dose and actual amount of fertilizer given to land is very high in case of urea. Due to unbalanced use of fertilizer; the loss in soil fertility is also significant in Ethiopia according to the report of IFDC (2015).

Ethiopia faces a wider set of soil fertility issues beyond chemical fertilizer use, which has historically been the major focus for extension workers, researchers, policymakers, and donors (IFPRI, 2010). If left unchecked, this wider set of issues will limit future output and growth in agriculture across the country; in some areas, they already limit the effectiveness of chemical fertilizer. These chemical, physical, and biological issues interact and include loss of organic matter, macronutrient, and micronutrient depletion, topsoil erosion, acidity, salinity, and deterioration of other physical soil properties. In addition, Ethiopia has soil types with inherent characteristics which can be problematic for crop production and which need special management.

2.4. The Requirement of Blended (NPSB) Fertilizer for Bread Wheat Crop

2.4.1. Effect of Nitrogen Fertilizer on Wheat Crops

Nitrogen is necessary for chlorophyll synthesis as a part of the chlorophyll molecule, involved in photosynthesis and constituent of all amino acids and protein which are considered responsible for quality of wheat. Nitrogen application rate and timing are very important for yield and quality of wheat. The application of essential plant nutrients particularly N nutrient in optimum quantity (120-150 kg ha^{-1}) and right proportion (3-4 splits) through correct methods and time of application is the key to increased and sustained crop production. The increase in quality due to nitrogen fertilization (120-330 kg ha^{-1}) may be due to its role in activation of cells division, metabolic and photosynthesis process and nutritive status of wheat plant (Harwinder and Hari, 2017).

Similarly, Wogene and Agena (2017) reported that, as the increments in yield of wheat with increasing N rates up to 46 kg ha^{-1} might be attributed to the effective role of N as an essential constituent of chlorophyll on dry matter accumulation. According to their investigation, nitrogen applied at the rate of 46 kg ha^{-1} enhanced wheat productivity and produced the maximum grain yield per nitrogen unit increase and showed the greatest agronomic efficiency.

Nitrogen application is important for wheat with speedy plant growth and improved quality. The nitrogen fertilizer plays a significant role in fertility of soils (Habtegebrial *et al.,* 2007) and it also increases biomass with better grain yield (Ogola *et al.,* 2002). Nitrogen as basic nutrients improves plant vegetative growth. Its optimum level of availability in the soil in relation to crop growth and development stage improves its use efficiency. Existing application rate of N and particularly the timings are compatible with the changes observed in the climate of the area for wheat crop production (Shahzad, k. and Akmal M., 2017).

Proper nitrogen management is important for rainfed agriculture. Application of nitrogen fertilizer 1/3 at sowing plus 2/3 at mid tillering gave the highest plant height, spike length, number of productive tillers, number seeds per spike, thousand kernel weights, harvest index and grain yield (Legesse and Sakatu, 2017). It also gave the highest economic return and agronomic Nitrogen Use Efficiency.

2.4.2. Effect of Phosphorus Fertilizer on Wheat Crops

Fertilizers are marvelous instruments if wisely used but highly dangerous if wrongly applied. Studies have demonstrated that Nitosols in the highland are marginally to severely deficient in Phosphorus (Regassa & Agegnehu, 2011). Phosphorus is an important nutrient element for wheat plant. Adequate quantity in available source of phosphorus is vital for the growth, reproduction, yield and quality of wheat. Phosphorus is essential for cell division, seed and fruit development (Ahmad and Rashid, 2003).

Likewise, Hagos and Hailemariam (2016) reviewed different research report conducted with respect to the effect of phosphorus fertilization on wheat crop production and productivity under different location of the country indicated that increased yield component of wheat was observed with the application of P fertilizer and the highest biological and grain yield was obtained at the highest P fertilizer rate (92 kg $P_2 O_5$ ha^{-1}) with 184 kg ha^{-1} of N interaction.

Moreover, an experiment carried out in Enderta, North Ethiopia indicated that application of different rates of phosphorus fertilizers had significantly increased both grain and straw yield of wheat in which the application rates of 10 and 20 kg of P ha^{-1}, showed increments of the grain and straw yields of wheat by 4 and 11% respectively over the control (Abreha *et al.,* 2008).

On the other hand, Alam and Jahan (2013) finding indicate that application of the highest dose of phosphorus (120 kg ha^{-1}) 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.

Another recent research conducted in northern part of Ethiopia Hawzen district to investigate effect of phosphorus fertilizer level on the growth and yield of wheat also indicated Phosphorus application at a rate of 46 kg P_2O_5 ha^{-1} increased significantly grain and straw yields by 38 % and 46 %, respectively than control (Bereket *et al.,* 2014).

2.4.3. Effect of Sulfur Fertilizer on Wheat Crops

N as well as S are utmost important constituents of plant proteins and are required throughout the crop growth period from vegetative stage to subsequent harvesting. The Sulfur Institute of

Washington has estimated that the annual Sulfur fertilizer deficit worldwide will increase from a current level of 8 million tones to over 11.5 million tons by 2012 (Beena *et al.*, 2012).

Sulfur is an essential element best known for its role in the synthesis of proteins, oils, vitamins and flavored compounds. The amino acids, methionine (21%S), cysteine (26%S) and cystine (27%S), that impact nutritional value of human food and feeds, contain sulfur (Chattopaddhyay and Ghosh, 2012). Similarly, Habtegebrial and Singh (2009) reported that Sulfur fertilization increased the concentration of cysteine and methionine by 27% and 14%, respectively, as compared to N alone. Sulfur is reported to be a macro-nutrient that is taken-up by crops in amounts similar to and sometimes exceeding those of P, 10-30 kg ha^{-1}(Weil, 2011), and considered to be one of the most limiting nutrient element for crop production. It is essential not only for plant growth and quality produce, but also enhances other nutrients use efficiency and ranks second only to N in importance for optimum crop yield or quality.

Several studies by, Jarvan *et al.* (2009a) and Salvagiotti *et al.* (2009) have shown that sulfur fertilization increase the efficiency of nitrogen use. The effect of sulfur addition had relevance when nitrogen was not a limiting factor, showing a positive interaction between these two nutrients on crop growth, reflected in higher nitrogen use efficiency (Salvagiotti and Miralles, 2008).

Without sulfur the effectiveness of nitrogen fertilization remained low. Continued use of N fertilizer without supplemental Sulfur on low Sulfur soils will reduce flour quality (Flaete, *et al*., 2005). Sulfur does not affect only nitrogen utilization and grain quality, but it also plays an important part in the formation of the baking quality (Ryant and Hrivna, 2004). So, availability of Sulfur and a desirable N: S ratio is critical when considering the positive interaction between nitrogen and Sulfur on grain protein quantity and quality. Similarly Sulfur applied at the rates from 4 to 16 kg S ha^{-1} with nitrogen increased the chlorophyll content in wheat leaves, number of productive tillers per plant, number of grains per ears, and the grain yield by 29.60% (Adamson and Jarvan, 2006). Sulfur was particularly effective when it was applied with nitrogen in the first topdressing (Jarvan *et al.*, 2009b).

Investigations have shown that the yield of wheat and some of the yield components significantly respond to the application of sulfur fertilizer (Girma *et al.*, 2005). At the beginning of tillering, the regenerative sulfur fertilization increased dry plant weight and sulfur concentration in dry matter by 28.1- 43.2%. Sulfur application reduced the number of unproductive tillers and increased the number of ears per unit area by 10 - 70% as well as, the highest grain yield was achieved after the application of solid fertilizers in the late growing stages (Hrivna *et al.*, 2014). The nutritional status of sulfur had also the strongest effect on the number of grains per ears. Cereal plants obviously retain the number of interflorescence bearing culms at the expense of grain setting under conditions of sulfur deficiency (Haneklaus *et al.,* 2007). Also other researchers, Malle Jarvan *et al.* (2012) have found that the grain yield increased under the influence of sulfur on the average of all trials conducted on pseudopodzolic soil by 1.25 ton ha^{-1}, i.e. by 22.4%.

2.4.4. Effect of Boron Fertilizer on Wheat Crops

Boron (B) is an essential micronutrient required for normal plant growth and development. It's unique among the essential mineral micronutrients because it is the only element that is normally present in soil solution as non-ionized molecule over the pH range suitable for plant growth (Singh *et al*., 2015). Boron is an essential element for better utilization of macro-nutrients by plants and thereby greater translocation of photo-assimilates from source to sink during growth period (Ali *et al*., 2013). Boron plays a vital role in grain setting of wheat. Boron is also involved in the transport of sugars across cell membranes and in synthesis of cell wall material. It influences transportation through the control of sugar and starch formation (Singh *et al*., 2015).

Boron-deficiency symptoms first become evident on the younger leaves, which change color and become hardened, malformed, and necrotic (Dursun *et al*., 2010). Deficiency of boron can also cause reduction in crop yield and inferior crop quality (Singh *et al*., 2015). In the field trial, sexual reproduction is often more affected by low boron and significant grain yield reductions may occur without visual symptoms expressed during vegetative growth (Muhammad *et al*., 2009). Boron normally becomes less available to plants with increasing soil pH and yield and yield components of crops were affected positively and negatively by B, depending upon soil status, crop types and the doses used (Dursun *et al*., 2010). But, it is one of those micronutrients which are currently reported as rapidly deficient nutrients in the soils. It is a very sensitive element, and plants differ widely in their requirements: the range of deficiency and toxicity level are narrow.

However, the toxicity of this nutrient is an important agricultural problem that limits crop productivity in different regions of the world, and can occur in B-rich soils or in soils exposed to B-rich irrigation waters, fertilizers, sewage sludge, or fly ash (Luis *et al.*, 2012). Though its average concentration inside the soil solution is 10 ppm, but the most preferable range for which plants encounter neither deficiency nor toxicity is very low i.e., 0.3–1 ppm (Tripathi *et al.,* 2015).

High boron concentrations caused a decrease in germination and germination rate, shoot and root lengths, shoot and root fresh and dry weights, vigor, tolerance and toxicity indices and relative water content of shoot and root in wheat. Low boron concentration (0.25 mg L^{-1}) showed the highest shoot fresh weight, shoot and root dry weights, seedling dry weight, and the lower shoot toxicity index (Habtamu *et al.,* 2014).

Boron deficiency impairs grain setting in wheat, resulting in increased number of open spikelets and decreased number of grains per spike. Number of grains per spike, 1000 grain weight and grain yield was significantly increased where boron was applied at booting stage for obtaining higher grain yield of wheat (Tahir *et al.,* 2009).

2.5. Effects of Different Varieties on Yield Components and Yield of Bread Wheat

Production and productivity problems of wheat start from access to varieties and variety selection systems. For decades wheat productivity in Ethiopia remained stagnant at very low levels, with national average wheat yields in 2017/18 were only 2.74 tons ha^{-1}, little higher than in 1994 (1.3 tons ha^{-1}). Contributing factors to this low productivity included: the use of low yielding traditional wheat varieties (Abro *et al.,* 2017; Shiferaw *et al.*, 2014).

There are many factors that are directly or indirectly affecting the rate of adoption of improved wheat varieties. Farmers low purchasing capacity with that of shortage of required credit results lack of resistance to the increasing cost of improved seed from time to time. Seed quality variability, problems of availability and timely delivery of improved seed and insufficient quantity of delivery were the major problems of the rate of adoption of improved wheat varieties (Adugnaw and Dagninet 2020)

Different reports are available on the low adoption rate of improved wheat varieties by resource poor farmers in Ethiopia. For instance, Nelson (2013) indicated that most of the released varieties in Ethiopia had been poorly adopted by the small scale farmers because of lack of effective seed production and delivery mechanism, weak integration of variety requirements between breeders and farmers and less adaptation of the breeders developed varieties to the local environments. In Ethiopia, farmers' variety preferences is not only grain yield but also disease resistance, straw yield, seed color, baking quality and other related social values (Bishaw *et al.*, 2010; Tesfaye *et al.*, 2014). Therefore, in order to enhance the adoption rate of new wheat varieties, and improve wheat production and productivity in the country farmers' production constraints and varietal preferences should be well known.

Comparative studies of wheat cultivars from different breeding eras revealed that improved varieties often out-yield old cultivars by at least 50%. Wheat cultivars significantly differed in grain yield and most of yield related traits. The number of grains/spike and, to a lesser extent, the number of spikes m^{-2} were the yield components most affected by breeding activities during the 20th century, as they increased at a relative rate of 0·60%/yr and 0·30%/yr, respectively. Grain yield during the 20th century increased by 88%, but the largest rises occurred before the end of the intermediate period, since no significant differences in yield and yield components appeared between intermediate and modern cultivars (Sanchez-Garcia *et al.*, 2013).

3. MATERIALS AND METHODS

3.1. Description of Experimental Site

The experiment was conducted at Degam District on farmer field/site during 2019 cropping period. The district is located at 124 km North-West of Addis Ababa, and 12 km from Fitche, the capital city of North Shewa Zone, and Oromia Regional State. The district is bordered on the West by Kuyu, on the North-West by Hidabu Abote, on the North by Jama River which separates it from Amhara Region, on the North-East by Girar Jarso, and on the East by Yaya Gulele and Debre Libanos district (Figure 1). Geographically, the district extends from 9°34′ to 10°03′N latitudes and 38°29′ to 38°44′E longitudes. The site is located at 9°49′48.2″ North latitude and 38°33′43.8″ East longitude with an elevation of 3014 masl. The temperature varied in between 5.6°C to 23°C. The annual rainfall ranges from 800 mm to 1300 mm and the rainfall pattern is bi-modal; a short rainy season (Belg) from February to March, and a main rainy season (Kiremt) that extends from June to September. The study area is characterized by *Nitosol* which is locally known as '*Biye Dima* and *Biye Bore'* and Wheat is the major crop produced in the area (Anonymous, 2017).

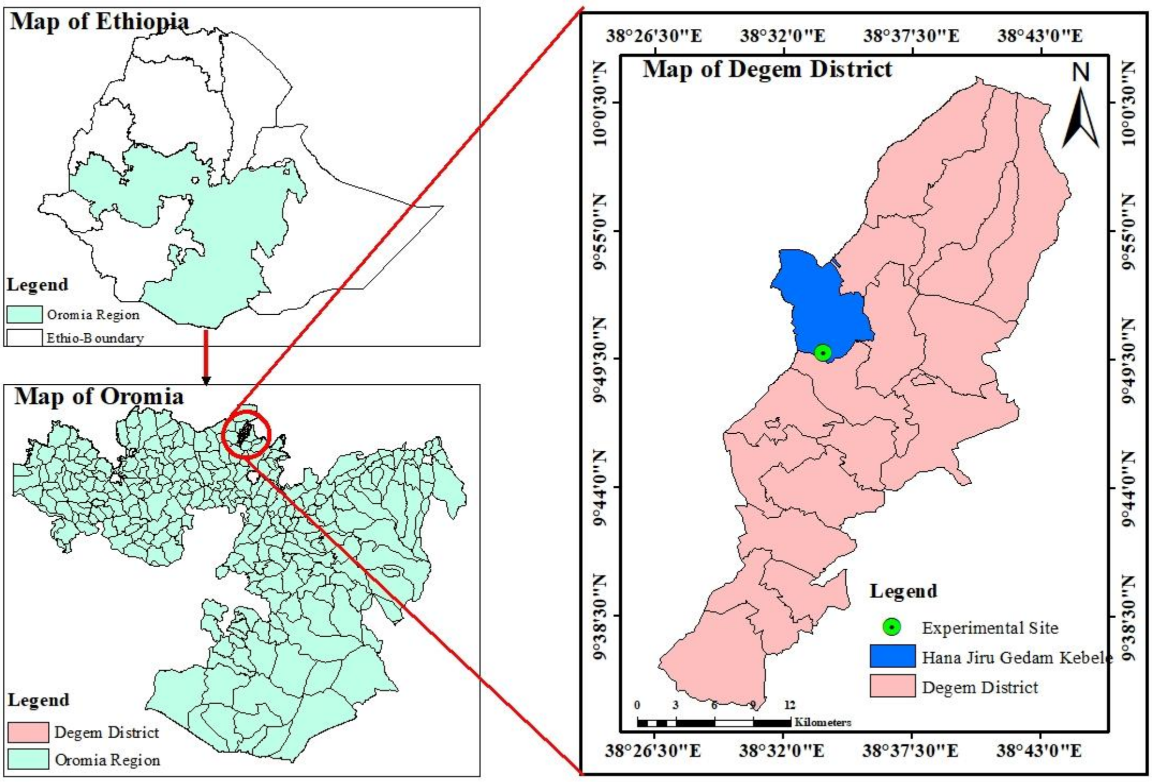

Figure 1. Location map of the study area

3.2. Experimental Materials

3.2.1. Plant Materials

Three bread wheat varieties: Danda'a (Danphe#1), Hidase (ETBW5795) and Kakaba (Picaflor #1) were used for the research study. The details of the three varieties are indicated in Table 1. These varieties are selected based on yield, disease resistance, farmer's acceptance and adaptability to the agro ecology of the study area (Zewdie and Dawit, 2017).

Table 1. Description of varieties used for the study

No	Variety name	Pedigree	Released by	Year of release	Grain yield (tons ha^{-1}) during releasing time		Adaptation zone	
					On station	On farm	Altitude (masl)	RF (mm)
1	Danda'a	Danphe #1	KARC	2010	3.5-5.5	2.5-5	2000-2600	>600
2	Hidase	ETBW 5795	KARC	2012	4.4-7	3.5-6	2100-2800	>500
3	Kakaba	Picaflor #1	KARC	2010			1500-2200	500-800

Source: MoA, Crop Variety Register (1995-2013) and; MoA, Crop Variety Register, 2016
KARC=Kulumsa Agricultural Research Center

3.2.2. Fertilizers Materials

Blended NPSB (18.9% N, 37.7% P_2O_5, 6.95% S and 0.1% B), Triple supper phosphate (TSP of 46% P_2O_5) and urea (46% N) were used as fertilizers source.

3.3. Treatments and Experimental Design

The treatment combinations of three improved varieties (Danda'a, Hidase and Kakaba) and five NPSB fertilizers rates [0, 50, 100, 150, 200 and NP (64/20) kg ha^{-1} of local control] with supplementation of 92 kg N for all treatment except of blanket recommended NP and the control were used for treatments (Table 2). The experimental field study was arranged with a total of 18 treatments in a factorial combination with a complete block design (RCBD) in three replications. The gross plot size of 2.4 meter length*3 meter width=7.2m^2 with 12 rows were considered as an experimental plot size. The spacing between rows, plots and blocks were 0.20 m, 0.5 m and 1 m, respectively and the experiment was generally conducted on 622.7 m^2 of total farmer field area. The net central unit's area of each plot consisting of nine central rows of 1.8 m length and 2 m width were harvested and used for yield determination.

Table 2. Formulation of fertilizer types and rates used in the experiment

Fertilizers code	Fertilizer rates	Nutrient contents			
		N	P_2O_5	S	B
F0	Control	0	0	0	0
F1	50 kg NPSB + 92 kg N	101.45	18.85	3.475	0.05
F2	100 kg NPSB + 92 kg N	110.9	37.7	6.95	0.1
F3	150 kg NPSB + 92 kg N	120.35	56.55	10.425	0.15
F4	200 kg NPSB + 92 kg N	221.8	75.4	13.9	0.2
F5	64/20 kg NP	64	46	0	0

3.4. Experimental Procedures and Field Management

The experimental field was prepared and ploughed manually by oxen three times to fine tilth of the soil before planting. Then according to the design, a field layout was made and each treatment was assigned randomly to the experimental units/plots within a block. The three selected improved varieties of bread wheat were sown at the recommended seed rate of 150 kg ha^{-1} in rows of 20 cm spacing manually by drilling method during at onset of rainfall on 03 July, 2019 of cropping season. The whole amount of NPSB blended and TSP fertilizers was applied at sowing time whereas, half, one-fourth and one-fourth of nitrogen was applied at a time of sowing and top dressed at knee height and tillering of the crops, respectively in order to reduce N fertilizer loss through denitrification and volatilization. Weeding and all necessary agronomic management as per the recommendation practice had been undertaken for all treatments.

3.5. Soil Sampling and Preparation

Pre- beginning of land preparation one representative of composite soil sample was taken at a depth of 0-20 cm from ten randomly selected sub-samples of soil across experimental field by zigzag method using of auger. Then after the sample was air dried under shade, grind using a pestle and a mortar and allowed to pass through a 0.5 mm for total nitrogen, and in 2 mm sieve for others. The analysis of sample was done for selected physico-chemical properties, such as texture, soil pH, cation exchange capacity (CEC), total nitrogen, available phosphorus, sulfur, and boron.

3.6. Soil Sample Parameters and Analysis

3.6.1. Soil Texture

Textural class of the soil was determined using of hydrometer method. During this the soil sample was sieved to separate the gravel from the grains less than 2 mm in diameter and the percent sand was isolated by wet sieving through a set of nested sieves (Salman, 2015). Then this method was used to measure the actual percent by weight of each particle size class of the main sand, silt, and clay fractions in samples of soil from each horizon of the soil profile.

3.6.2. Soil pH

The pH of the soil was determined on 1:2.5 (Weight/volume) soils to water ratio using a pH meter (Motsara and Roy, 2008).

3.6.3. Cation Exchange Capacity (CEC)

Cation exchange capacity of the soil was determined by sodium saturation method where the sample is saturated with 1M NaOAc solution following by replacing Na^+ from the saturation soil sample by 1M NH_4OAc at pH 7.0.Then the amount of Na^+ in the solution was determined by flame photometer.

3.6.4. Total Nitrogen

Total nitrogen content in the soil sample was determined by Kjedahl method. The soil sample was digested with 30% H_2O_2, concentrated H_2SO_4 and catalyst mixture (K_2SO_4:$CuSO_4.5H_2O$: Se=10:1:0.1).Then finally nitrogen in the digest was determined by distillation with 40% NaOH which then followed by titration of the distillate trap in H_3BO_3 with 0.01N of H_2SO_4 (Bremner and Mulvaney, 1982) for its final determination.

3.6.5. Available Phosphorus

Available P content in the soil sample was extracted using of 0.5M $NaHCO_3$ solution at pH of 8.5 (Olsen *et al.,* 1954). Then, available phosphorus content of the soil was determined from the extractable P by developing of blue color with $SnCl_2$ reduction of phosphomolybdate complex and finally the measurement of reading value of the color by spectrophotometer at 660 nm wavelength was recorded (Olsen and Sommers, 1982).

3.6.6. Available Sulfur

Available sulfur(S) content of the soil was determined by extracting soil sample with $CaCl_2$ (0.15%) solution as described by Tabatabai (1982). Accordingly the S content in the extract was determined turbidimetrically and the turbidity is measured by spectrophotometer at the wavelength of 420 nm.

3.6.7. Available Boron

Available B content of the soil was extracted by using of hot water and the extractable B had determined by azomethine-H method (Hunter, 1984).

3.7. Data Collection and Measurements

3.7.1. Phenological and Growth Parameters

Days to heading: This refers to the number of days from the date of sowing up to the stage when 50% of wheat crops fully emerged (headed) and was estimated visually in each plot.

Days to physiological maturity: Days to physiological maturity also determined by consideration of duration period taken by the crops to change its 90% of spikes/panicles in to yellow straw color. It was recorded when the crops totally completes the green color on the glumes and panicles of the plants as well as the grains becomes resistant to break with the thumb nail.

Plant height (cm): Ten plants was randomly selected and tagged from the net plots area of each experimental unit. Then the heights were measured from the selected plant from the ground to the tips of spike (excluding of awns) using of ruler and the mean value was determined in respective to each plots.

Spike length (cm): The spike length of crops was determined by taking ten effective tillers randomly from each plot at the time of harvesting and can be measured from the bottom of spike to the tip of the spike excluding of the awns. Then, the mean value was determined for each plots of experimental unit in centimeter (cm).

3.7.2. Yield Components and Yield

Number of total tillers per plant: Number of total tillers per plant was measured from ten plant samples taken randomly from each plot at full tillering stage of crops by counting the total number of tillers and then the mean value was determined.

Number of productive tillers per plant: Number of productive tillers was determined from those ten plant samples of spikes which can bear kernels and randomly selected at full tillering of the crop.

Number of kernels per spike (NKS): The number of kernel per spike was recorded and computed from ten spike head randomly taken from each plot at the time of harvesting. Then the spike was threshed separately and the seed was counted carefully for the purpose of determined mean number of kernels per spike for each experimental unit.

Thousand kernel weight (TKW): Thousand kernels weight was determined by weighting of 1000 kernels grain yield sample randomly taken and weighted with electronic balance for each experimental units.

Above ground dry biomass (tons ha^{-1}): Above ground dry biomass yield was measured from the plants parts (stems, leaves and grain seeds) harvested from the net plot area for each treatment after sun drying of 4 days of the harvest.

Grain yield (GY) in kg ha^{-1}: The grain yield was taken and determined by harvesting and threshing of crops separately from the net plot area and then weighted by electronic balance. Then the grain yield was expressed by adjusting of it's to 12.5% of moisture content as:

$$AGY\ (kg\ ha^{-1}) = \frac{(\text{Total Grain yield obtained}) \times (100 - MC\ \%)}{(100 - 12.5\%)}$$

Where AGY: is the adjusted grain yield

MC: Moisture content and 12.5 is the standard moisture content for wheat grain in percent.

Straw yield (SY) in tons ha^{-1}: The straw yield was determined by subtracting the grain yield from the total above ground biomass yield for each respective treatment and expressed in tons ha^{-1}.

Harvest index (HI) in percent (%): Harvesting index (HI) was computed as the ratio of adjusted grain yield to total above ground dry biomass yield for each treatment in experimental plot and finally expressed in percent (%) as:

HI (%) = (Grain yield/Above ground dry biomass)*100

3.8. Statistical Analysis

All data recorded and collected were subjected to the procedure of analysis of variance (ANOVA) using of Genstat, 18th edition software version 18.1 (Genstat, 2015). The comparisons among and within treatments means were employed by using of Duncan multiple Range test (DMRT) at 5% and 1% significant level.

3. 9. Partial Budget Analysis

The economic analysis was carried out by using of the methodology described in CIMMYT (1988) in which prevailing the value of market prices for inputs at planting and that of outputs at harvesting time. The economic advantages of applied blended NPSB and nitrogen fertilizers were carried out using partial budget analysis. In this experiment, the costs that vary were calculated by adding costs of fertilizer and labor for fertilizer application. In addition the prices incurred for purchasing of improved bread wheat varieties was also considered in total variable cost during economic feasibility analysis. Accordingly, 13 ETB, 9.42 ETB, 18 ETB and 16 ETB, 2.67 ETB incurred for purchasing of blended NPSB, Urea, Bread wheat seed variety at time of planting and market price value of wheat grain and straw yield at harvesting time per kg for all inputs were used respectively; whereas 2, 4, 6 and 8 persons for application of 50, 100, 150 and 200 kg rate of fertilizers per hectare with the cost for one person 75 ETB per day were considered in the calculation However, other management and fixed costs were assumed to be equal for all and not included in the calculation.

The concepts used in the partial budget analysis were a mean grain yield of each treatment, the gross benefit (GB) ha^{-1}, net income of grain yield of each treatment and the total variable cost (the costs of bread wheat varieties, NPSB fertilizer, Urea and the application costs). The benefit of straw yield was included in the calculation of the net benefit since the farmers of the study area use it as animal fodder and for other purposes. All variable costs and net benefits incomes were calculated on hectare basis in Birr.

Following the CIMMYT partial budget analysis methodology, total variable costs (TVC), gross benefits (GB) and net benefits (NB) were calculated. To identify treatments with maximum return to the farmer‘s investment marginal analysis was performed on non-dominated treatments.

Marginal rate of return, which refers to net income obtained by incurring a unit cost of fertilizer and its application, was calculated by dividing the net increase in yield of bread wheat due to the application of each fertilizers rate.

Marginal rate of return (MRR) (%): was calculated by dividing change in net benefit (ΔNB) by change in total variable cost (ΔTVC) as:

$$MRR = \frac{\Delta NB}{\Delta TVC} * 100$$

The net benefit (NB) was calculated as the difference between the gross field benefit and the total variable (TVC) using the formula

NB= GFB -TVC Where GFB = Gross Field Benefit, TVC = Total Variable Cost; Actual yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers could expect from the same size field.

For a treatment to be considered as a worthwhile option to farmers, the marginal rate of return (MRR) need to be at least between 50% and 100% (CIMMYT, 1988). However, other researchers suggested a MRR of 100% as realistic (Amanuel and Gorfu *et al.*, 1991; Getachew Agegnehu and Rezene Fessehaie, 2006). Accordingly, in the experiments like fertilizer trials the MRR above 100% was the most benefit earned and best recommendation for farmers (CYMMIT, 1988).

4. RESULTS AND DISCUSSION

4.1. Selected Physico Chemical Properties of Experimental Soil before Sowing

Selected physico-chemical properties of the soil were analyzed at Ethiopian Construction Design and Supervision Works Corporation, for composite surface soil (0-20 cm depth) samples collected before sowing of the crop. On the basis of particle size distribution, the soil contained 34.98% sand, 29.36% silt and 35.66% clay (Table 3). According to the soil textural class determination triangle, the soil of the experimental site is Clay loam which is suitable for wheat crop production (Miyan *et al.,* 2011).

The soil reaction of the experimental site (pH = 5.57) is moderately acidic, according to the rating of Tekalign (1991). According to Roy *et al.* (2006), the suitable pH range for wheat crop is between 5.5 and 7.0. Thus, the pH of the experimental soil is within the range for productive soil.

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, 25 - 40 cmol (+) kg^{-1} as high, 15 - 25, 5 - 15 and < 5 cmol (+) kg^{-1} of soil are classified as medium, low and very low, respectively, in CEC. According to this classification, the soil of the experimental site had high CEC (38.67 meq/100 g soils). The organic carbon (%) content of an experimental site was about 2.01% which is rated as moderate according to the rating of Tekalign (1991).

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 (0.25%) (Table 3), indicating that the nutrient is a limiting factor for optimum crop growth.

The available P content of the soil was 27.6 mg P_2O_5 kg^{-1} soil or 12.05 ppm of Available P which was medium according to the rating of Horneck *et al.* (2011). This indicates the need for external application of phosphorus fertilizer sources for good crop growth and yield (FAO, 2008).

The available sulfur content of the soil was 362.81mg kg^{-1} soil which is very high according to the soil critical point concept classification of macro and micronutrients by EthioSIS (2016).

The results of the analysis also indicated that the soil of an experimental site has medium available Boron (Table 3) according to the rating of Horneck *et al*. (2011).

Table 3. Some selected physico-chemical properties of the experimental soil site before sowing

Soil physico chemical properties	Result	Rating	References
pH-H_2O (1:2.5)	5.57	Slightly acidic	Tekalign (1991)
Sand (%)	34.98		
Clay (%)	35.66		
Silt (%)	29.36		
Texture Class	Clay loam		
CEC(meq/100 gm of soil)	38.67	High	Landon (1991)
Organic Carbon (OC) (%)	2.01	Moderate	Tekalign (1991)
Total Nitrogen (TN) (%)	0.25	Moderate	Tekalign (1991)
Available P (mg P_2O_5 kg^{-1} soil)	27.60	Medium	Horneck *et al.* (2011)
Available B (mg kg^{-1} soil)	0.59	Medium	Horneck *et al.* (2011)
Available S (Av.S) (mg kg^{-1} soil)	362.81	Very high	EthioSIS (2016)

4.2. Effects of Blended (NPSB) fertilizers on Phenological Traits and Growth Parameters

4.2.1. Days to Heading

The analysis of variance showed that days to heading were very highly significantly ($P < 0.001$) affected due to the main effect of NPSB fertilizer and variety whereas the interaction effect of both factors was not statistically significant ($P < 0.05$) (Appendix Table 1).

The mean number of days required to 50% panicle heading ranged between 75 days for variety Kakaba and 83.3 days for variety Hidase. The earliest days to heading (77.9 days) was recorded with unfertilized plots and the longer days to heading (82.4 days) was recorded with maximum application of 200 kg ha^{-1} blended NPSB fertilizer (Table 4). Similarly, the shortest days to panicle heading (72.3 days) on variety Kakaba in unfertilized plot and the longest (85.3 days) on variety Hidase treated with 200 kg of blended NPSB supplemented by nitrogen fertilizer (Urea) were recorded (Table 4). The longest days to heading was observed for all varieties at 200 kg ha^{-1} blended NPSB supplemented with nitrogen fertilizer (Urea). This difference in days to 50% panicle heading among varieties could be attributed to their genetic factor variability and amount of nutrient management (different rates of blended NPSB fertilizer supplemented with nitrogen fertilizer) provided for them especially due in fact that nitrogen fertilizer has favored vegetative growth stage and delayed the heading of crops.

This result was in line with Alemu Lakew (2019) who reported that, time to heading of bread wheat was significantly affected by different rate of nitrogen fertilizers. Similarly, Abebe and Hirpa (2018) reported that blended NPSZnB fertilizer and sowing methods was significantly affected days to heading by indicating that the application of blended fertilizer (macro and micro) and Urea, resulting in higher rate of nitrogen nutrients which appeared to prolong vegetative growth stage of wheat and delay time to heading of crop. Similarly, Shahzad and Akmal (2017) found that days to anthesis was significantly affected by nitrogen application rate and time in which the maximum days to anthesis was recorded with the application of 160 kg N ha^{-1} indicating that increasing nitrogen application rate delayed the anthesis of wheat. Likewise, Melesse (2015) also reported similar result who found that flowering was significantly affected due to nitrogen rate which indicated that flowering of wheat crop was delayed as nitrogen level increased from 0 to 69 kg ha^{-1} due to greater vegetative development for longer period of time before reproductive phase begins.

4.2.2. Days to Physiological Maturity

The result of analysis of variance revealed that days to physiological maturity was highly significantly ($P < 0.01$) affected due to the main effect of NPSB fertilizer and varieties; and the interaction effect due to NPSB fertilizer and varieties showed a significant ($P < 0.05$) effect (Appendix Table 1).

The earliest mean days to maturity (141.0 days) was recorded on variety Kakaba in unfertilized plot, while the longest (171.0 days) was observed on variety Hidase in plots treated with 200 kg ha^{-1} of NPSB fertilizer (Table 5). The longest days to maturity was observed for all varieties treated with 200 kg ha^{-1} of blended NPSB fertilizer supplemented with nitrogen fertilizer (Urea); whereas crops matured early in unfertilized (control) plots.

The bread wheat varieties grown under 200 kg NPSB supplemented with nitrogen (Urea) fertilizers matured 11, 11 and 9 days later than crops grown under unfertilized (control) for varieties of Danda'a, Hidase and Kakaba respectively (Table 5). These variations in days to physiological maturity could be due to genetic makeup of the varieties and an adequate amount of nutrient that crops have got from blended NPSB fertilizer as well as due to in fact that nitrogen fertilizer promotes greater vegetative development before the beginning of reproductive phase and there by delay the maturity. Similar to this result, Abebe and Hirpa (2018) indicated that crops grown under 150 kg blended NPSZnB + 82.71 kg of Urea $ha^{-1}$and 200 kg blended NPSZnB + 63.91 kg Urea ha^{-1}were matured with delay of 12 days than crops grown under no fertilizer. The result also similar with Diriba *et al.* (2019) who reported the longest days to physiological maturity for variety Wane and Kingbird at 300 kg $ha^{-1}$of blended NPSB fertilizer application with supplementary urea. Although, Melesse (2015) found that varieties and N rates showed highly significant difference in relation to the days to 90% physiological maturity indicating that the highest doses of 69 kg N ha^{-1} delayed physiological maturity of the two wheat varieties.

4.2.3. Plant Height (cm)

The result of analysis of variance showed that plant height was very highly significantly ($P < 0.001$) affected by the main effect of blended NPSB fertilizer supplemented with nitrogen fertilizer and varieties. The interaction effect of both factors also found highly significant ($P < 0.01$) for plant height of bread wheat in the study area (Appendix Table 1).

The mean tallest plants height of 105 cm was observed with Danda'a variety under the application of 150 kg ha^{-1} NPSB which is statistically at par with 104.9 cm with Hidase variety under application of 200 kg ha^{-1} NPSB fertilizer. The shortest plant 77.9 cm was recorded with Danda'a variety under unfertilized plot (Table5). The result showed that plant height increased with an increase of blended fertilizer rate supplemented by nitrogen fertilizer (Urea). This might be due to a total increase of nitrogen nutrient fertilizer provided for plants with the increase rate of blended NPSB fertilizer and adequate supply of other nutrients for the growth and development of plants thereby resulting in increment of plant height.

In agreement with this result, Diriba *et al.* (2019) found highest plant height of 95.5cm for bread wheat at a maximum application of 300 kg ha^{-1} blended NPSB fertilizer along with 100 kg ha^{-1} of urea and the shortest plant height was obtained from the control plots. These results is also in agreement with the findings of Debnath *et al.* (2014) who reported that plant height was found to increase by nitrogen fertilizer application up to 120 kg N ha^{-1} and boron application up to 2 kg B ha^{-1}. Likewise, Ali *et al.* (2013) also reported that the combined application of 2 kg B ha^{-1} and 5 kg Zn ha^{-1} enhanced the plant height by 30.6% over NPK fertilizer alone indicating that the increment was due to balanced macro and micro nutrients which improve photosynthetic and metabolic activity in the plant system.

Table 4. Main effect of blended NPSB fertilizers and varieties on days to 50% heading, days to maturity, plant height and spike length of bread wheat

Treatments	DH	SL (cm)	NTT
0	77.9[c]	6.7[e]	4.4[c]
50 NPSB	80.2[b]	7.7[c]	4.9[b]
100 NPSB	80.6[b]	8.0[bc]	5.2[b]
150 NPSB	80.8[b]	8.3[ab]	5.1[b]
200 NPSB	82.4[a]	8.5[a]	5.6[a]
64/20 NP	79.7[b]	7.3[d]	4.6[c]
LSD (5%)	1.14	0.43	0.26
Variety			
Danda'a	82.50[a]	7.8	5.0[ab]
Hidase	83.28[a]	7.8	4.8[b]
Kakaba	75.00[b]	7.6	5.1[a]
LSD (5%)	0.81	NS	0.18
CV (%)	1.5	5.8	5.5

Means with the same letter in a column for a trait are not significantly different at 5% level of significance's; DH= Days to Heading, SL= Spike Length, and NTT= Number of total tillers. LSD=Least significant differences at 5% and CV (%) =Coefficient of variation.

Although different plant height was reported for different bread wheat cultivar with the tallest of 101.97cm for Digalu and 85.87cm for Hidase (Wogene, 2017) who indicated that the difference was due to variety, nitrogen fertilizer level and genetic constitution of crops. Moreover, this result is in line with Tilahun and Tamado (2019) who reported that application of NPS and supplemented nitrogen was significantly ($P < 0.05$) increased plant height of durum wheat and recorded the highest height of 79.59cm and 74.49cm at application of 200 kg NPS and 92 kg ha^{-1} N respectively.

4.2.4. Spike Length (cm)

The main effect of blended NPSB fertilizer was very highly significant ($P < 0.001$) on spike length while the main effect of variety and interaction were not significant (Appendix Table 1). As the rate of blended NPSB fertilizer increased there was an increased trend in spike length.

The highest rate of 200 kg ha^{-1} followed by 150 kg $ha^{-1}$of blended NPSB fertilizer which statistically similar with each other resulted in the longest spike length of 8.5cm and 8.3cm respectively; whereas the shortest spikes length of 6.7cm was obtained from unfertilized plants (Table 4). This might be due to an increase of adequate nutrient supply especially nitrogen and phosphorus nutrient available in the formulation of applied blended NPSB fertilizer as in fact that it have a great role in cell division and grain filling there by it attributes to spike length. All the treatment showed increasing tendency of spike length with increasing blended NPSB rates supplemented with nitrogen fertilizer.

The result is in agreement with Melkamu *et al.* (2019) who reported that application of different blended NPSB fertilizers had significant influence on spike length of barley with increasing blended NPSB fertilizers application rates up to 200 kg ha^{-1}. Similarly, Bereket *et al.* (2014) also reported that macro and micro nutrients (Nitrogen, Phosphorous with Sulfur and Boron) fertilizers application can increase spike length of bread wheat with increasing doses and combination.

Moreover, Diriba *et al.* (2019) found that the highest spike length (7.3cm) was recorded from the plot treated with 300 kg ha^{-1} of NPSB application which improved by 12% as compared to the shortest spike length (6.4cm) obtained from control plot indicating that; use of mixed blended fertilizer along with supplementary nitrogen had significant influence on the spike length. Similarly, Abebe and Hirpa (2018) reported that as Spike length was significantly affected by the main effect of blended fertilizer rate and sowing methods indicating that the highest spike length (8.33 cm) obtained with application of 150 kg blended fertilizer ha^{-1} + 82.71 kg urea ha^{-1} which resulted in the increment of 48.18% and 20.93% over the control treatments (0 kg fertilizer) and 100 kg DAP + 100 kg Urea, respectively.

4.3. Effects of Blended (NPSB) fertilizers on Yield Components and Yield

4.3.1. Total Number of Tillers

The analysis of variance showed that the main effect of blended NPSB fertilizer was highly significant ($P < 0.01$) while the variety was significant ($P < 0.05$) on the number of total tillers. However, the interaction effect of blended NPSB fertilizer and variety was not significant (Appendix Table 2).

The highest number of total tillers per plant (5.6) was produced from crops treated with 200 kg ha^{-1} of blended NPSB supplemented with nitrogen fertilizer while the lowest number (4.4) was recorded from unfertilized plots.

Table 5. Interaction effect of blended NPSB fertilizer and varieties on days to maturity, plant height and number of productive tillers of bread wheat

Blended NPSB Fertilizer (kg ha^{-1})	DM			PH (cm)			NPT		
	Varieties			Varieties			Varieties		
	Danda'a	Hidase	Kakaba	Danda'a	Hidase	Kakaba	Danda'a	Hidase	Kakaba
0	159.0^{g}	160.3^{fg}	141.0^{l}	77.9^{i}	77.6^{i}	79.1^{hi}	3.7^{h}	4.1^{d-h}	3.9^{gh}
50 NPSB	162.0^{de}	162.3^{de}	143.0^{jk}	88.7^{efg}	84.0^{ghi}	96.7^{bcd}	3.9^{gh}	4.0^{e-h}	4.5^{bcd}
100 NPSB	164.0^{c}	163.3^{cd}	144.3^{j}	98.7^{abc}	92.1^{cde}	98.2^{a-d}	4.4^{c-f}	4.3^{c-g}	4.5^{b-e}
150 NPSB	167.0^{b}	168.3^{b}	146.0^{i}	105.0^{a}	91.7^{def}	100.0^{ab}	4.9^{ab}	4.3^{c-g}	4.3^{c-g}
200 NPSB	170.0^{a}	171.0^{a}	149.7^{h}	104.9^{a}	99.9^{ab}	102.5^{ab}	4.6^{bc}	4.5^{b-e}	5.0^{a}
64/20 NP	162.3^{de}	161.7^{ef}	142.7^{k}	85.6^{fgh}	85.3^{fgh}	96.4^{bcd}	4.0^{fgh}	3.9^{gh}	4.2^{c-g}
LSD(5%)	1.50			5.98			0.38		
CV (%)	0.6			3.9			5.4		

Means followed by the same letter/s in columns and rows of each trait are not significantly different at 5% level of significance; DM= Days to Maturity, PH= Plant Height, NPT=Number of productive tillers, LSD=Least significance difference at 5% and CV (%) =Coefficient of variations.

Among the varieties the highest total tillers number (5.1) was recorded by variety Kakaba which is statically at par with a total tiller number (5.0) recorded under variety Danda'a and the lowest (4.8) was recorded by Hidase variety (Table 4). Total number of tillers per plant responded differently to blended NPSB fertilizer with supplementary nitrogen and bread wheat varieties. This might be due to an increase in cell division, differentiation of growing cell which ultimately resulting from an adequate provision of sufficient nutrients by crops from blended fertilizer in addition to genetic makeup of cultivars. In line with this result, Bizuwork (2018) reported that the highest number of total tillers was produced by plants treated with the highest rate of combined application of blended (150/115 NPSB/N kg ha^{-1}) fertilizers and the lowest from unfertilized plots which stating that; the synergetic role of the four nutrients played in enhancing growth and development of the crop. Similarly, Dinkinesh (2018) also reported as the main and interaction effect of NPSB blended fertilizer application rate and varieties were highly significantly affect the total tillers of wheat indicating the highest number of tillers (301.7 m^{-2}) was obtained from Mangudo at 183 kg NPSB ha^{-1} the lowest total number of tillers (142.4 m^{-2}) from Ude variety without NPSB application.

This result also agrees with the finding of Girma (2018) who reported the maximum number of total tillers (466.7 m^{-2}) under application of the highest rate of NPS and seed rate (200 kg NPS ha^{-1} + 150 kg seed rate ha^{-1}) and a minimum of 160 m^{-2} under unfertilized plots. In parallel, Abdulatif *et al.*(2010) found highest number of tillers 467 m^{-2} where 175-150-125 NPK kg ha^{-1} was applied which indicated that progressive increase in number of tillers with different fertilizers levels increases but did not continue beyond of (175:150:125 NPK kg ha^{-1}) application rate.

4.3.2. Number of Productive Tillers per Plant

The result of analysis of variance showed that number of productive tillers was significantly ($P < 0.05$) affected by main effect of blended NPSB fertilizer and variety; whereas the productive tillers was highly significantly ($P < 0.01$) affected by interaction effect of both factors (Appendix Table 2). The maximum number of productive tillers (5.0) was obtained in Kakaba variety at application of 200 kg ha^{-1} of blended NPSB fertilizer followed by Danda'a variety treated with 150 kg ha^{-1} of blended NPSB fertilizer (4.9) although the difference between the two is statistically at par. While the minimum number of productive tillers 3.7 was obtained from unfertilized plot with Danda'a variety (Table 6). The reason for differences on productive tillers by different levels of blended NPSB fertilizers might be due to provision of sufficient supply of essential nutrient and balanced fertilization of crops especially at a time of its emerging, growth and developmental period of crops which results in a higher number of total and productive tillers.

The result in this study was in conformity with Tilahun and Tamado (2019) who reported that the highest number of productive tillers 306.7 m^{-2} at 150 kg NPS ha^{-1} supplemented with 92 kg N ha^{-1} which indicate that the productive tillers was higher by 107.4% over that of control plots. Likewise, Diriba *et al.* (2019) also found that the higher effective tillers 7.7 per plant were obtained in wane variety under application of 300 kg NPSB with supplementary urea. The result also in agreement with the finding of Girma (2018) which indicate the maximum number of tillers 413.3 m^{-2} with application of the highest rate of NPS (200 kg NPS ha^{-1}) and seed rate of 150 kg ha^{-1} indicating that increasing seed rates increased plants emerged in area and NPS fertilizers favored tillering.

Moreover, this result is in agreement with Dinkinesh (2018) who found that the highest number of productive tillers (245.6 m^{-2}) was obtained from variety Mangudo at 183 kg NPSB ha^{-1}which was statically at par with variety Utuba (227.2) at 122 kg NPSB ha^{-1}(227.2 m^{-2}) and lowest number of productive variety Alemtena with nil NPSB application and it was statistically at par with all cultivars on no NPSB fertilizer

4.3.3. Number of Kernels per Spike

The main effect of blended NPSB fertilizer and variety had highly significant ($P < 0.01$) effect whereas the interaction effects of both factors are found to be non-significant on number of kernels per spike (Appendix Table 2).

The highest number of kernels per spike (54.9) was obtained at application of 200 kg blended NPSB fertilizer with supplementary nitrogen (urea) fertilizer whereas the lowest number of kernels (42.5) was recorded in unfertilized plot. Among the varieties, the highest mean of kernels (54.3) was recorded by variety Danda’a which followed by statistically at par with kernels (53.6) under variety Hidase and the lowest kernel’s number (39.3) was recorded by Kakaba variety (Table 6). The higher number of kernels per spike under different level of blended NPSB fertilizer could be due to an optimum nutrient provision for growth and development of crops from respective source of applied fertilizers as in fact phosphorus is essential for grain development and boron for grain setting and the difference among bread wheat varieties might be due to genetic variability of crops. So, the synergistic effect of nutrients supply in combination with genetic capacity of cultivar might ultimately results in increases of number of kernels per spike.

This result was in agreement with that of Demisew (2018) who reported that application of 175 kg ha^{-1} NPS fertilizer increased number of seeds per spike by 20.48% than treatment without fertilizer. Similarly, Bizuwork (2018) also found that the highest (50.07) and the lowest (34.73) number of kernel's per spike at combined application of 150/92 kg blended NPSB/N ha^{-1} fertilizer and unfertilized plots respectively; indicating that adequate application of NPSB and N fertilizer supply enables the crop to make rapid growth and to intercept more solar radiation and thus attribute for more number of kernel's per spike.

In agreement with this result Usman (2018) also observed that the highest number of kernel's per spike (47.1) under Kingbird variety whereas Hidase and Huluka record lower number of kernel's indicating that the differences was due to genetic variability among varieties. The result also observed that the highest number of kernels per spike (48.3) under 150 NPSB kg ha^{-1} fertilizer applications. Similarly, Dinkinesh (2018) also reported highest number of kernels (43) produced from the highest rate of NPSB fertilizers (183 kg ha^{-1} of blended NPSB) whereas the minimum number of kernels per spike (35) was produced at nil blended NPSB rate.

Moreover, Diriba *et al.* (2019) found that the higher number of seeds per spike (45.2) from wane variety and as application of 250 and 300 kg of blended NPSB significantly increased number of seeds per spike by 35% and 38%, 37% and 40% respectively for wane and kingbird varieties indicating that application of blended fertilizer increased the appearances of seeds in their spikes.

4.3.4. Thousand Kernel Weight

Thousand kernel weight was very highly significantly ($P < 0.001$) affected by the main effect of variety. Whereas the main effect of blended NPSB fertilizer as well as the interaction effect of both factors were found to be non-significant (Appendix Table 3).

Table 6. Main effect of blended NPSB fertilizer and varieties on number of kernels per spike, thousand kernels of weight and above ground biomass yield of bread wheat

Treatments	NKS	TKW	AGBM (tons ha^{-1})
Fertilizers			
0	42.5^{c}	46.0	6.9^{d}
50 NPSB	47.7^{bc}	46.0	9.1^{c}
100 NPSB	52.5^{ab}	48.2	9.9^{c}
150 NPSB	48.12^{bc}	47.2	11.8^{b}
200 NPSB	54.9^{a}	45.4	13.8^{a}
64/20 NP	48.7^{abc}	46.2	9.3^{c}
LSD (5%)	6.15	NS	1.41
Varieties			
Danda'a	54.3^{a}	46.3^{b}	10.1
Hidase	53.6^{a}	49.3^{a}	10.0
Kakaba	39.3^{b}	44.4^{b}	10.3
LSD (5%)	4.35	2.18	NS
CV (%)	13.1	6.9	14.5

Means with the same letter/s in column are not significantly different at 5% level of significance's; NKS= Number of Kernels per Spike, TKW= Thousand Kernels Weight, ABGB=Above Ground Biomass Yield, LSD=Least significant differences at 5% and CV (%) =Coefficient of variation.

Among varieties the maximum thousand kernels weight of 49.3 g was obtained by Hidase variety while the minimum of 44.4 g was obtained by Kakaba variety (Table 6). These differences in weight of kernels might be due to the genetic capacity of a variety to absorb light and the highest photo assimilate and nutrient use efficiency of the plants other than the nutrient management practices which there by attributes for more grain filling of the crops and increase in size of seeds as well as weight of crops.

Similarly, Usman (2018) also reported that as the variety Hidase had the highest thousand kernels weight (43.7 gm) and the effect of fertilizer rates showed the highest thousand kernels weight (43.8 g) was recorded from 150 kg ha^{-1} of NPSB fertilizer. In agreement with this result Dinkinesh (2018) also reported that as thousand kernels weight was affected by blended NPSB fertilizer and varieties indicating maximum thousand kernels weight (44.8 g) at the NPSB rate of 183 kg ha^{-1} and it was statistically at par with the NPSB rate of 122 kg ha^{-1} (44.3 g) while the lowest was in unfertilized plot.

Moreover, many research findings reported that too much amount of nitrogen fertilizer application had not significant effect on thousand kernels weight. i.e., it has a negative correlation on the parameter. For example, Berekat *et al.* (2014); Gerba *et al.* (2013) and Tilahun *et al.* (2016) reported that the highest thousand kernels weight was obtained from application of 92 kg N ha^{-1} but, the value decrease as the rate of nitrogen exceeds above this rate.

In general the result of this study showed that the values of thousand kernels weight were negatively correlated with the number of kernels per spike. i.e. the highest thousand kernels weight of crops, the lowest number in kernels per spike and vice versa.

4.3.5. Above Ground Biomass Yield

The result of analysis of variance showed that the main effect of fertilizer highly significantly (P < 0.05) affected the above ground biomass yield. However, the main effects of variety as well as the interaction effect of both factors were found to be non-significant (Appendix Table 3).

The highest above ground biomass yield (13.8 tons ha^{-1}) was recorded under 200 kg NPSB ha^{-1} application followed by 11.8 tons ha^{-1} under application of 150 kg ha^{-1} of blended NPSB fertilizer while; the lowest biomass yield was recorded from unfertilized plot (Table 6). These increased in biomass yield with increase of blended NPSB fertilizer might be due to better crop growth rate, maximum accumulation of photo-assimilate and LAI in parallel with maximum days to maturity by the crop which ultimately results in highest biomass yield. In addition the highest biomass might also resulted from the synergetic effect of the nutrients which increased uptake of nutrients and root growth favoring better growth of above ground biomass yield.

The present result is in agreement with Abebe and Hirpa (2018) who reported that the highest biomass yield under application of 200 kg blended fertilizer and 63.91 kg of urea ha^{-1} followed by 150 kg blended fertilizer and 82.71 kg of urea ha^{-1} and the lowest was under no fertilizer application. Similarly, Tilahun and Tamado (2019) found that the maximum biomass yield (11728 kg ha^{-1}) obtained at maximum supplementation of 92 kg N ha^{-1} and the lowest biomass yield (10150 kg ha^{-1}) in plot with no nitrogen supplementation; indicating that biomass yield increased with increase of nitrogen from 0 to 92 kg N ha^{-1}.

Moreover, the result is in conformity with Diriba *et al.* (2019) who reported that the highest above ground biomass yield in Wane (14053 kg ha^{-1}) and Kingbird (12009 kg ha^{-1}) varieties was recorded from application of 300 kg NPSB and the lowest (5302 kg ha^{-1}) from the control. The result also indicated that increasing the application of blended fertilizer rates increased the growth, vegetative condition and the production of yield and above ground biomass yield of bread wheat varieties. Similarly, the result is in agreement with Bizuwork (2018); Dinkinesh (2018) and Girma (2018) who reported the increase in biomass yield as the rate of blended NPSB fertilizer increases.

4.3.6. Straw Yield

The analysis of variance showed that the main effect of blended NPSB fertilizer highly significantly ($P < 0.01$) affected the straw yield whereas the main effect of variety and interaction effect of both factors were found to be not significant (Appendix Table 3).

The highest straw yield (9.4 tons ha^{-1}) was obtained at the application of 200 kg ha^{-1} of blended NPSB fertilizer with nitrogen supplementation and the lowest straw yield (4.8 ton ha^{-1}) was from the control plot (Table 7). The highest straw yield from the highest blended NPSB rate of 200 kg ha^{-1} might be contributed from the synergetic effect of nutrients as in fact that the presence of sulfur increases the nitrogen use efficiency of crops which play a great role in promoting the vegetative growth and development thus by increases the straw yield of bread wheat.

The result is consistent with that of Bizuwork (2018) who reported increased in straw yield of bread wheat with the increase of blended NPSB and nitrogen from 150/115 to 100/92 NPSB/N kg ha^{-1} even if the yield is statically at par to each other. Similarly, Usman (2018) reported that the highest straw yield 7818 kg ha^{-1} obtained at the highest blended NPSB rate of 200 kg ha^{-1} whereas the lowest 6684 kg ha^{-1} was from the control.

The result also in agreement with Diriba *et al.* (2019) who reported that the highest production of straw yield 9070 kg ha^{-1} was recorded under application of 300 kg of blended NPSB and the lowest 3099 kg ha^{-1} from the control indicating that the higher productivity of yield and yield components like plant height, spike length and effective tillers there by attributes for increment of straw yield.

4.3.7. Grain Yield

The analysis of variance showed that the main effect of blended NPSB fertilizer and varieties were highly significantly ($P < 0.01$) affected the grain yield of bread wheat. However, the interaction effects of the two factors were found to be non-significant (Appendix Table 3).

The highest grain yield (4549 kg ha^{-1}) was obtained under application of 200 kg of blended NPSB ha^{-1} supplemented with nitrogen fertilizer whereas the lowest was under no fertilizer application. The mean of grain yield was increased with the increment of blended NPSB from 50 kg ha^{-1} to 200 kg ha^{-1}. Grain yield obtained at application of 200 kg of blended NPSB ha^{-1} with supplementary nitrogen increased grain yield by 38.62% and 54.51% as compared to blanket recommendation (64/20 NP) and control respectively (Table 7). The highest mean grain yield (3351 kg ha^{-1}) was recorded in Hidase variety whereas the lowest was recorded in Kakaba variety which is statically at par with Danda'a variety.

Table 7 Main effect of blended NPSB fertilizer and varieties on straw yield, grain yield and harvest index of bread wheat

Treatments	SY (tons ha^{-1})	GY (kg ha^{-1})	HI (%)
Fertilizers			
0	4.8^{c}	2069^{e}	30.7
50 NPSB	6.4^{b}	2694^{d}	30.4
100 NPSB	6.8^{b}	3125^{c}	32.6
150 NPSB	7.8^{b}	3993^{b}	34.3
200 NPSB	9.4^{a}	4549^{a}	34.2
64/20 NP	6.5^{b}	2792^{d}	30.6
LSD (5%)	1.45	217.5	NS
Varieties			
Danda'a	7.0	3125^{b}	31.9
Hidase	6.8	3351^{a}	33.7
Kakaba	7.1	3135^{b}	30.9
LSD (5%)	NS	153.8	NS
CV (%)	21.8	7.1	13.8

Means with the same letter in columns are not significantly different at 5% level of significance's; SY= Straw Yield, GY= Grain Yield, HI= Harvest Index, LSD=Least significant differences at 5% and CV (%) =Coefficient of variation.

The main and final ultimate goal in every crop production is achievement in maximum economic profit in yield, which is a complex function of environmental condition, response of yield components and yield of the genetic potential of varieties, management practice and the interaction of all of these factors. The various differences in grain yield under different rates of blended NPSB fertilizers and varieties might be due to an adequate and sufficient supply of balanced nutrient from blended NPSB fertilizer for crops both in quantity and quality from respective increased rates of blended fertilizer for growth and development of crops thus by which attributes for increment of grain yield. This result was in agreement with the finding of Abebe and Hirpa (2018) who reported that the highest grain yield 29.58 qt ha^{-1} was produced with application of 200 kg of blended NPSZnB fertilizer + 63.91 kg of urea ha^{-1} and the lowest yield 18.19 qt ha^{-1} was found under no fertilizer application. The finding of Tilahun and Tamado (2019) indicate that the highest grain yield 5274 and 5738 kg ha^{-1} was obtained at application of 200 kg ha^{-1} blended NPS and 92 kg ha^{-1}N supplemented respectively.

Moreover, the finding of this result is similar with Bizuwork (2018) who reported that the highest mean grain yield of 5666 kg ha^{-1} was obtained at combined application of 150 kg of blended NPSB and 92 kg N ha^{-1}, whereas the lowest mean grain yield of 1960 kg ha^{-1} was obtained from unfertilized plots. Similarly, Diriba *et al.* (2019) also reported that the better performance of grain yield 4236 kg ha^{-1} at the highest rate of 300 kg ha^{-1} of blended NPSB fertilizer application with Wane variety.

4.3.8. Harvest Index

The analysis of variance for harvest index showed that main effect of blended NPSB fertilizer rates, varieties and their interaction effects were found to be non-significant (Appendix Table 3).

4.4. Analysis of Correlation of Parameters

Days to heading and maturity , number of total tillers and number of productive tillers, number of kernels per spike and thousand kernels weight, above ground biomass yield and straw yield, grain yield and harvest index; and above ground biomass yield and grain yield showed strongly significant positive correlation. Furthermore, maturity date and number of kernels per spike, number of total tillers and number of kernels per spike; and plant height with spike length were significantly positive correlations. Among those parameters considered; number of total tillers and thousand kernels weight, straw yield and grain yield as well as above ground biomass yield and harvest index had negatively significant correlation (Table 8).

Table 8. Correlation coefficient of various parameters of bread wheat

	DH	DM	NTT	NPT	PH	SL	NKS	TKW	AGBM	SY	GY	HI
DH	1											
DM	0.867**	1										
NTT	0.174	-0.243	1									
NPT	-0.094	0.078	0.534**	1								
PH	-0.065	-0.149	0.196	0.154	1							
SL	0.056	0.1	0.071	0.006	0.459*	1						
NKS	-0.111	0.404*	0.375*	-0.185	0.138	0.054	1					
TKW	0.087	-0.166	-0.351*	0.248	-0.238	0.164	0.522**	1				
AGBM	-0.069	0.129	0.11	0.043	0.205	-0.125	-0.012	-0.037	1			
SY	0.07	-0.084	-0.123	-0.108	-0.05	0.038	0.066	-0.03	0.868**	1		
GY	0.023	-0.061	0.004	0.066	-0.199	0.238	-0.143	0.177	0.749**	-0.353*	1	
HI	-0.062	0.146	0.036	-0.137	0.265	-0.219	0.11	-0.138	-0.373*	-0.122	0.841**	1

DH= Days to heading, DM= Days to maturity, NTT= Number of Total Tillers, NPT= Number of Productive Tillers, PH= Plant Height, SL= Spike Length, NKS= Number of Kernels per Spike, TKW= Thousand Kernels Weight, AGBM= Above Ground Biomass, SY=Straw Yield, GY=Grain Yield and HI=Harvest Index.

4.5. Partial Budget and Economic Analysis

In the present study, the prices for purchasing of the NPSB fertilizer, Urea, bread wheat and labor cost for fertilizer application were considered as variable cost where as other costs were constant for each treatment. In order to recommend the present finding in the study area, it is necessary to estimate the minimum rate of return acceptable to producers in the recommendation domain.

It is quite evident from the result presented in Table 9, the partial budget analysis showed that mean highest net benefit of (97993) Birr ha^{-1} was obtained from variety Hidase that received 200 kg NPSB ha^{-1} with nitrogen fertilizer supplementation. However, the lowest mean net benefits of (39582) Birr ha^{-1} were obtained from the unfertilized treatment with the variety Danda'a. This indicates that a bread wheat producers can get an extra of 9.60 ETB for 1.00 ETB investments in the blended NPSB and N fertilizers application on the rates less than or equal to 200/92 kg blended NPSB/N ha^{-1} fertilizers.

According to partial budget analysis indicated, variety Hidase gave both the highest marginal rate of return (959.97%) and economic benefit of (97993 ETB ha^{-1}) at 200 kg NPSB ha^{-1} fertilizer rate followed by Danda'a variety which gave MRR (906.99%) and net economic benefit of (88596 ETB ha^{-1}) at 200 kg NPSB ha^{-1}which indicates us with net benefit increment about a (9397 ETB) by Hidase over Danda'a variety within the same rate of blended NPSB fertilizers per hectare. Additionally, as a third and fourth option both varieties namely Kakaba and Danda'a at 200 kg NPSB and 150 kg NPSB ha^{-1} fertilizer rate gave the maximum economic benefit of (82996 ETBha^{-1}) and (79459 ETB ha^{-1}) with marginal rate of return (722.02%) and (853.17%), respectively.

Therefore, application of blended NPSB fertilizer at the rate of 200 kg with the supplement of 92 kg N ha^{-1} in the production of Hidase and Danda'a varieties was more economically beneficial and recommended as the best alternative option respectively for around Degam district area with similar soil types and agro ecologies.

Table 9. Partial budget and economic analysis of the effect of blended NPSB fertilizer rates supplemented with nitrogen fertilizer on bread wheat varieties at Degam District in 2019 cropping season

Treatments				Net Income (ETB ha^{-1})						
Fertilizer (kg ha^{-1})	Varieties	AGY (kg ha^{-1})	ASY (kg ha^{-1})	Grain yield	Straw Yield	TGB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	ΔNB (ETB ha^{-1})	MRR (%)
0	Danda'a	1875	4600	30000	12282	42282	2700	39582	39582	D
50 NPSB	Danda'a	2625	5900	42000	15753	57753	5984	51769	12187	371.10
100 NPSB	Danda'a	3083	6800	49328	18156	67484	6644	60840	21258	539.00
150 NPSB	Danda'a	4042	8300	64672	22161	86833	7374	79459	39877	853.17
200 NPSB	Danda'a	4375	10000	70000	26700	96700	8104	88596	49014	906.99
64/20 NP	Danda'a	2750	6300	44000	16821	60821	8669.38	52151.62	12569.62	D
0	Hidase	2250	4800	36000	12816	48816	2700	46116	46116	D
50 NPSB	Hidase	2875	6000	46000	16020	62020	5984	56036	9920	302.07
100 NPSB	Hidase	3208	6500	51328	17355	68683	6644	62039	15923	403.73
150 NPSB	Hidase	4000	6800	64000	18156	82156	7374	74782	28666	613.31
200 NPSB	Hidase	4979	9900	79664	26433	106097	8104	97993	51877	959.97
64/20 NP	Hidase	2792	6400	44672	17088	61760	8669.38	53090.62	6974.62	D
0	Kakaba	2083	5000	33328	13350	46678	2700	43978	43978	D
50 NPSB	Kakaba	2583	7400	41328	19758	61086	5984	55102	11124	338.73
100 NPSB	Kakaba	3083	7000	49328	18690	68018	6644	61374	17396	441.08
150 NPSB	Kakaba	3938	8300	63008	22161	85169	7374	77795	33817	723.51
200 NPSB	Kakaba	4292	8400	68672	22428	91100	8104	82996	39018	722.02
64/20 NP	Kakaba	2833	6700	45328	17889	63217	8669.38	54547.62	10569.62	D

NPSB= Nitrogen, Phosphorous, Sulfur and Boron; NP= Nitrogen and Phosphorus; AGY= Adjusted Grain Yield; ASY= Adjusted Straw Yield; TGB= Total Gross Benefit; TVC= Total Variable Cost; NB= net Benefit; ΔNB= Change in Net Benefit; MRR= Marginal Rate of Return; ETB= Ethiopian Birr per hectare and D= Dominated.

5. SUMMARY AND CONCLUSIONS

The experiment was conducted during the 2019 main cropping season (from July to December) at Degam district on farmer field. Thus, the study was conducted with the aim to investigate the effect of blended NPSB fertilizer rates on different yield components and yield of bread wheat varieties as well as to assess the most profitable blended fertilizer rates for the different bread wheat varieties for wheat crop production in the study area. The treatments consist of factorial combination of five levels of blended NPSB fertilizers [(0, 50, 100, 150 and 200 kg ha^{-1}) and recommended NP (64/46 as local check)] with three bread wheat varieties (Danda'a, Hidase and Kakaba); resulting into a total of 18 treatment combinations. The experiment was laid out in a randomized complete block design (RCBD) with factorial arrangement in three replications.

The results of the field experiment showed parameters like 50% days to heading, 90% physiological maturity, total number of tillers, productive number of tillers, plant height, number of kernels per spike and grain yield are highly affected by the main effect of the varieties and blended NPSB fertilizers except spike length, above ground biomass and straw yield which were not significantly affected by varieties as well as thousand kernels weight and harvest index which were not significantly affected by blended NPSB fertilizer.

Variety Hidase recorded the highest days to heading (83.3), maturity (164.5), thousand kernels weight (49.3 g), maximum thousand kernel weight (44.7 g), and grain yield (3351 kg ha^{-1}). Similarly, variety Danda'a scored the highest number of kernels per spike (54.3) while variety Kakaba scored highest plant height (95.5 cm), number of total tillers (5.1) and productive number of tillers (4.39). However; Kakaba variety recorded earliest days to heading and maturity (75 and 144.4 respectively), and the lowest number of kernels per spike (39.3).

The highest, maximum grain yield (4549 kg ha^{-1}), above ground biomass yield (13.8 tons ha^{-1}), straw yield (9.4 tons ha^{-1}), number of kernels per spike (54.9), total number of tillers(5.6), number of productive tillers (4.7), the longest days to heading (82.4 days), physiological maturity (163.6 days), highest number of kernels per spike (54.9) and highest plant height (102.4 cm) were recorded at the maximum NPSB rate application (200 kg ha^{-1}) supplemented with nitrogen fertilizers. While the lowest and minimum result for all parameters were recorded from unfertilized plot except for thousand kernels weight and harvest index.

However, only days to 90% physiological maturity, plant height and productive number of tillers were significantly affected by interactions of both factors.

The result of economic analysis showed that combined production of 200 kg ha^{-1} blended NPSB fertilizer with Hidase variety gave economic benefit of 97993 ETB ha^{-1} with the acceptable marginal rate of return (640.14%). Similarly, the grain yield also showed that statistically the highest grain yield (4979 kg ha^{-1}) was obtained from the combined application of 200 kg ha^{-1} of blended NPSB fertilizer with Hidase variety.

Therefore, it could be concluded that application of 200 kg blended NPSB in supplement of 92 kg N ha^{-1} fertilizer with Hidase variety was temporarily the best producing alternatives and economically profitability and with acceptable grain yield of bread wheat production at the study area. Thus, for shorter term this rate of fertilizer would be recommended for the study area. However, definite recommendation may not be drawn from this research result, as the present result came from single experiment involving one location and few varieties. Therefore, it is advisable to undertake further research across soil types, season and locations involving others best performing cultivar to draw sound recommendation on a wider scale and for longer duration and variable cropping systems.

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7. APPENDICES

Table of Appendix 1. ANOVA of mean square value for days to heading, days to maturity, plant height and spike length of bread wheat as influenced by blended NPSB fertilizer and varieties

Source of variation	Mean squares				
	Df	DH	DM	PH	SL
Block	2	6.24	5.06	5.9	0.55
NPSB fertilizer(F)	5	19.99***	123.20***	675.39***	3.79***
Varieties(V)	2	376.13***	2361.06***	234.16***	0.44NS
F×V	10	1.35NS	1.99*	40.94**	0.18NS
Residual	34	1.42	0.82	12.99	-
CV (%)		1.5	0.6	3.9	5.8

NS=Non-significant,*=Significant at 5% level, **=highly significant at 1% level, ***=Very highly significant at 0.1% level, NPSB= Nitrogen Phosphorus Sulfur and Boron, DF=Degree of freedom, DH= Days to Heading, DM= Days to Maturity, SL= Spike Length and CV= Coefficient of variation.

Table of Appendix 2. ANOVA of mean square values for number of total tillers, number of productive tillers, number of kernels per spike and thousand kernels weight of bread wheat as influenced by blended NPSB fertilizer and varieties

Source of variation	Mean squares				
	Df	TNT	NPT	NKS	TKW
Block	2	0.02	0.22	99.57	66.15
NPSB fertilizer(F)	5	1.67**	0.803***	166.06**	6.95ns
Varieties(V)	2	0.277*	0.247*	1302.60***	111.24***
F×V	10	0.075NS	0.170**	61.96NS	2.48NS
Residual	34	0.075	0.053	41.21	10.33
CV (%)		5.5	5.4	13.1	6.9

NS=Non-significant,*=Significant at 5% level, **=highly significant at 1% level, ***=Very highly significant at 0.1% level, DF=Degree of freedom, TNT= Total Number of Tillers, NPT= Number of Productive Tillers, NKS= Number of Kernels per Spike, TKW=Thousand Kernel’s Weight, and CV= Coefficient of variation.

Table of Appendix 3. ANOVA of mean square values for above ground biomass yield, straw, grain yield and harvest index of bread wheat as influenced by blended NPSB fertilizer and varieties

Source of variation	Mean squares				
	Df	AGBM yield (tons ha^{-1})	SY (tons ha^{-1})	GY(kg ha^{-1})	HI (%)
Block	2	37.94	38.97	81887	407.99
NPSB fertilizer(F)	5	51.16^{***}	21.45^{***}	7476678^{***}	30.66^{NS}
Varieties(V)	2	0.314^{NS}	0.68^{NS}	292173^{**}	38.18^{NS}
F×V	10	1.397^{NS}	1.296^{NS}	67954^{NS}	5.03^{NS}
Residual	34	2.15	2.304	51556	19.78
CV (%)		14.5	21.8	7.1	13.8

NS=Non-significant,*=Significant at 5% level, **=highly significant at 5% level, ***=Very highly significant at 1% level, DF=Degree of freedom, AGBM=above ground biomass, SY= Straw Yield, GY=Grain yield, HI=Harvest index, and CV= Coefficient of variation.