RESPONSE OF BREAD WHEAT VARIETIES TO APPLICATION OF BLENDED NPS FERTILIZER RATES AT AGARFA DISTRICT, OROMIA REGIONAL STATE, ETHIOPIA

M.Sc. THESIS

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Response of Wheat Varieties to Application of Blended NPS Fertilizer at Agarfa District, Oromia Regional State, Ethiopia

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APPROVAL SHEET-I

This is to certify that the thesis entitled Response of Bread Wheat Varieties to Application of Blended NPS Fertilizer at Agarfa District, Oromia Regional State, Ethiopia, submitted in partial fulfillment of the requirements for the degree of Master of Sciences with specialization in Agronomy of the Graduate Program of the School of Plant and Horticultural Sciences, College of Agriculture, Hawassa University, is a record of original research carried out by Yeaynishet Alemu, under our supervision, and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged. Therefore, we recommend that it be accepted as fulfilling the thesis requirements.

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APPROVAL SHEET -II

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As members of the Examining Board of the Final MSc Open Defense, we certify that we have read and evaluated the thesis prepared by **Yeaynishet Alemu** entitled **Response of Bread Wheat Varieties to Application of Blended NPS Fertilizer at Agarfa District, Oromia Regional State, Ethiopia** and recommend that it be accepted as fulfilling the thesis requirement for the degree of master of science in Agriculture (specialization: Agronomy)

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Final approval and acceptance of the thesis is contingent upon the submission of the final copy of the thesis to the Department of Graduate Council (DGC) of the candidate's major department.

DEDICATION

This thesis is dedicated to the memory of my mother, Azalech Habtemariam, who passed away without seeing my success, my father Alemu Kibret and my beloved husband, Fikre Kassaye for their support and understanding during my study time.

STATEMENT OF AUTHOR

I declare that this thesis is my own work and all sources of materials used for this thesis have been duly acknowledged. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate.

Name: **Yeaynishet Alemu** **Signature:**……….……………

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LIST OF ABBREVIATIONS AND ACRONOMYS

ATVET:	Agricultural Technical Vocational Education Training
CEC:	Cation Exchange Capacity
D:	Dominated
DAP:	Diamonium Phospate
ENR:	Efficient and Not Responsive
ER:	Efficient and Responsive
FAO:	Food and Agriculture Organization of the United Nations
GYRI:	Grain Yield Response Index
Masl:	Meter above Sea level
MRR:	Marginal rate of return
N:	Nitrogen
NENR	Neither Efficient Nor Responsive
NER:	Not Efficient but Responsive
NSIA:	National Seed Industrial Agency
P:	Phosphorus
S:	Sulphur

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RESPONSE OF BREAD WHEAT VARIETIES TO APPLICATION OF BLENDED NPS FERTILIZER RATES AT AGARFA DISTRICT, OROMIA REGIONAL STATE, ETHIOPIA

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ABSTRACT

Field experiment was conducted during 2012/13 E.C cropping season to study the response of Bread wheat vfertilizerarieties to blended NPS at Agarfa district, Oromia Regional State, Ethiopia. The treatments consisted of four rates (50,100,150,200 kg NPS ha^{-1}) and recommended rate of Urea and DAP (50 + 100 kg ha^{-1} and three bread wheat varieties (Sinja, Huluka and Gelan) laid out in randomized complete block design arranged factorialy and replicated three times. All plots were supplemented with different rate of Urea to make the N rate uniform. The main effect of blended NPS fertilizer significantly influenced most agronomic parameters except days to heading and maturity, and harvest index. The maximum number of total tillers (213.89), biomass yields (10.46 t ha $^{-1}$), 1000 seed weight(45.5g), grain yields (4.96 t ha^{-1}) , straw yield (5.49 t ha^{-1}) and plant height (77.4 cm) were obtained at the highest rate of 200 kg ha^{-1}NPS) but maximum number of productive tillers(188.3) was recorded from 150 kg ha $^{-1}$ NPS. Varieties showed significant difference for all agronomic parameters except harvest index. The highest plant height (76.86 cm), the longest days to heading (63.47 days) and days to physiological maturity (105.3 days), highest grain yield (5.09 t ha^{-1}) and straw yield (5.48 t ha^{-1}), largest biomass yield (10.58 t ha^{-1}), maximum 1000 seed weight (47.83 g) were recorded from variety Gelan. Interaction of fertilizer rates and varieties was significant on number of kernels per spike. Regarding the economic feasibility of the fertilizer and varieties, maximum net return, 84184 birr/ha and 96890 Birr ha^{-1}, were recorded from 200 kg ha $^{-1}$ NPS and Gelan variety respectively. The result of grain yield response index (GYRI) illustrated that variety Gelan belonged to ER group and both Huluka and Sinja varieties were under the NENR group. Thus, variety Gelan and the NPS rate of 200 kg ha^{-1} can be recommended for producing wheat in the study area.

Keywords*: Blended fertilizers, recommended Urea and DAP, varieties, yield and yield related parameter*

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most widely grown crop in the word. It is an important source of food and energy with its unique protein characteristics (Cooke and Law, 1998). Moreover, it is one of the major cereal crops growing in Ethiopian highlands at altitudes ranging from 1500 to 2800 masl and with mean minimum temperatures of 6 to 11°C (MoA, 2012). It is cultivated both in bi-modal and uni-modal rain fall areas and predominantly grown in the southeastern, central and northwestern regions of the country. Bread wheat (*Triticum aestivum* L.) and durum wheat (*Triticum turgidum* var.durum Desf.) are the most dominant species which are mainly cultivated by small scale farmers in Ethiopia (Tamene et al., 2018; Zewdie, 2004). Durum wheat accounts for 40% of production, and bread wheat, accounts for the remaining 60% (Bergh et al., 2012).

In Ethiopia Wheat is the fourth most important cereal crop after *tef*, maize and sorghum, covering about 13.49% of the area of grain crops. As to production, wheat covers 15.63% next to maize and tef of the grain production (CSA, 2017). Arsi and Bale highlands are the major wheat producing regions of Ethiopia and are deemed to be the wheat belts of East Africa (Tamene et al., 2018). However, to ensure sustainable crops production including wheat, healthy soils with good physical, chemical and biological fertility are important. In contrast, poor quality soils exhibit various dysfunctional attributes (Assefa et al., 2015).

Any factor influencing the metabolic activity of the plant at any period of its growth affects crop yield. Metabolic processes in wheat plants are greatly governed by both internal i.e. genetic makeup of the plant and external conditions which includes climatic and edaphic environmental factors. It is obvious that, increasing wheat production per unit area can be achieved by cultivating the promising wheat cultivars developed by breeding and applying the optimum cultural practices such as suitable fertilizers (Hassanein et al., 2018).

For the last three decades, Ethiopian agriculture depended mainly on imported fertilizer products involving urea and di-ammonium phosphate (DAP) as sources of nitrogen N and phosphorus P. However, recently it is perceived that the production of such high protein cereals like wheat and legumes can be limited by the deficiency of S and other nutrients (Assefa et al., 2015). Thus, the practice of using blended fertilizers that included various micronutrients is underway in the country.

Nitrogen is the most limiting nutrient for wheat production. It occupies a conspicuous place in plant metabolism. All vital processes in plant are associated with protein, of which nitrogen is an essential constituent that affects the rapid plant growth and improves grain yield. Consequently to get more crop production, nitrogen application is essential in the form of chemical fertilizer (Amjed et al., 2011; Violeta et al., 2015). Nitrogen fertilizer applications that exceed crop N requirements lead to environmental pollution including nitrate leaching and N gaseous emissions. As a result, it is so essential to determine the plant response to N fertilization and its real N demand (Tayebeh et al., 2011).

Phosphorus (P) is essential to all known life forms because it is a key element in many physiological and biochemical processes. A component of every cell in all living organisms, P is indispensable and cannot be replaced by any other element (Johnston & Steén, 2000). Soil P deficiency is one of the major factors limiting crop yields worldwide. Although required by plants in a smaller quantity compared with other primary macronutrients (e.g. nitrogen). The inadequate supply of P results in severe limitations to plant growth. In order to adequately supply P to crops, the addition of P fertilizer or other sources of P becomes necessary in most agricultural soils, especially in highly weathered tropical acidic soils. However, due to the complex behavior of P in soils, it is well known that only a small fraction of added P fertilizer is taken up by plants when soils are initially fertilized with P (McLaughlin et al., 2011).

In the last two decades year's S deficiency has become an increasing problem for agriculture resulting in decreased crop quality parameters and yields (Zhao et al., 1999). Although sulfur is often overshadowed by N, P and K, it is an essential element best known for its role in the synthesis of proteins, oils, vitamins and flavored compounds (Assefa et al., 2015). Similar to N adequate supplies of S is also important for optimum crop yield (Klikocka and Cybulska, 2014; Dostálová et al., 2015).

Crops require a sufficient, but not excessive, supply of essential mineral elements for optimal productivity. An insufficient supply of mineral elements may lead to limited plant growth (Nadian et al., 2010). According to Gashaw et al., (2014) wheat yields in Ethiopia are relatively low. The reasons given for these are several socio- economic, abiotic, and biotic constraints. Most parts of Ethiopian soils showed deficiency of 3 to 6 nutrients N, P, S, Zn, Mo and B and the plant analysis data in different sites indicated that wheat plants are deficient in N, P, Zn and K (Hailu et al., 2015). Because of this, Ethiopia must change from blanket recommendations rates to recommendations based on soil and crop type (Tilahun and Tamado, 2019). Therefore, different fertilizer materials would be required to ensure balanced fertilizer use involving all or most of the nutrients required by crops including several combinations of blended fertilizers (Melaku, 2019).

Study on response of durum wheat (*Triticum turgidum* L. var. Durum) to blended NPS fertilizer at Arsi Negelle showed that increasing the rate of blended NPS fertilizer from 100 to 200 kg ha^{-1} increased grain yield and the highest grain yield was obtained at the highest (200 kg ha^{-1}) of blended NPS fertilizer (Tilahun and Tamado, 2019). Moreover, Assefa et al. (2015) reported that grain yield and yield components of bread wheat (100%) responded to applied nitrogen in all experiment field, 72.3% of the fields showed response to sulfur, 78% showed response to applied phosphorus on eighteen fields studied in central high lands of Ethiopia strongly indicating sulfur deficiency along with its importance to include in balanced fertilizer formula.

There is little information on blended NPS fertilizer response for different crops and environments in Ethiopia in general and Agarfa in particular and farmers currently use 100 kg ha^{-1} blended NPS as blanket recommendation. Even if, NPS (blended fertilizer) is considered as more effective than DAP and UREA, farmers who use NPS blended fertilizer at studied area were obtained less product than DAP(100 kg ha^{-1}) and UREA (50 kg ha^{-1}) (which was used by farmers previously). Therefore, to recommend better fertilizer studying and identifying the effect of both fertilizers (NPS blended fertilizer and DAP and UREA) on bread wheat varieties have important implication for future fertilizer management and recommendation. Moreover, this study was conducted to know effects of NPS blended fertilizer on growth and yield performance of bread wheat varieties and to recommend more effective fertilizer in the study area.

Objectives:

- To evaluate the effects of NPS application rate on growth, yield and yield related traits of three wheat varieties
- To determine economically appropriate rate of blended NPS fertilizer and identifying high yielding varieties for bread wheat production in Agarfa district.
- To study the extent of the interaction effects of wheat varieties and fertilizer rates on growth and yield of bread wheat at Agarfa district.

2. LITERATURE REVIEW

2.1. Origin of Wheat

The development of agriculture arose 10,000 years ago, as a shift from the hunter-gather mode to a more domesticated system which allowed for the growth and development of permanent civilizations. Through selective gathering or deliberate cultivation, humans were able to domesticate common varieties of wild wheat, most likely wild emmer or einkorn. With time, the process of preparing soil, sowing seeds, and eliminating competing plants helped fuel the great success of Wheat production, shown today though the ability to process, store, cultivate and trade grain world-wide . The debate over wheat's origin has never been fully resolved, and although the region of greatest development seems to lie in the eastern region (Mediterranean to Asia), it cannot be determined whether wheat stemmed from the Far or Near East (Kipel and Kriemhild, 2000).

Most archeological evidence suggests that the earliest domestication of wheat occurred around 7500–6500 BC in the 'Fertile Crescent' consisting of the mountain chains flanking the plains of Mesopotamia and the Syrian Desert. Cultivated Einkorn and Emmer appear to have become established by farmers selecting landraces from wild-grass stands. Cultivation of both forms appears to have spread around the Near East by 7000 BC, and subsequently to the lowlands of Mesopotamia, Egypt, the Mediterranean basin, Europe, central Asia, India and Ethiopia by 4000 BC. Bread wheat probably arose independently more than once during the cultivation of Emmer wheat, and was probably selected by farmers for its bigger grains and better yields. Distinct crops of bread wheat have been found and dated from around 7000 BC in Syria, Iran and Iraq (John, 2006).

2.2. Nutritional Aspects of Wheat

The nutritional value of wheat is addressed through its macronutrient and micronutrient components. These groups consist of carbohydrate, proteins and lipids, for macronutrients, and vitamins, minerals and phytochemicals for micronutrients. First to macronutrients, grains consist of approximately 75% carbohydrate and therefore many believe that the importance of carbohydrate and fiber within wheat takes precedence over their concentrations of vitamins, minerals, and phytochemicals (Basey, 2005).

The nutritional value of wheat is of key importance, since wheat is the world's largest food crop in terms of production after rice and maize; thereby it contributes more calories and nutrients to the human diet than any other cereal crop. Wheat is consumed as bread, pasta, noodles, biscuits and many other confectionary products. Wheat is nutritious, easy to transport and store and it is a good source of protein, dietary fiber and vitamins (Abrar, 2012).

2.3. Effect of Nitrogen Fertilizer on Yield and Yield Components of Wheat

Nitrogen is essential for all living things. Nearly 98% of the world's nitrogen is found in the solid earth within the chemical structure of rock, soil, and sediment. The remainder moves in a dynamic cycle involving the atmosphere, oceans, lakes, streams, plants, and animals. (Eva, et al., 2000).

Nitrogen is required in large quantities by most crops, and adding N is a basic part of most fertilizer programs. Nitrogen (N) plays a central role in plant biochemistry. It is an essential constituent of cell Wall, cytoplasmic proteins, nucleic acids (the regenerative portions of the living cell), Chlorophyll (the green plant pigment important for photosynthesis) and a vast array of other cell components. Therefore, a low supply of N has a profound influence on crop growth and may lead to a great loss in grain yield (Miller and Danahue, 1995). Plants absorb N as $NH4^{+}$ or $NO3^{-}$. Generally $NO3^{-}$ occur in higher concentration than $NH4^{+}$ and it is free to move to the root by mass flow and diffusion. The preference of plants for either $NH4^{+}$ or $NO3^{-}$ determined by the age, type of the plant, environment and other factors. The rate of $NO3^{-}$ uptake is usually high and favored by low PH and absorption of $NO3^{-}$is more rapid at low PH value (Tsidal et al., 1993).

Nitrogen is one of the most important macronutrients and is the most limiting factor in crop production which results in higher biomass and protein yields in plant tissue (Hassanein et al., 2018). It occupies a conspicuous place in plant metabolism. All vital processes in plant are associated with protein, of which nitrogen is an essential constituent. Consequently to get more crop production, nitrogen application is essential in the form of chemical fertilizer (Amjed et al., 2011). The efficiency of nitrogen fertilizer increased by using ammonium gas (Violeta et al., 2015; Hassanein et al., 2018). A greater response to nitrogen fertilization was noted when meteorological conditions, especially rainfall, were not limiting factors. Finally, we have shown that the positive effect of nitrogen fertilization levels on grain yield was related to better performance of grain yield components (Glovani et al., 2012).

The yield of wheat is a function of many factors, among them the cultivars and nitrogen fertilization being the most important ones. Grain yield is the most integrative character because it is influenced by all factors that determine productivity (Melaku, 2019). In a study on bread wheat and durum wheat it was found that grain yield increased with increasing irrigation frequency and N rate (Dawood and Kheiralla, 1994).

Several researchers in Ethiopia have reported that the role of N in wheat production changes in yield and yield components have been affected with the application of N fertilizer. Studies conducted under sandy soil in Egypt showed that, of all yield and its components characters plant height (cm), number of tillers/ m^2, number of spikes/ m^2, weight of spikes (g/m^2), grain yield (g/m), grain index (g), straw yield and biological yield were significantly affected by different rates of nitrogen applied in the form of ammonia gas ((Hassanein et al., 2018). The study indicate that increasing nitrogen fertilizer from zero to 90 kg N increased significantly yield and its components. An increase in yield with N application on wheat is well documented (Tayebeh et al., 2011). According to this study, the different N rates (120, 240 and 360 kg ha^{-1}) have a significant effect on grain yield increasing it by 46% at N120, 72% at N240, and 78% at N360 compared to control. Plant height, number of spikelet's per spike, weight of grains per spike, 1000-grain weight, number of spikes, and grain yield were significantly increased with increasing N level (Violeta et al., 2015).

Studies on N application on loam and clay loam soils at Gamo-gofa Zone showed that grain yield of wheat was highly significantly influenced by the interaction of time and rate of N fertilizer application, and rate of N fertilizer application (Assefa et al., 2015). A similar experiment done by Amjed et al., (2011) showed that all the nitrogen treatments significantly increased the number of tillers m^{-2} than control with application of 130 kg N ha^{-1} (N) resulted into maximum number of tillers. Sofonyas et al., (2018) reported that the application of different rates of nitrogen produced grain yield of wheat was significantly influenced by sources and rates of N. In their study, application of 64 kg N^{-1} ha exhibited the highest performance among the treatments and is statistically significant over the control.

2.4. Effect of Phosphorus on Yield and Yield Components of Wheat

Phosphorus is one of the 17 essential elements required for plant growth and development. It contributes to many vital functions in the plant, such as early root and seedling growth, promotion of early heading and uniform maturity, seed formation and quality, and increased water-use efficiency (Adrian, 2001). Also it is essential for photosynthesis, the process by which plants harvest energy from the sun to produce carbohydrate molecules, i.e. sugars (Johnston & Steén, 2000).

Deficiency Symptoms are more noticeable in young plants, which have greater relative demands for P than more mature plants. Mild deficiencies cause stunted growth but no obvious leaf symptoms. More severe deficiencies produce small, dark green plants that have short, erect leaves, stout stems, and often develop orange, red, or purple areas. Tiller production and grain yield are reduced even by mild deficiencies. When a deficiency persists or becomes severe, little grain is produced because many young tillers die before maturity and the surviving tillers produce small heads that set few grains. (Jones 1930).

Wheat is an exhaustive crop which depletes soil fertility and degrades its physical condition. The common problem in Wheat Production is deficiency of Phosphorus because it is expensive nutrient compared to nitrogen (Khan *et al*., 2014). Phosphorus is immobile in soil and thus proper placement of phosphorus can make its available to roots of plants (Wahid et al., 2015). Plant P uptake is influenced by P supply, characteristics of the soil and P requirement of crop plants. In early stages of development, crop plants absorb phosphorous faster from fertilizer than from soil and hence a high proportion of the total P absorbed by young plants is derived from the fertilizer (Melaku, 2019).

Grain yield of wheat can be affected by varieties, phosphorus levels and application methods. Effect of varieties, phosphorus levels and application methods are significant on productive tillers m^{-2}, Grain $spike^{-1}$, thousand grains weight and Grain yield (Mohammad et al., 2015). Application of 105kg ha^{-1} phosphorus produced maximum number of productive $tillers^{-2}$ and grain $spike^{-1}$, maximum grain yield and thousand grain weight (Mohammad et al., 2015).

According to Muhammad et al., (2014), Increase in phosphorus and irrigation application cause increased in number of tillers, grain $spike^{-1}$ and grain weight. More phosphorus application at early flowering stage compensates the drastic effect of water shortage. It is observed that grain and straw yield increased significantly as irrigation and P application rate increases. With the application of 120 kg ha^{-1} phosphorus, maximum grain yield was observed in well irrigated field conditions. Saqib et al., (2015) showed significant effect of phosphorus levels and application methods on productive tillers m^{-2}, non-productive tillers m^{-2}, and plant height, number of grain $spike^{-1}$, thousand grain weight and grain yield of wheat. Maximum productive tillers m^{-2} are recorded from 100 kg P_2O_5 ha^{-1} and are statistically similar to 75 and 125 kg P_2O_5 ha^{-1}. In case of application methods, more productive tillers m^{-2} are recorded from double band P application and are statistically at par with broadcast method.

2.5. Effect of Sulfur Fertilizer on Yield and Yield Components of Wheat

Sulphur (S) is an essential plant nutrient required by all crops for optimum production. Plants take up and use S in the sulphate (SO_4-S) form, which like nitrate (NO_3-N), is very mobile in the soil and is prone to leaching in wet soil conditions, particularly in sandy soils (Ross and McKenzie 2013). Sulphur plays many important roles in the growth and development of plants.

Sulphur is essential in the structural and enzymatic components in plants. Sulphur is a key component of some essential amino acids and is needed for protein synthesis. Chlorophyll synthesis also requires S (Ross and McKenzie 2013). It also improves milling and baking quality of cereal crops; enhance oil content of oilseed crops; controls certain soil borne diseases and helps in formation of glycosides that give characteristic odors and flavors to onion, garlic, and mustard; necessary for the formation of vitamins and synthesis of some hormones It serves to enhance water solubility of organic compounds, which may be important in dealing with salinity stress (Clarkson and Hanson,1980).

Sulphur deficiency symptoms vary between crops. For cereals and forage grasses, the yellowing of newly emerging leaves is a strong indicator of S deficiency. Depending on the degree of deficiency, the leaves may be a shade of light green to entirely yellow. Yellowing of the new growth occurs because S is immobile in the plant. This situation is in contrast to nitrogen deficiency symptoms in which the older leaves turn yellow first because nitrogen is translocated or “scavenged” from older leaves to support new growth. A sulphur deficiency at any growth stage can result in reduced crop growth and yield. Adequate S results in rapid crop growth and earlier maturity (Ross and McKenzie 2013).

The principal sources of sulfur addition to soil are chemical amendments or fertilizers, farmyard manures, or crop residues. It has been predicted that greater areas will be sulfur deficient in the future in many parts of the world because of growing high yielding crop cultivars, use of S-free fertilizers. The high cost of chemical fertilizers, and implementation of air pollution control measures or environmental pollution concern (Melaku, 2019).

Klikocka et al., (2016) determined the significant effect of sulphur and nitrogen fertilizer on grain yield of spring wheat and most of quality characteristics of grain in south-eastern Poland. Analysis of the results showed a significant beneficial effect of N and S fertilizer on the grain yield of spring wheat and on most of the quality characteristics of the grain.

According to Shawl et al., (2014) growth and yield components of bread wheat were not affected by different levels of S while, grain yield and straw yield of wheat were signicantly affected by S in both Cambisols and Vertisols.

Shawel et al.,(2021) also revealed that application of P and S fertilizer has significantly increased yield component, grain and straw yield of wheat compared to unfertilized control plot optimum grain and straw yield of wheat was obtained with treatment involving at 22 P + 15 S kg ha^{-1} While, partial budget analysis result revealed that, combination of 22P and 15S kg ha^{-1} produced the highest MRR (54.9%)

2.6. Effect of Blended NPS Fertilizer on Yield and Yield Components of Wheat

In the past, Ethiopian agriculture used fertilizers products mostly involving only urea and di-ammonium DAP, which are sources of N and P. Nowadays production of wheat and other cereals is limited by S deficiency. In Ethiopia, major prone areas of S deficiency are the central highlands (HLs), because of their high crop production. Reasons that lead to S deficiency in soils of central HLs include improved use of high-analysis fertilizers that contain no S, intensive agriculture that leaves behind little organic matter (OM), and/or complete removal of OM for alternative uses, including farm yard manure (FYM), increased crop yields due to high yielding varieties, resulting in more S removal and intensive cropping-systems (Assefa et al., 2015).

New fertilizer materials with value addition and micronutrients would be required to ensure balanced fertilizer use involving all or most of the nutrients required by crops. Nutrients such as Zn, B, and S can often be included relatively economically in new fertilizer formula; when targeted to deficient soils, these nutrients can dramatically improve fertilizer-use efficiency and crop profitability. Balanced fertilization is important for optimal crop production, better food quality and benefits for the growers, and is also the best solution for minimizing environmental pollution (Melaku, 2019).

For durum and bread wheat new blended fertilizers such as NPS (19% N, 38% P_2O_5 and 7% S) are currently being used by the farmers with blanket recommendation of 100 kg NPS ha^{-1} in Ethiopia but the amount of N in the blended NPS is small as compared to the requirement of durum wheat (Tilahun and Tamado, 2019). Response of blended NPS fertilizer on wheat (*Triticum aestivum* L.)) growth, yield component and yield is studied by different researchers in different areas. The studies of Tilahun and Tamado, (2019) showed blended NPS fertilizer and supplemented N rates had significant influence on grain yield. Increasing the rates of blended

NPS fertilizer from 100 to 200 kg ha^{-1} and supplemented N from 0 to 92 kg ha^{-1} showed consistent increase on grain yield on loam type of soil. Similarly Assefa et al., (2015) showed the grain yield and other yield components of wheat have shown highly significant response to applications of N, S and P.

3. MATERIALS AND METHODS

3.1 Description of the Study Area

This study was conducted at Agarfa ATVET College which is located in Agarfa District of Bale Zone in the Oromia Regional State of Ethiopia. Agarfa Agricultural College is located about 458 km south east of Addis Ababa. It lies at an altitude of 2350 m.a.s.l. between 6^0 58’ 40” and 7^0 20’ 0” N, and 39^0 44’ 0” and 40^0 26’ 40” E. The site is characterized by a cool sub-humid climate. The average annual rainfall of the area based on 10-years meteorological data is 799.05 mm, with bimodal pattern and has two growing seasons. The mean annual temperature is 23.47 $^{\circ}$C while the mean maximum and mean minimum are 24.22 $^{\circ}$C and 22.73 $^{\circ}$C, respectively (Bale Robe metriological station) (Figure 1). The major crops grown in studied area are bread wheat (*Triticum aestivum* L.), food barley (*Hordeum vulgare* L), maize (*Zea mays* L.) and potato (*Solanum tuberosum* L.). These major crops are produced usually once in a year.

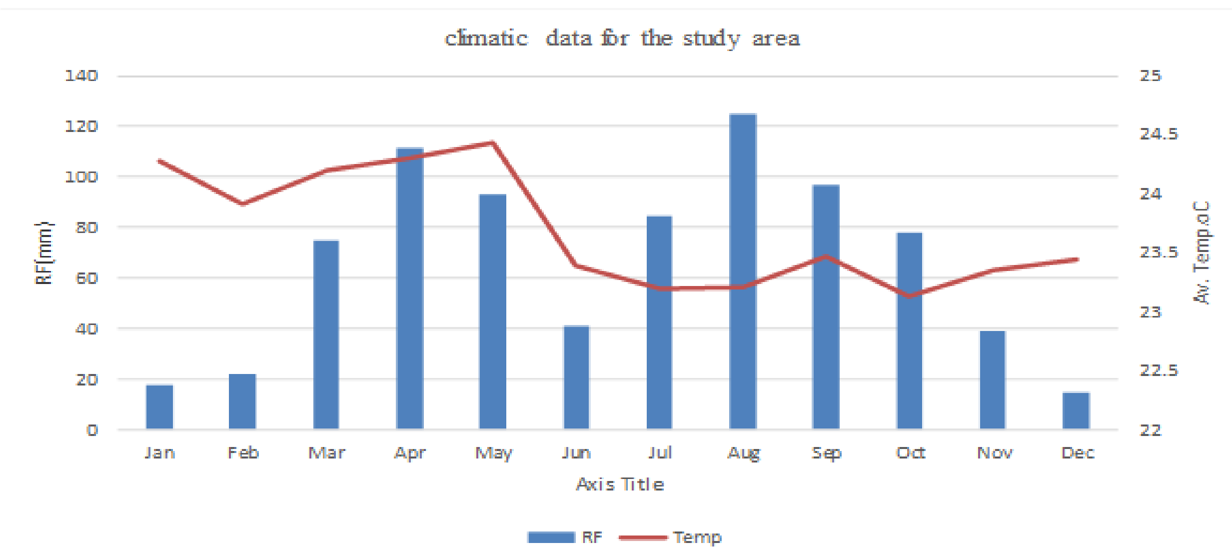

Figure 1.Annual rainfall and average monthly temperature of Agarfa (Ten year average).

3.2. Experimental Treatments, Design and Procedures

The experiment is a two factor experiment involving three varieties of bread wheat and four levels of NPS and recommende rate of NP fertilizer with supplemental urea. Accordingly, three bread wheat varieties (Sinja, Huluka and Gelan) which are the latest varieties were used for this study. Likewise, the four levels of NPS fertilizer that were used in this experiment were 50, 100, 150 and 200 kg NPS ha^{-1} with different rate of urea as supplemental N and the recommended rate of urea and DAP which is 50 kg and 100 kg ha^{-1} respectively used as one treatment (control) .

The experiment was laid down in randomized complete block design (RCBD) with three replications. The treatment combinations consisting of the three varieties of wheat, four levels of NPS and one recommended rate of urea and DAP, are presented on Table 1.

Table 1. Treatment combinations

S.No.	Fertilizer treatments ($kg\ ha_{-1}$)	composition of fertilizers N	P_2O_5	S	varities **Sinja (V_1)**	**Huluka(v_2)**	**Gelan (V_3)**
1	Recommended urea & DAP(50 $kgha^{-1}$urea +100 $kgha^{-1}$DAP)	**41**	**46**	**0**	$RNPV_1$	$RNPV_2$	$RNPV_3$
2	NPS1+U1 (50kg NPS+68 kg urea)	41	19	3.5	$NPS_1U_1V_1$	$NPS_1U_1V_2$	$NPS_1U_1V_3$
3	NPS2+U2(100kg NPS+48 kg urea)	41	38	7.0	$NPS_2U_2V_1$	$NPS_2U_2V_2$	$NPS_2U_2V_3$
4	NPS3+U3 (150kg NPS+27 kg urea)	41	57	10.5	$NPS_3U_3V_1$	$NPS_3U_3V_2$	$NPS_3U_3V_3$
5	NPS4+U4 (200kg NPS+6 kg urea)	41	76	14	$NPS_4U_4V_1$	$NPS_4U_4V_2$	$NPS_4U_4V_3$

Where, RNP: recommended rate of urea and DAP

The experimental plot size was 2m x 2m with a spacing of 20 cm between rows. The space between blocks and plots within a block was 1 and 0.5 m, respectively. Total area was 37 m length × 8 m width having an area of 296 m^2. The net plot area was 30m length × 6 m width having an area of180 m^2. Seeding was carried out by drilling in rows at the rate of 125kg/ha. All blended fertilizer (NPS), DAP and 1/3 part of Urea was applied at sowing and remaining 2/3 part of urea was top dressed at mid-tillering.

Table 2- list of varieties and their characteristics

Variety	Year of release	Source center	Productivity (kg/ha)	Altitude range
Sinja	2018	SARC	48-52	2000-2400
Huluka	2018	KARC	45-48	-
Gelan	2019	SARC	55-60	2200-2500

3.3. Soil Sampling and Analysis

Surface soil (0-20 cm depth) samples were collected from the experimental field by using auger sampler using a zigzag pattern from 10 spots of the experimental field and composited into one sample before sowing the crop. From this mixture, a sample weighing one kg was taken. Air dried soil sample was ground with a pestle and mortar. Before analysis, the sample was sieved through a 2-mm sieve for selected chemical and physical soil properties.

The soil samples for some parameters relevant to the study were analyzed at Hawassa University laboratory. Soil particle size distribution was determined by the Bouyoucos hydrometer method (Van Reeuwijk, 1992) using particles less than 2 mm diameter. The pH of the soils was measured in water suspension in a 1:2.5 (soil: water ratio) potentiometrically using a glass-calomel combined electrode (Van Reeuwijk, 1992). Cation Exchange Capacity (CEC) of soil was determined by neutral sodium-acetate saturation and neutral NH_4 –acetate displacement. Total N was analyzed by the Micro-Kjeldhal digestion method with sulphuric acid (Jackson, 1962). Available soil P was analyzed according to the standard procedure of Olsen method (Olsen et al., 1954). Available S was determined by mono-calcium phosphate extraction method or turbidimetric estimation (Johnson and Fixen, 1990)

3.4. Agronomic Data Collection

From the agronomic data, crop phenology, plant height, biomass and grain yields and major yield components were counted and measured. These include seedling emergence, days to heading, days to maturity number of seedling per meter square, number of tillers, plant height, number of seeds per spike, grain yield and total above ground biomass yield.

Days to 50% heading refers to the number of days from the date of seedling emergence to the stage when 50% of the spikes fully emerged (headed), and was estimated visually.

Days to 90% maturity was recorded as number of days from the date of seedling emergence up to the date when 90% of the crop stands in a plot changed their green color to light yellow color in each plot.

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

Number of total tillers was determined by counting seedlings from 0.2 m^2 (0.5 m x 0.4 m) area of two middle rows immediately after seedling emergence and counting plants from the same marked area of the two rows before flowering. Then the difference between the first and the second counts converted as number of total tillers per m2.

Number of productive tillers was determined by counting seedlings from 0.2 m^2 (0.5 m x 0.4 m) area of two middle rows immediately after seedling emergence and counting plants from the same marked area of the two rows at physiological maturity. Then the difference between the first and the second counts converted to m2 is the number of fertile tillers per m^2.

Number of kernels per spike was recorded as an average of 10 randomly taken spikes from the net plot area.

Total above ground biomass (ton ha^{-1}) was determined from plants harvested from the net plot area after sun drying until constant weight attained and weighed to obtain the total biomass yield and expressed in ton ha^{-1}.

Thousand seed weight (g): - It was determined based on the weight of 1000 kernels sampled from the grain yields using an electric seed counter. It was weighed with an electronic balance and adjusted to 12.5% moisture level.

Straw yield (ton ha^{-1}) was measured by subtracting grain yield per plot from the total above ground biomass.

Grain yield (ton ha^{-1}) was taken by harvesting and threshing the grain yield from net plot area an d converted to ton ha^{-1}. The yield was adjusted to 12.5% moisture.

Harvest index was calculated as ratio of grain yield per plot to total aboveground dry biomass yield per plot.

$$\text{Harvest index} = \frac{\text{grain yileld per plot}}{\text{above ground biomass per plot}} \times 100$$

3.5. Grain Yield Response Index Analysis'

Grain yield response index (GYRI) was calculated for each cultivar, according to Fageria and Barbosa Filho (1981) using the following conditions. Where in this case low NPS levels was 50kg/ha and high NPS levels was 200kg/ha. It is an indication to the efficiency of wheat cultivars for producing higher grain yield at low blended NPS rate and their response to increase blended NPS fertilizer rates.

$$GYRI=\frac{\text{Grain yield under high blended NPS level} - \text{Grain yield under low blended NPS level}}{\text{High blended NPS level} - \text{Low blended NPS level}}$$

(kg grain kg NPS^{-1})

3.6. Economic Feasibility Analysis

Economic analysis was performed to investigate the economic feasibility of the treatments. It is carried out by using the methodology described in CIMMYT (1988) in which prevailing market prices for inputs at planting and for outputs at harvesting were used. The concepts used in the economic analysis were the mean grain yield of each treatment, the gross benefit (GB) ha^{-1} (the mean yield for each treatment) and the field price of fertilizers (the costs of NPS and Urea & DAP and the application costs). Cost of straw yield was not included in the calculation in the benefit since the farmers in the area do not use it. Marginal rate of return was calculated as change of benefit divided by change of cost as described by CIMMYT (1988). The yield adjustment is 90% of the actual yield means. This 10% downward adjusted was done to reflect the difference between the experimental yield and the yield farmers could expect from the same treatment. The discarded and selected treatments using this technique were referred to as dominated and undominated treatments, respectively.

MRR (%) = (ΔNR/ΔTVC) x 100

Where, MRR= marginal rate of return, ΔNR= change in net revenue, ΔTVC= change in total variable cost.

NR= TR – TVC, Where, TR= Total revenue, TVC= total variable cost.

TR= AGY x Price of the wheat grain

TVC= Cost of NPS fertilizer + Cost of Urea + Cost of DAP fertilizer

Where, AGY= Adjusted grain yield

AGY= GY – (UGY x 10%), Where, GY= Grain yield, UGY= unadjusted grain yield.

The % MRR between any pair of un-dominated treatments was the return per unit of investment in fertilizer. To obtain an estimate of these returns, the % MRR was calculated as changes in NB (raised benefit) divided by changes in cost (raised cost). Thus, a MRR of 100% implied a return of one Birr on every Birr spent on the given variable input.

The fertilizer cost was calculated for the cost of each fertilizer of NPS (Birr 25 kg^{-1}) DAP (Birr 22 $kg^{-1)}$and UREA (Birr 25 kg^{-1}) during sowing time. The average price of Bread wheat at Bale robe, Agarfa market was Birr 22 kg^{-1} during harvesting time.

4. RESULTS AND DISCUSSION

4.1. Soil Physico-Chemical Properties of the Experimental Site

The physical and chemical properties of the soil of the experimental field are indicated in Table 2. The analytical results of the experimental soil before sowing of bread wheat indicated that the soil textural class is silt clay loam with a particle size distribution of 37.87% clay, 47.9% silt and 14.23% sand.

The analysis revealed that the pH of the soil was 6.0 which is moderately acidic (Jones, 2003) (Table 2). The available P of the soil was 12.23 mg kg^{-1} which is low level and which is unsatisfactory for optimum wheat growth and yield. The soil of experimental field have poor level of total N (0.12%), low OC (%) (1.75%), very high CEC (50.66) and low available sulphur (17.96 mg kg^{-1}).

Table 3-Selected physico- chemical properties of the experimental soil before planting:

Soil characteristics	**Value**	**Rating**	**Reference**
Textural class	Silt clay loam		FAO (1990)
pH-H2O (1:2.5)	6.04	Moderately acidic	Jones (2003)
OC (%)	1.75	Low	Tekalign (1991)
Total N (%)	0.12	Poor	Tekalign (1991)
CEC (cmol(+)kg soil)	50.66	Very high	FAO(2006)
Available P (mg kg^{-1})	12.23	Low	Cottenine (1980)
Available S (mg kg^{-1})	17.96	Low	EthioSIS (2013)

4.2. Phenological and Growth Parameters

4.2.1. Days to Heading of the Bread Wheat

Analysis of variance revealed that days to heading was significantly ($P < 0.01$) affected by main effect of varieties. However, the main effect of blended NPS fertilizer rates and interaction of the two factors did not significantly influence days to heading (Appendix table 1). There was no significant difference between the recommended Urea and DAP with other NPS rates because of constant nitrogen level and low level of phosphorus as nitrogen and phosphorus are the major nutrient affecting such phenological parameters. In agreement with this result, Beena et al. (2012) reported no significance effect of S application on days to flowering and physiological maturity among wheat varieties. Esayas and Alemu et al. (2019) also indicated that P showed a non-significant effect on days to heading of wheat varieties. Similarly, Abebual (2018) reported that the recommended NP treatment had no significant difference with all blended treatments and additional application of S, K, B and Zn on wheat crop as compared with recommended treatment.

The mean number of days required to heading was between 58.2 and 63.47 for the Varieties (Table 3). Variety Gelan had delayed heading duration, which significantly differed from the other two varieties on days' to heading. This significant difference among the varieties for these phenological traits could be attributed to their genetic difference, which reflects their different response to environmental conditions (Esayas Lemma, 2015). This result is in line with the findings of Amare and Mulatu (2017) on their work comparing bread Wheat varieties which showed significant difference among the four varieties on days to heading. Similar result was also obtained by Lemi and Negash (2020) who found that four tested bread wheat varieties differed significantly for days to heading due to their genetic background.

4.2.2. Days to Physiological Maturity

The main effect of varieties was highly significant ($P < 0.01$) on days on physiological maturity. However, the main effect of blended NPS fertilizer rate and their interaction did not significantly influence days to physiological maturity (Appendix table 1). Since all the treatments had uniform dose of N, there was probably no significant variation found between recommended Urea and DAP and among the different rates of blended NPS for days to physiological maturity. Different rate of P in this blended fertilizer formulation did not have significant influence. This result is also supported by Alemu et al., (2019) who showed that P fertilizer showed a non-significant effect on days to wheat maturity. The result is also in agreement with Tilahun and Tamado (2019) who reported that the main effect of blended NPS fertilizer did not significantly influence days to physiological maturity of durum wheat. Similarly, Esayas (2015) report that no significance effect of S, B, and Zn application on days to physiological maturity of wheat.

Variety had significant effect on physiological maturity. The highest number of days required for physiological maturity (105.3 days) was recorded in the Gelan variety while Huluka and Sinja varieties took the shortest growth period for days to physiological maturity, which were 100.5 and 102.3 days, respectively. There was no significant difference between variety huluka and sinja (Table 3). The result of this study is in line with Amare and (2017) and Jemal et al. (2015) who reported that the main effect of variety had highly significant ($p<0.01$) effect on days to physiological maturity of wheat.

Table 4-Mean values for days to 50% heading (DH), days to 90% physiological maturity (DPM), and plant height (PH)

Treatment	DH	DPM	PH(cm)
Fertilizer rate (Kg ha^{-1})			
Recommended NP	60.67	102.6	76 b
50 NPS,68 urea	60.22	102.2	74.8 c
100 NPS,48 urea	60.56	102.4	76 b
150 NPS,27 urea	61	103	76.3 ab
200 NPS,6 urea	61.33	103.3	77.4 a
LSD(0.05)	NS	NS	1.126
Varieties			
Sinja	60.6 b	102.6 b	75.86 b
Huluka	58.2 c	100.5 b	75.6 b
Gelan	63.47 a	105.3 a	76.86 a
LSD(0.05)	1.898	2.087	0.87
CV(%)	4.18	2.72	1.53

Means within a column followed by the same letter are not significantly different at 5% level of significance according to Fisher's protected LSD test; NS=non-significant; CV = Coefficient of variation; LSD= Least significant difference.

4.2.3. Plant Height (cm)

The main effects of varieties and blended NPS fertilizer with supplemental N was significant ($P<0.05$) on plant height, while the interaction effect of two factors did not show significant effect on this parameter. (Appendix Table 1).

The maximum application rate of blended NPS (200 kg ha^{-1}) supplemented with 6 kg urea resulted in the highest plant height (77.4cm) and the shortest plant height (74.78 cm) was obtained from 50 kg ha^{-1} NPS supplemented with 68 kg urea.(Table 3). There was significant variation among recommended DAP and blended NPS fertilizers rates. Even if the N amount was constant throughout the treatments stimulating vegetative growth uniformly, the different rates of sulphur and phosphorus could have played a role for this significant difference. Adequate P enhances many physiological processes and the fundamental processes of photosynthesis, thus, helping in plant growth ((Brady and Weil, 2002).

This result is in agreement with the result of Tagesse et al.(2018) who found plant height was significantly ($P<0.01$) affected by the main effects of blended NPS and supplemental nitrogen and maximum plant height (106.27 cm) for bread wheat is obtained at maximum application of 200 kg ha^{-1} NPS supplemented with 92 kg N ha^{-1}. Similarly, Dagne (2016) also reported that application of blended fertilizer NPKSBZn with micronutrient (Cu+Zn) increased plant height of maize by 66.81% over control plot and 6.11% over the recommended NP fertilizers.

Muhammad et al. (2014) also reported that plant height of wheat increase with increasing phosphorus application rate and highest plant height (92 cm) was observed in well irrigated field conditions with the application of 120 kg ha-1 phosphorus. This finding contradict with Shawel et.,al. (2021) who reported that plant height didn't respond significantly to different rates of S both on cambisols and vertisols.

Varieties showed significant difference in plant height and variety Gelan had significantly the tallest height (76.86 cm) followed by Sinja and Huluka varieties (Table 3), which could be due to the genotypic variation among varieties. This result is in conformity with the finding of Dinkinesh (2018) who reported such significant differences in plant height that ranged from 66.7 to 74.4 cm among four durum wheat varieties. This finding contradicts with the result of Kanchan (2011) who reported no significant difference among three wheat varieties (Shotabdi, Prodip and Bijoy) on plant height.

4.3. Yield Components and Yield

4.3.1. Total Number of Tillers Per Area

Analysis of variance showed that main effect of blended NPS fertilizer application rate and varieties had significant ($P < 0.01$) effect on total number of tillers per meter squire while the interaction effect of the two factors was not significant (Appendix Table 1).

Total number of tillers per meter square variably responded to blended NPS fertilizers. The maximum number of total tillers (213.89) obtained from 200 kg ha^{-1} NPS supplemented with 6 kg ha^{-1} urea followed with recommended NP which gave (201.9) tillers. The lowest tillers number (187.78) was recorded from 50 kg ha^{-1} NPS supplemented with 68 kg ha^{-1} urea (Table 5).

Phosphorus was responsible for overall plant growth and increase in total tiller of bread wheat by improved root development at early growth stage and N uptake assimilation by growth points. Similarly, Dinkinesh (2020) also investigated the increase in the numbers of tillers in response to increasing rate of blended NPSB fertilizer and indicated the importance of availability of balanced nutrients for better growth and development of wheat and also shown the positive role of NP.

The highest number of total tillers (204 m^{-2}) was obtained from Gelan followed by variety Sinja (202.8 m^{-2}) (Table 5). However, the lowest total number of tillers (188.7m^{-2}) was recorded from Huluka variety. This might be attributed due to different capacity of genotype in tillering. This is in agreement with Hussain (2005) who reported tiller production is considered as an inherent genotype feature and showed that there were significant difference in tillers per meter square of four tested Bread Wheat cultivars**.** In a similar way, Suleiman et al. (2014) reported significant difference among varieties for tillering that could be attributed to difference in tillering capacity of varieties.

4.3.2 Number of Productive Tillers Per Area

Productive tillers are among the most important yield contributing traits which leads to higher grain yield. Number of productive tiller was significantly ($P < 0.05$) influenced by the main effect of blended NPS fertilizer rates with supplemented Urea and highly significantly ($P<0.01$)

by varieties. However, this parameter was not significantly influenced by the interaction of two factors (Appendix Table 1).

On this study there was significant variation among blended NPS fertilizer rate due to the difference rate of phosphorus and sulphur. The maximum number of productive tillers (188.3) was obtained from 150 kg ha^{-1} NPS supplemented with 27 kg urea and minimum number (174.4) was obtained from 50 kg ha^{-1} NPS supplemented with 68 kg urea (Table 5). In this study rate of phosphorus showed enhanced number of tillers by preventing abortion of formed tillers. In line with this, Shawl et al., (2021) reported that application of S and P produced significant effect on productive tillers of bread wheat in north central Ethiopia. Similar results were reported by Assefa (2016), who showed that application of S significantly increased number of tillers per plant of wheat grown in east Shewa zone of Ethiopia.

The highest number of fertile tillers per meter squire (190.3) was recorded from Sinja variety. On the other hand the lowest (169.3) was obtained from Huluka (Table 5). The differences in the number of tillers produced by the wheat varieties could be attributed to genetic differences (Alam et al., 2007). This is in agreement with the finding of Jemal et al., (2015) who indicated that there was significant difference among four different bread wheat varieties on their number of productive tillers.

4.3.3. Number of Kernels Per Spike

Kernel $spike^{-1}$ is among important yield contributing parameters having direct effect on grain yield. The result revealed that three varieties and blended NPS fertilizers with supplemental N showed highly significant ($p<0.01$) difference with respect to the number of kernels per spike. The interaction between the two factors was also significant. (Appendix table 1).

Table 5: The interaction effect of blended NPS fertilizer with varieties on number of kernels per spikes

Treatments					
Varieties	NPS (kg ha^{-1})				
	Recommended Urea & DAP	50	100	150	200
Sinja	45.5 cd	44.97 de	42.87 ef	43.87def	48.63 ab
Huluka	45.1 d	41.93 f	44.07 def	44.43 de	47.4 bc
Gelan	49.17 ab	45.2 cd	48.73 ab	49.23 ab	50.6 a
LSD(0.05)	2.23				
CV(%)	2.89				

The highest number of kernels (50.6) was obtained from variety Gelan at 200 kg NPS ha^{-1} which was statically at par with 100,150,200 kg ha^{-1} NPS and recommended Urea and DAP and for Sinja at 200 kg ha^{-1} NPS. However, the minimum number of kernels per spike (41.93) was recorded from Huluka variety with (50 kg ha^{-1}NPS application (Table 4).

In agreement with this result, Lemi and Negash (2020) showed that the interaction effect of four varieties by fertilizer rate were significant ($P<0.05$) for number of kernels per spike of Bread Wheat. In line with this finding, Muhammad et al. (2014) reported that phosphorus application showed enhanced number of grain spike^{-1} and maximum number of grain spike^{-1} is obtained from 120 kg ha^{-1} of phosphorus. Similarly, Zhao et al., (1999) reported that nitrogen and sulphur Supply can also beneficially influence the numbers of kernels per spike.

4.3.4. Kernels Weight (g)

Analysis of variance revealed that the main effect of varieties and blended NPS fertilizer rate with supplemental Urea was highly significant (P<0.01) on thousand kernels weight. However no significant difference among interaction of two factors on thousand kernels weight (Apendix table 2).

The recommended rate of Urea and DAP are statistically similar with the higher NPS rates due to similar rate of N. Heavier grains (45.50 g) were recorded from 200 kg ha^{-1} NPS supplemented with 6 kg ha^{-1} Urea and lighter grains (43.2 g) were noted from 50 kg ha^{-1} NPS supplemented with 68 kg ha^{-1} Urea (Table 5). The increase in thousand kernels weight with increased rates of NPS might be due to the provision of adequate and balanced nutrients which enhanced accumulation of assimilate in the grains, resulting in good grain filling and development of bigger kernels. In agreement with this Demisew et al., (2020) showed that in response to blended NPS fertilizer the thousand kernel weight increased significantly and this might be due to the good nutrition of the mother plant during growth up to the physiological maturity. Similarly, Shawl *et al.*(2021) reported that both S and P fertilizers have significant effect on yield components of wheat including thousand kernel weight grown in Gerba and Deneba locations in north central Ethiopia

Generally, variety Gelan produced the maximum value of seed weight (47.83g) whereas the minimum value of seed weight (41.67g) was produced from variety Sinja (Table 5). The variation that existed among the varieties might be due to the genetic difference of the varieties, to take up nutrient differently during development and maturity period. These results are similar to those found by Dinkinesh et al., (2020) who reported that varieties showed highly significant ($P < 0.01$) effect on thousand kernels weight among four durum wheat varieties. In a similar way Esayas (2015) reported that variety had significant ($P < 0.05$) effect on thousand kernel weight and it ranged from 36.14g to 44.08g for four durum wheat varieties.

Table 6-Mean values of Total number of tillers (TT), Productive tillers (PT) and 1000 kernel weight (TKW).

Treatment	TT (m^{-2})	PT ($m^{-2)}$	TKW (g)
Fertilizer rate kg ha^{-1}			
Recommended NP	201.89 b	181.1 ab	44.39 ab
50 NPS,68 urea	187.78 d	174.4 b	43.22 b
100 NPS,48 urea	193.89cd	178.3 b	43.83 b
150 NPS,27 urea	195.0 c	188.3 a	45.33 a
200 NPS,6 urea	213.89 a	181.67ab	45.5 a
LSD(0.05)	6.33	8.3	1.442
Varieties			
Sinja	202.8 a	190.3 a	41.67 c
Huluka	188.67 b	169.3 c	43.87 b
Gelan	204 a	182.67 b	47.83 a
LSD(0.05)	4.91	6.455	1.12
CV(%)	3.3	4.77	3.367

Means within a column followed by the same letter are not significantly different at 5% level of significance according to Fisher protected LSD test; NS=non-significant; CV = Coefficient of variation; LSD= Least significant difference

4.3.5. Grain Yield (ton ha^{-1})

Economic yield is a complex function of individual yield components in response to the genetic potential of the cultivars and inputs used. Main effect of blended NPS fertilizer and varieties had highly significant ($p < 0.01$) influence on grain yield (Appendix Table 2). However, their interaction did not significantly influence grain yield.

The highest grain yield (4.96 t ha^{-1}) was recorded as a result of 200kg ha^{-1} NPS rate with 6 kg supplemental Urea and minimum grain yield (4.57 t ha^{-1}) was obtained from the application of 50 kg ha^{-1} NPS with 68 kg supplemental urea (Table 6). The grain yield obtained from 200 kg ha^{-1} NPS differ from recommended Urea and DAP and this might be due to nutrients like P. Phosphorus plays a fundamental role in metabolism and energy producing reaction to enhanced grain yield. The result is in agreement with the observation made by Abebual et al., (2019) who showed application of blended fertilizer NPSBZn increased grain of bread wheat by 19% over the recommended NP in North Shewa, Ethiopia.

Similarly Tagese et al., (2018), indicated that grain yield of wheat was highly significantly ($P < 0.01$) affected due to the main effects of blended NPS and supplemental N rates and the highest grain yield was obtained due to 200 kg blended NPS $ha^{-1.}$ In contrast, Esayas (2015) has shown that effect of blended fertilizer (N,P,S,Zn,B) treatments did not show significant influence on grain yield against the constant amount of N and P fertilizer.

Table 7-Mean values of above ground dry biomass (AGB), Grain yield (GY), Harvest Index (HI), and Straw yield (SY).

Treatment	AGB((t ha^{-1})	GY(t ha^{-1}	HI (%)	SY(t ha^{-1})
NPS rate (kg ha^{-1})				
Recommended NP	9.89 c	4.69 c	0.4	5.2 bc
50 NPS,68 urea	9.64 d	4.57 d	0.47	5.07 c
100 NPS,48 urea	9.72 cd	4.66 cd	0.47	5.05 c
150 NPS,27 urea	10.17 b	4.84 b	0.48	5.33 ab
200 NPS,6 urea	10.46 a	4.96 a	0.48	5.49 a
LSD(0.05)	0.23	0.12	NS	0.25
Varieties				
Sinja	9.531 b	4.656 b	0.48	5.17 b
Huluka	9.825 c	4.488 c	0.48	5.045 b
Gelan	10.577 a	5.098 a	0.479	5.48 a
LSD(0.05)	0.18	0.09	NS n	0.198
CV(%)	2.41	2.61	3.79	5.06

Means within a column followed by the same letter are may not significantly different at 5% level of significance according to Fisher protected LSD test; NS=non-significant; CV = Coefficient of variation; LSD= Least significant difference

The main effect of variety showed a significant effect on grain yield per hectare. The variety Gelan showed better performance of grain yield (5.098 t ha^{-1}) followed by Sinja (4.654 t ha^{-1}), while variety Huluka gave the lowest grain yield (4.488 t ha^{-1}) (Table 6). In line with this study Hasan Kiliç (2010) showed significant effect on grain yield among five different durum wheat verities. Similar result was also obtained by Jema et al., (2015) who showed a highly significant differences in grain yield among wheat varieties and seed rates.

4.3.6. Aboveground Dry Biomass (t ha^{-1})

Biomass yield represents overall growth performance of the plant and is considered to be the essential yield parameter to get useful information about total growth of the crop. Analysis of variance showed that biomass yield was highly significantly ($P<0.01$) affected by the main effects of varieties and blended NPS fertilizer rates but the interaction of two factors did not significantly influence biomass yield. (Appendix Table 2).

The highest aboveground dry biomass (10.46 t ha^{-1}) was obtained at the application of the highest rate (200 kg ha^{-1}NPS) with 6 kg supplemental Urea. The lowest aboveground dry biomass (9.64 t ha^{-1}) was produced under treatment with 50 kg ha^{-1} NPS with supplement of 68 kg urea (Table 6). Due to differences in amount of phosphorus used throughout all the treatments, variation in vegetative growth, plant height and tiller numbers were evident contributing to observed differences in total above ground biomass. According to Saqib (2015) biological yield increased with increasing P levels up to 100 kg ha^{-1}.

Fageria et al. (2011) also indicated that application of S enhanced the photosynthetic assimilation of N in crops which in turn increased the dry matter accumulation. In conformity with this result, Salvagiotti and Miralles (2008) reported that wheat yield is known to respond to N and S fertilization, which is associated with an increase in aboveground biomass.

Variety Gelan had the highest above ground biomass (10.577 t ha^{-1}) while variety Huluka had the lowest (9.8 t ha^{-1}) biomass (Table 6). This result agrees with findings made by Kanchan et al., (2011) who investigate significant difference among three varieties of wheat on aboveground biomass yield. Similar findings were also observed by Lemi and Negash (2020), where variety effect is significant (P<0.05) for aboveground biomass yield with the highest yield obtained from variety Ogolcho (10.20 t ha^{-1}) and lowest yield observed for Liben (2.0 t ha^{-1}) variety, which is statistically at par with the mean values for Hulluka (2.10 ha^{-1}). In contrast, Amare and Mulatu (2017) reported that effect of variety did not show significant effect on aboveground biomass of bread wheat.

4.3.7. Straw Yield (t ha^{-1})

The straw yield of cereal crops is an important agronomic parameter that is sensitive to nutrient level of soil or the nutrient applied from external sources. Analysis of variance revealed that straw yield was highly significantly (P<0.01) influenced by varieties and blended NPS fertilizer rates with supplemental Urea. However, interaction of the two factors did not significantly influence on this parameter (Appendix table 2). The highest straw yield (5.49 t ha^{-1}) was recorded from highest NPS rate (200 kg ha^{-1}) with supplement of 6 kg Urea though statistically at with that from 150 kg rate (Table 6). The lowest straw yield was (5.06kg ha^{-1}) from 100 kg ha^{-1} NPS with supplement of 48 kg Urea. The significant increase in straw yield in response to the highest rate of application of NPS might be attributed to the synergic roles of the nutrients played in enhancing growth and development of the vegetative part of the crop. This result is in line with Teklay and Girmay (2016) who reported that, application of blended fertilizer exceeded 7% over the recommended NP on straw yield of teff. Similarly, Abebual (2018) also reported that additional application of blended fertilizer S, B, Zn increased straw yield by 35% over recommended NP treatment.

The variety Gelan (5.48t ha^{-1}) showed better performance of straw yield while variety Huluka had the lowest straw yield (5.045 t ha^{-1}) which was at par with Sinja (5.17 t ha^{-1}) (Table 6). In agreement with this Kanchan et al. (2011) showed that there is a significant difference among wheat varieties on straw yield.

4.4. Harvest Index (%)

The ability of varieties to partition the dry matter into economic (grain) yield is indicated by its harvest index. It is the relationship of the economic yield to the total or biological yield expressed as coefficient of effectiveness. Thus, harvest index (HI) is the balance between the productive parts of the plant and the reserves, which form the economic yield. Analysis of variance revealed that, harvest index was not significantly affected by main effect of blended NPS fertilizer rates, varieties and their interaction (Appendix table 2). This may be related to the fact that all the treatments had uniform dose of N and had no significant difference with all blended treatments. This is in harmony with Abebual et al., (2018) who reported that the presence or absence of other additional nutrients (S, B, K, and Zn) may not have an influence on harvest index. Similarly, Amare and Mulatu (2017) also investigated the effects of variety on harvest index of bread wheat and found no significant effect. However, this comparison among limited number of varieties does not indicate or imply absence of variability among other wheat genotypes for harvest index.

4.5. Grain Yield Response Index

Grain yield response index (GYRI) in this study was calculated at 50 and 200 kg/ha as low and high NPS levels, respectively. Accordingly, it is possible to classify wheat cultivars into four groups: (i) efficient and responsive (ER) that produce high grain yield at low as well as high rates of NPS fertilizer; (ii) efficient and not responsive (ENR) that produce high grain yield at low NPS rate with lower response to increased NPS fertilizer than ER; (iii) not efficient but responsive (NER) that has low grain yield at low blended NPS but responds to increased NPS fertilizer; and (iv) neither efficient nor responsive (NENR) that has low grain yield at low NPS rate and low response to increased NPS fertilizer (Fageria and Barbosa Filho 1981).

The grain response indices of Gelan, Huluka and Sinja cultivars were 3, 2.58 and 2.44, respectively. The average grain yield at 50 level of NPS rate was 4571.3 kg/ha and the average grain yield response index of three cultivars was 2.67.

Variety Gelan belonged to ER group because it exceeded the averages grain yield at 50 rate and the mean GYRI (Fig. 3). Both Huluka and Sinja varieties were categorized under NENR, where both grain yield at 50 level of blended NPS and GYRI were lower than the averages. However, Variety Huluka was better than variety Sinja in efficient utilization of nutrients under low soil fertility (Fig.2). According to GYRI parameter, results indicated clearly considerable differences among wheat varieties for absorbing and utilizing NPS from deficient soils. Gelan exhibited less reduction in yield under low NPS fertilizer level indicating the significance of focusing on this cultivar as an efficient gene pool to incorporate the adaptation for low NPS availability (in the soil) and with high efficiency in the utilization of NPS fertilizer applied.

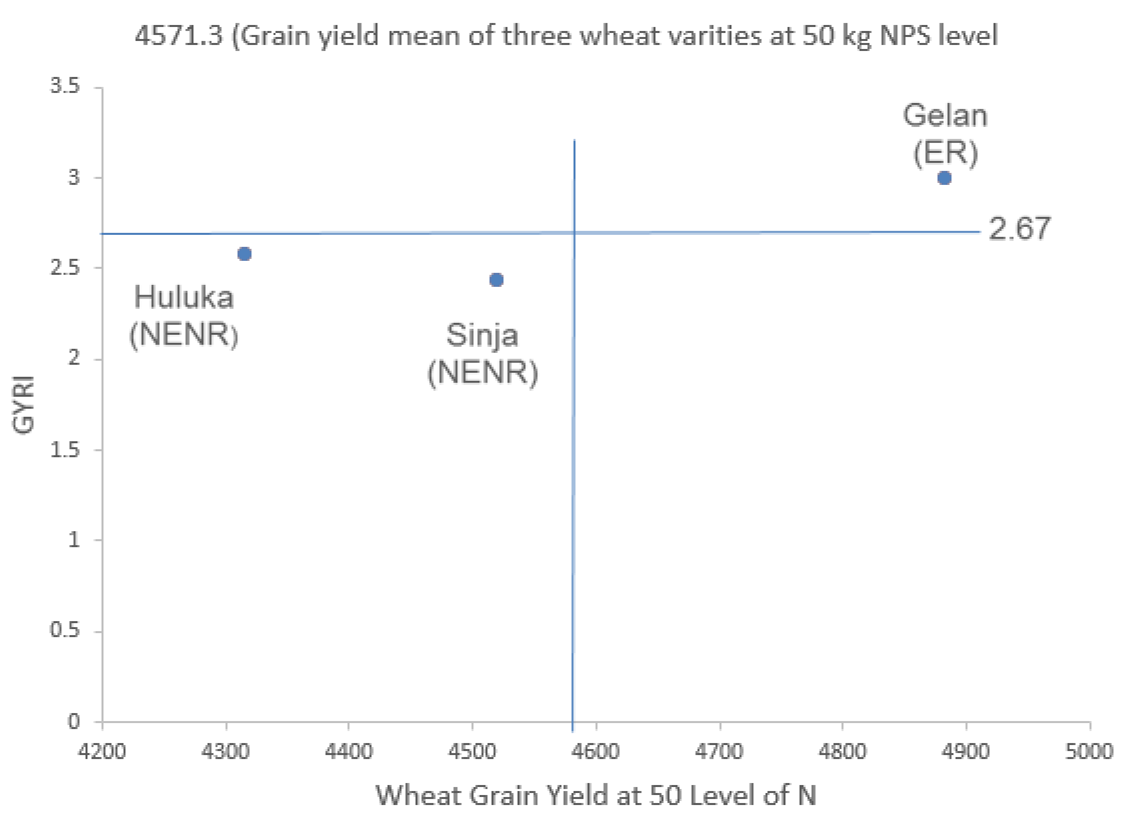

Figure 2: Grain yield response index (GYRI) of some wheat varieties. (ER, efficient and responsive; NENR, neither efficient nor responsive.

4.6. Partial Budget Analysis

The economic cost and benefit analysis of the application on different rates of NPS and recommended rate urea with DAP fertilizers on three varieties of bread wheat production were carried out using partial budget analysis method. The analysis was calculated on main effect base because of non-significant effect of interaction between variety and fertilizer rates. To calculate the cost of production labour cost and input cost that varied were considered. The costs of the fertilizers were used in computation according to the local market price of Agarfa district. To identify treatments with the optimum return to the farmer's investment, marginal analysis was performed on non-dominated treatments. Dominated treatments are those their net benefit (NB) became decrease when their total variable cost (TVC) increase from the value before them, hence, eliminated from further economic analysis (CIMMYT, 1988).

Table 8- Summary of Cost that varies and benefits of each varieties on wheat production at Agarfa district.

Variety	Average Yield (Kg/ha)	Adjusted Yield (Kg/ha)	Gross Benefit (birr/ha)	TVC (birr/ha)	Net Return (birr/ha)
Huluqa	4488	4039.2	88862.4	2500	86362.4
Sinja	4654	4188.6	92149.2	3900	88249.2
Gelan	5098	4588.2	100940.4	4050	96890.4

Seed cost for huluka=19 birr; sinja and gelan =28birr kg^{-1} ; labour and transport cost for huluka was 125 birr, for sinja 400 birr and gelan was425 birr ; selling price of wheat at harvest =22 birr.

Table 9: The marginal rate of return of the varieties

Variety	TVC (birr/ha)	Marginal cost	Net Return (birr/ha)	Marginal Net Return	MRR(%)
Huluqa	2500		86362.4		
Sinja	3900	1400	88249.2	1886.8	134.7
Gelan	4050	150	96890.4	8641.2	5760.8

For a treatment to be considered as worthwhile to farmers, above 100% marginal rate of return (MRR) was the minimum acceptable rate of return (CIMMYT, 1988). The partial budget analysis showed variety Gelan gave the maximum economic benefit (96890 birr ha^{-1}) with marginal rate of return (5760.8 %) and the secondly variety sinja gave (88249 birr ha^{-1}) economic benefit and with MRR (134.7 %). This means for every 1.00 birr invested, farmers can expect to recover the 1.00 birr and obtain an additional 57 birr for Gelan and 13 birr for Sinja variety respectively (Table 7&8). There for, Gelan variety was economical, and uncertainly recommended for production of bread wheat in the study area and other areas with similar agro-ecological condition.

From five different fertilizers rate recommended rate of Urea and DAP gave economic benefit of 81114 Birr ha^{-1} with marginal rate of return of 353.6% and 200 kg ha^{-1}NPS gave economic benefit of 84184 birr ha^{-1}and marginal rate of return 202.8%.. This means for every 1.00 birr invested in using recommended rate of Urea and DAP and 200 kg ha^{-1} NPS , farmers can expect to recover the 1.00 birr and obtain an additional 3.53 and 2.02 birr respectively. Whereas 100 kg ha $^{-1}$NPS supplemented with 68 kg ha $^{-1}$urea was dominated treatment and eliminated from the comparison. (Table 9&10).

Table 10- Summary of cost that varies and benefits of the fertilizer rates on wheat production at Agarfa District.

Fertilizer rate			Average Yield (kg/ha)	Adjusted Yield (kg/ha)	Gross Benefit (birr/ha)	TVC (birr/ha)	Net Return (birr/ha)
NPS (kg/ha)	DAP (kg/ha^{-1})	Urea (kg/ha)					
50	0	68	4572	4114.8	82296	2950	79346
0	100	50	4698	4228.2	84564	3450	81114
100	0	48	4660	4194	83880	3700	80180 D
150	0	27	4841	4356.9	87138	4425	82713
200	0	6	4963	4466.7	89334	5150	84184

Table 11:The marginal rate of return of the fertilizer rates

Fertilizer rate			TVC	Marginal cost	Net Return (birr/ha)	Marginal Net Return	Marginal Rate of Return (%)
NPS (kg/ha)	DAP (kg/ ha^{-1})	Urea (kg/ha)					
50	0	68	2950		79346		
0	100	50	3450	500	81114	1768	353.6
150	0	27	4425	975	82713	1599	164
200	0	6	5150	725	84184	1471	202.8

Where, NPS cost = 25 Birr kg^{-1}, Urea cost=25 Birr kg^{-1}, DAP cost=22 Birr kg^{-1}, TVC= Total variable cost, MRR (%) = Marginal rate of return, D= Dominated treatment

5. SUMMARY AND CONCLUSION

A study was conducted in Agarfa College to investigate Response of Different bread Wheat Varieties to Application of Blended NPS Fertilizer rates. Accordingly, five fertilizer rates (50, 100, 150, 200kg ha^{-1} NPS with supplemental N and recommended UREA and DAP) and three wheat varieties (Sinja, Huluka and Gelan) were selected. In this work, the effects of blended fertilizers and varieties on bread wheat yield and yield related traits were laid out in a randomized complete block design with three replications.

Most of phonological and growth parameters as well as yield and yield components studied were influenced by different rates of NPS fertilizer with supplemental Urea and Varieties except harvest index. Only one parameter (number of kernels per spike) was significantly influenced by interaction of main effect varieties and blended NPS fertilizer rates with supplemental urea and maximum number of kernels per spike (50.6) were recorded at the combination of 200 kg NPS ha^{-1} supplemented with 6 kg ha^{-1} urea with variety Gelan. Higher values of days to heading and maturity, plant height, thousand kernel weight, grain yield, above ground biomass and straw yield were obtained from variety Gelan. Moreover, highest number of total and productive tillers was recorded from variety Sinja. Because of the genetic difference of the varieties this variation was existed among three varieties.

The results of the samples taken from different treatments showed significant differences due to the blended fertilizer treatments on plant height, total and productive tillers per meter squire, thousand seed weight, above ground dry biomass, grain and straw yield due to presence of P and

S but date of 50% heading and 90% maturity, and harvest index did not show significant difference.

The economic analysis revealed that recommended rate of Urea and DAP was record the highest marginal rate of return (353.6%) with net benefit of 81114 birr and was the appropriate fertilizer application rate in the study area and 200kg NPS ha^{-1} supplemented with 6 kg ha^{-1} Urea can be used as alternative application rates for the study area. From three varieties Gelan record the highest marginal rate of return (5760%) with net return of 96890 birr and was economical and uncertainly recommended for production of bread wheat in the study area

Grain yield response index (GYRI) in this study was calculated at 50 and 200 kg/ha as low and high NPS levels, respectively. The result illustrated that variety Gelan belongs to ER (efficient and responsive) group being exceeded the averages of grain yield at low rate and the mean GYRI. Both Huluka and Sinja varieties was NENR (neither efficient nor responsive), where both grain yield at low level of blended NPS and GYRI were lower than the averages. Therefore variety Gelan exhibited less reduction in yield under low NPS fertilizer level indicating the significance of focusing on these cultivar as an efficient gene pool to incorporate the adaptation for low NPS availability (in the soil) and with high efficiency in the utilization of NPS fertilizer applied.

Suggested concluding remarks

- It is concluded that the selected phenological, growth parameters as well as yield and yield components studied in the experiment varied widely in response to different wheat varieties at Agarfa, south eastern Ethiopia indicating that difference in genetic makeup among varieties have profound impact on yield and yield related traits of bread wheat

- The effect of different rate of blended NPS fertilizers have significant difference on most growth and yield parameters due to effect of Phosphorus and sulphur nutrients on phenological, growth and yield parameters.
- The highest rate of blended NPS fertilizer (200 kg ha^{-1}) was significantly differed from other rates on grain yield and gives the maximum marginal rate of return value. Thus, variety Gelan and the recommended rate of Urea and DAP can be recommended for producing wheat in the study area. However, a follow-up study with preferably grater NPS rates should be run to verify the results observed in this study.

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7. APPENDICES

Appendex table 1-ANOVA for the mean squares for Agronomic parameters for the study site

Source of variation	d.f	DH	DPM	PH	NTT	NPT	NKPS
Rep	2	0.155	1.62	0.95	38.75	223.9	2.05

Varities(V)	2	104.28**	88.622**	6.69*	1090.75**	1693.9**	70.08**
Fertilizer(F)	4	1.633^{NS}	1.811^{NS}	8.16**	892.7**	234.16*	29.39**
Fert X var	8	0.066^{NS}	0.178^{NS}	1.3^{NS}	35.75^{NS}	55^{NS}	4.42*
Error	28	6.44	7.79	1.36	43.04	74.5	1.77
CV(%)		4.18	2.7	1.5	3.3	4.8	2.89

NS and *, **, = not significant, significantly different at 5%, 1%, level of probability, *respectively. df = degree of freedom, DH = Days to 50% heading DM = Days to 90% physiological maturity, NTT= Number of Total Tillers, NPT= Numbers of Productive Tillers PH= Plant height, NKPS = Number of kernels Per Spike*

Appendix table 2-ANOVA for the mean squares for Agronomic parameters for the study site

Source of variation	Mean squares					
	d.f	TSW	AGB	GY	HI	SY
Rep	2	0.339	0.18	0.02	0.0001	0.074
Varities(V)	2	146.5**	4.36**	1.49**	0.00006^{NS}	0.754**

Fertilizer(F)	4	8.492**	1.02**	0.21**	0.00035^{NS}	0.307**
Fert x var	8	1.34^{NS}	0.06^{NS}	0.005^{NS}	0.000024^{NS}	0.05^{NS}
Error	28	2.23	0.06	0.015	0.00033	0.07
CV(%)		3.4	2.4	2.6	3.8	5.06

NS and *, ** = not significant, significantly different at 5%, 1% level of probability *TSW=1000 seed weight, GY= Grain yield, AGB=Above ground Biomass yield, HI = Harvest index, SY = Straw yield*

Appendix table 3-Ten year climatic data of the study area

A. Average temperature

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean
2010	22.86	22.85	23.21	23.69	23.2	22.76	22.63	22.91	22.85	22.75	22.88	22.73	22.94

2011	22.94	22.13	23.28	23.87	23.62	22.32	22.97	22.32	22.22	22.88	22.08	22.19	22.73
2012	23.91	23.1	24.07	24.08	24.74	23.57	22.52	23.28	23.6	22.63	23.68	23.43	23.55
2013	24.89	23.02	23.25	24.06	24.6	23.48	23.75	23.02	23.27	23.03	23.75	23.11	23.60
2014	23.99	24.94	24.39	24.25	23.64	23.05	23.41	23.54	23.81	23.73	23.83	24.4	23.91
2015	24.84	24.46	24.73	24.34	24.8	23.54	23.63	23.85	23.79	23.76	23.45	23.88	24.09
2016	24.51	24.45	24.22	23.74	24.3	23.6	23.22	23.39	23.11	22.86	23.44	23.84	23.72
2017	24.65	23.84	25.33	25.17	24.92	24.02	23.75	23.96	24.2	23.77	23.69	23.04	24.19
2018	25.63	24.41	24.5	24.95	25.65	23.95	23.51	23.15	23.96	23.43	23.41	24.14	24.22
2019	24.55	25.9	25.03	24.83	24.82	23.61	22.52	22.71	23.95	22.51	23.34	23.7	23.95
mean	24.277	23.91	24.20	24.29	24.43	23.39	23.19	23.21	23.48	23.13	23.35	23.45	23.69

B. Mean monthly rain fall

Year	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual

	Jan												R.F
2010	4.30	53.50	44.80	135.60	90.40	37.10	81.30	97.10	115.50	174.71	36.70	45.70	916.71
2011	1.30	55.20	55.00	152.20	58.70	98.80	184.00	254.30	133.00	59.10	57.80	0.00	1109.40
2012	8.90	0.00	140.30	146.10	192.86	14.50	40.50	62.50	220.20	114.28	90.10	3.50	1033.74
2013	11.87	7.75	32.03	178.70	89.27	24.04	56.00	68.80	74.40	95.80	44.70	89.90	773.25
2014	139.40	98.70	190.10	201.50	150.00	39.40	107.40	139.40	55.10	45.90	1.80	0.00	1168.70
2015	0.00	0.00	3.50	49.60	137.10	40.15	80.10	69.10	73.50	43.30	70.50	0.00	566.85
2016	0.00	0.00	37.60	133.00	67.20	23.40	71.30	145.10	135.05	60.20	11.40	10.00	694.25
2017	10.90	0.80	200.60	73.70	20.40	18.70	122.50	245.30	83.40	59.40	59.10	0.00	894.80
2018	0.00	3.13	22.00	18.80	53.50	45.50	54.90	97.00	80.10	127.30	21.80	0.54	524.57
2019	1.13	0.00	25.10	25.30	75.10	65.40	48.80	67.40	0.00	0.00	0.00	0.00	308.23
Mean	17.78	21.91	75.10	111.45	93.45	40.70	84.68	124.60	97.03	78.00	39.39	14.96	799.05

BIOGRAPHICAL SKETCH

The author was born on November -06-1985 in Debrebirhan District of Amhara region. She pursued her primary school and secondary education at Andinet primary school and Debrebirhan General Secondary School in Debrebirhan respectively. Then she attained preparatory education at Hailemariam Mamo preparatory school. She joined Debre Birhan University in 2004 and graduated in Plant science in 2006. She then served as ATVET instructor at Agarfa ATVET in Bale Zone till she joined Hawassa University for her MSC study.