RESPONSE OF MALT BARLEY (*Hordeum vulgare* L.) TO DIFFERENT RATES OF NPSB AND UREA FERTILIZERS IN BULE HORA WOREDA, GUJI ZONE, OROMIA REGIONAL STATE

M.Sc. THESIS

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HAWASSA UNIVERSITY

COLLEGE OF AGRICULTURE

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RESPONSES OF MALT BARLEY (*Hordeum vulgare* L.) TO DIFFERENT RATES OF NPSB AND UREA FERTILIZERS IN BULEHORA WOREDA, GUJI ZONE, OROMIA REGIONAL STATE

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We, undersigned, members of the Board of Examiners of the final open defense by **Ashenafi Tadesse Folla** have read and evaluated his thesis entitled “**Response of Malt Barley (*Hordeum vulgare* L.) to Different Rates of NPSB and Urea Fertilizers in Bulehora Woreda, Guji Zone, Oromia Regional State”** and examined the candidate. This is therefore to certify that the thesis has been accepted in partial fulfillment for the requirements for the Degree of **Master of Science** in Plant Science with Specialization in (**Agronomy**)**.**

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I dedicate this thesis manuscript to my lovely Wife Abadit Asgadi, my cute daughter Befiker Ashenafi and my close friend Habtamu Lelisa.

STATEMENT OF THE AUTHOR

First of all, I declare that this thesis is a result of my genuine work and that I have duly acknowledged all sources of materials used for writing. I submitted this thesis to Hawassa University in partial fulfillment for the Degree of plant of Science in (**Agronomy**) and it is deposited in the library of the University to be made available to borrowers for reference. I solemnly declare that I have not so far submitted this thesis to any other institution anywhere for the award of any academic degree, diploma, or certificate. Brief quotations from this thesis are allowed without requiring special permission provided that an accurate acknowledgement of the source is made. Requests for extended quotations from reproduction of this manuscript in whole or in part may be granted by the Head of the school of Plant and Horticultural Sciences or by the Dean of the School of Graduate Studies of the college when, his or her judgment, the proposed use of the material is for a scholarship interest. In all other instances, however, permission must be obtained from the author.

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LIST OF ACRONOMYS AND ABBREVIATIONS

AACC	American Association of Cereal Chemists
ATA	Agricultural Transformation Agency
CIMMYT	Centro International de Mejoramiento e Maiz Y Trigo (Spanish)
CSA	Central Statistical Authority
CSIOFMBPE	Current Situation, Investment Opportunities and Future outlooks of Malt barley production in Ethiopia
DAP	Di-Ammonium Phosphate
EthioSIS	Ethiopian Soil Information System
EQSA	Ethiopia Quality Standards Authority
FAO	Food and Agricultural organization
ha	hector
ICARDA	International Center for Agricultural Research in Dry Areas
Masl	Meters Above sea level
NPSB	Nitrogen Phosphorus Sulfur Boron
PPM	Parts Per Million
SAS	Statistical Analysis System
TN	Total Nitrogen
USDA	United States Department of Agriculture

TABLE OF CONTENTS

LIST OF TABLE

Tables **Page**

LIST OF FIGURES

Figures **Page**

LIST OF TABLES IN THE APPENDCES

Appendix Tables **Page**

LIST OF FIGURES IN THE APPENDICES

Figures **Page**

Response of Malt Barley (*Hordeum vulgare* L.) to Diffrent Rates of NPSB and N Fertilizer in Bule Hora Woreda, Guji Zone, Oromia Regional State

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ABSTRACT

Malt Barley (Hordeum vulgare L.*) is one of major crops grown in Bule Hora woreda,oromia region South western Ethiopia. The soil in the area is poor in most of the available nutrients due to intensive soil erosion and long history of cultivation. Therefore, a field experiment was carried out in 2019 cropping season to evaluate response of malt barley to the different rates of NPSB and N fertilizer. The treatments consisted of four levels of NPSB (0, 50, 100, and 150 kg NPSB ha*$^{-1}$*) and four levels of N (0, 23, 46, 69 kg N ha*$^{-1}$*). The experiment was laid out in three replication of the randomized complete block design in a factorial arrangement. The results revealed that the interaction effect had a highly significant (*$p<0.001$*) on Days to heading, Days to physiological maturity, thousand kernel weight, grain yield and Hectoliter weight. The main effect N fertilizer had a significant effect on spike length, number of tiller per plant, number of spikelet per spike and protein content. Blended NPSB also had significant (*$p<0.05$*) effect on number of effective tiller, above ground biomass. Plant height had significantly (*$p<0.05$*) by blended NPSB and N fertilizer The highest yield (3691kgha*$^{-1}$*) was recorded from the interaction effect of 150 kg NPSB ha*$^{-1}$* and 69kg N ha*$^{-1}$*. The partial budget analysis also indicated that the best treatments were interaction of 150 kg NPSB ha*$^{-1}$* and 69kg N ha*$^{-1}$*, which gave net benefits of 63203 ETB ha*$^{-1}$*with acceptable marginal rate of return (5776%). Therefore, it could be concluded that application of 150 kg blended NPSB ha*$^{-1}$* with 69kg N ha*$^{-1}$* fertilizer rates were economically profitable yield and the application of 23kg N ha*$^{-1}$* acceptable for grain quality for malt barley production in the study area*.

Keywords: Blended fertilizer, Boron, Grain yield, Hectoliter weight, Protein content, Sulfur, Yield.

1. INTRODUCTION

Barley (*Hordium vulgare* L.) is one of the most important cereal crops in the world, it is a member of the grass family, poaceae and genus Hordeum and a major cereal grain grown in temperate climates globally (Badr *et al*., 2000; Lapitan *et al*. 2009). It is the most important for food grain and raw material of malt industry it is ranks fourth after corn, wheat and rice by production of 141 million tons from the total global grain production 2 billion tones (FAO, 2016). Global production volume of barley amounted to 143.99 million metric tons in the 2017/2018 crop year (USDA, 2018). European Union, Russia, Austria, Africa, Middle East and South America are the major barley producers. European Union produces the greatest quantities of barley with 58.81 million tons which accounts for 40.8% of the total production followed by Russia with a production of about 34.4 million tons, whereas south America and others, Middle east, Austria and Africa barley production was 24.1, 11.25, 9.25 and 6.18 million tons respectively (USDA, 2018).

Both food and malt barley are grown side by side sharing similar agro-ecologies. While food barley is produced mainly for subsistence consumption by the rural farm households whereas, barley is largely a commercial crop produced for the market both for industrial malt grain production and for cottage local beer and liquor production (CSIOF, 2013).

Barley is an important grain crop in Ethiopia and has diverse ecologies being grown from 1800 to 3400 masl altitude in different seasons and production systems. It grows well on well-drained soils with moderate acidity and neutral pH. It has good tolerance to frost and drought and also to saline and alkaline soil conditions, but is sensitive to high levels of aluminum usually associated with low pH. It requires an evenly distributed rainfall of over 500mm (Muluken, 2013).

Ethiopia is the second largest producer of barley in Africa next to Morocco. It is the fifth important cereal crop next to *tef*, maize, sorghum and wheat in the country's domestic production according to CSA report 2017/18 cropping season. The total area coverage by barley was 951,993.15 hectares and production was 2.05 million tons in main season. The average production per hectare was 2.16 ton from the total grain production barley account 7.66% (CSA, 2018). In Ethiopia, many regions produce barley but production is highly concentrated in Oromia National Regional State in 2017/18 main cropping season with total area coverage of 451,279.26 hectares and total annual production of about 1.08 million tons. (CSA, 2018).

In Ethiopia, Barley production started long years ago, but up to this date there is shortage of malt barley both in quality and quantity to meet the demand of the local breweries (Mohammed et al., 2003). Malt barley is one of the principal ingredients in the manufacture of beer. Brewers can either purchase malt barley from local farmers to manufacture malt themselves or purchase malt from malting companies. In either case, malting quality barley like grain moisture content, physical purity and protein contents barley must meet the special quality specifications (Berhan, 2017). The malting characteristics of barley also depend on growing conditions, harvesting conditions, and storage of grain as well as seeds (Fekadu *et al*., 1996).

There are several factors affecting barely production in Ethiopia, among which the most important factors that reduce yield of barley are poor soil fertility, water logging, drought, frost, soil acidity, diseases and insects, and weed competition (ICARDA, 2008). Among the most important constraints that threaten barley production in Ethiopia are poor soil fertility and low pH. Since the major barley producing areas of the country are mainly located in the highlands, severe soil erosion and lack of appropriate soil conservation practices in the past have resulted in soils with low fertility and pH (Grando and Macpherson, 2005)

Low soil fertility is due to the fact that the removed nutrients in crop harvesting and other losses are greater than the input, resulting in highly negative nutrient balances (Nandwa, 2003). In most regions of Ethiopia, soils are deficient in nitrogen (N) and phosphorus (P), this aggravated by the long history of cultivation without any NP replenishment, which led to low soil fertility and low crop yields Assefa *et al*. (2017) .Studies show that Ethiopia as having a high nutrient depletion rate of more than 60 kg N, P, and K $ha^{-1}yr^{-1}$. These nutrients are the major constraints for barley production in Ethiopia (Tolessa *et al*., 2002).

In Ethiopia, nutrient deficiency and unbalanced nutrient supply are the vital yield limiting factors of the country that farmers producing crops using the recommended blanket fertilizer, Urea, DAP and NPS fertilizers throughout the years (Asefa *et al*., 2014).

Assefa *et al*. (2017) reported that, soils in the highlands of Ethiopia usually have low levels of essential plant nutrients, especially low availability of nitrogen and it is the major constraint to cereal crop production. It is the key nutrient input for achieving higher yield of barley. Barley is very sensitive to insufficient nitrogen and very responsive to nitrogen fertilization (Almaz *et al*., 2007). Similarly, Sinebo *et al*. (2003) reported that about 65% of grain yield variability in barley was attributed to nitrogen stress. The most important role of nitrogen in the plant is its presence in the structure of protein and nucleic acids, which are the most important building and information substances from which the living material or protoplasm of every cell is made. Nitrogen increased leaf area, tiller formation, leaf area index and leaf area duration and this increasing led to much greater production of dry matter and grain yield (Franklin *et al*., 2017). Excess soil N may raise the protein content of the kernel (>11.5%), which is undesirable for malting (Mather *et al*. 1997).

Phosphorus is believed to be the second most often limiting plant nutrient (Tisdale *et al*., 1995). It is an essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance, and of ribonucleic acid (RNA), which directs protein synthesis in both plants and animals. Phospholipids, which play critical roles in cellular membranes, are another class of universally important phosphorus-containing compounds. Plants absorb phosphorus in the form of HPO_4^{-2} and H_2PO_4 (Tisdale *et al.,* 1995). It is important for seed and fruit formation and crop maturation. Phosphorus hastens the ripening of fruits thus counteracting the effect of excess nitrogen application to the soil. It helps to strengthen the skeletal structure of the plant thereby preventing lodging (Onasanya *et al*., 2009).

Sulfur has a beneficial effect on soil properties as it may reduce soil pH which improves the availability of microelements such as Fe, Zn, Mn and Cu as well as in increasing crop growth and improving yield (Tantawy *et al*., 2009). Sulfur is rated as fourth major nutrients after N, P and K and its importance is being recognized in view of its role in improving crop production and balance of anions in agricultural crops including barely (Walker and Booth, 1994). Sulfur increases the resistance of this species to environmental stresses and plays an important role in protecting the plants from pests and diseases (Walker and Booth, 1994).

Micronutrients are essential elements for plant growth and development which are utilized in very small amounts by plants. Among micronutrients, boron plays several important physiological roles in plants such as, in cell elongation, nucleic acid synthesis, hormone responses and membrane function (Jafar-Jood *et al*., 2013).

Statement of the problem

Bule Hora district is one of the potential food and malt barely producing areas in Guji Zone as it has suitable soil and climatic conditions and about 923 hectare of land in the district was covered by barley with average productivity of 14 quintal/ha under rain fed condition in 2017/2018**,** which is very low compared to the national production 21.57 in Ethiopia .The major reason for declining productivity is soil fertility declining from time to time ,unavailability of improved varieties and farmers shifting to market oriented and cash crops. Most farmers in the district produce maize, other cash crops and cereal like barley is produced in the area but for only home consumption in the form of roasted “kolo”. The importance of malt barley in beer industry is not well known and the farmers don’t have awareness on the production of malt barley for malt production factory. The reference rates of the fertilizer use in Bule Hora woreda is 100kg/ha NPS and 100 kg/ha urea for food barley. However, there are huge research gaps on recommendation of full necessary agronomic practices like seed per hectare, fertilizer rates and fertilizer use efficiency and other physiological studies have not been undertaken.

Therefore, direct investigation of the response of malt barley to applied NPSB and N fertilizers under this specific agro-ecology is required to come up with optimum fertilizer recommendations so as to help farmers increase productivity of the crop in the area and strong help for producers to achieve sustainable production increase their income and improve their livelihood.

In view of this, the present study was conducted at Bule Hora with the following objective

General objectives

To determine fertilizer requirement of malt barley at Bule hora woreda, south west Ethiopia.

Specific objectives

- To assess the effect of NPSB and N-fertilizer on growth, and yield of malt barley.
- To assess the effect of NPSB and N-fertilizer on quality parameter of malt barley.
- To investigate whether there is interaction between the two fertilizers on how they affect phenology, growth, yield and yield components of malt barley.
- To identify the economically feasible rates of N and NPSB for malt barley production in the study area.

2. LITERATURE REVIEW

2.1 Origin, Distribution and Description of Barley

Barley (*Hordeum vulgare* L.), a member of the grass family, poaceae genus Hordum is a major cereal grain grown in temperate climates globally. Barley is believed to have originated in Ethiopia and Southeast Asia (Badr *et al*., 2000). Barley was one of the first domesticated grains in the Fertile Crescent, an area of relatively abundant water in Western Asia, and near the Nile River of northeast Africa (Badr *et al*., 2000). The grain appeared in the same time as einkorn and emmer wheat (Kamiyama , 2012) .Wild barley (*H. vulgare* ssp. spontaneum) ranges from North Africa and Crete in the west, to Tibet in the east (Zohary and Hopf, 2000). According to some scholars, the earliest evidence of wild barley in an archaeological context comes from the Epipaleolithic at Ohalo II at the southern end of the Sea of Galilee (Kamiyama , 2012) . The remains were dated to about 8500 BCE (Zohary and Hopf, 2000). Other scholars have written that the earliest evidence comes from Jarmo in Kurdistan present day Iraq (Zohary and Hopf, 2000). It was one of the first cultivated grains, particularly in Eurasia as early as 10,000 years ago (Zohary and Hopf, 2000). One of the world's most important crops was domesticated in the Near East around 11,000 years ago (circa 9,000 Before the Common Era) (Jones *et al*., 2018)**.** Barley is a highly resilient crop, able to grown in varied and marginal environments, such as in regions of high altitude and latitude (Jones *et al*., 2018). Archaeobotanical evidence shows that barley had spread throughout Eurasia by 2,000 Before the Common Era (Jones *et al*., 2018). To further elucidate the routes by which barley cultivation was spread through Eurasia, genetic analysis was used to determine genetic diversity and population structure in extant barley taxa (Jones *et al*., 2018). Genetic analysis shows that cultivated barley spread through Eurasia via several different routes, which were most likely separated in both time and space (Jones *et al*., 2018).

Barley is a member of the grass family. It is a self-pollinating, diploid species with 14 chromosomes. The wild ancestor of domesticated barley, *Hordeum vulgare* subsp. spontaneum, is abundant in grasslands and woodlands throughout the Fertile Crescent area of Western Asia and northeast Africa, and is abundant in disturbed habitats, roadsides, and orchards. Outside this region, the wild barley is less common and is usually found in disturbed habitats (Zohary and Hopf, 2000). However, in a study of genome-wide diversity markers, Tibet was found to be an additional center of domestication of cultivated barley (Dai *et al*., 2012).

2.2 Agro- Ecological Requirements of Barley

Ethiopia has enormous potential for malt barley production though its current share is very small as compared to food barley. Malting barley requires a favorable environment to produce a plump and mealy grain. It is being grown from 1800 to 3400 masl altitude in different seasons and production systems with uniform rain fall distribution of 500-800 mm during the crop growing season. It requires well-drained soils with moderate to neutral pH. It has good tolerance to frost and drought and also to saline and alkaline soil conditions, but is sensitive to high levels of aluminum usually associated with low pH. It requires an evenly distributed rainfall of over 500mm (Muluken, 2013). Currently malt barley grain is mainly produced in the South eastern part of Ethiopia, Central Highlands and North-Western part of the country.

2.3 Importance of malt Barley in Ethiopia

There are two types of barley that farmers grow in Ethiopia: food barley and malt barley the majority of barley that farmers grow is food barley and it is the main ingredient for several staple dishes such as injera, porridge, and bread (CSIOF, 2013). Food barely is a cheaper cereal than maize, wheat, and tef and is often used as a substitute for lower income families. Recently, there has been an increasing demand for farmers to grow malt barley, which presently constitutes 10 percent of the total barley production with the introduction of several new malt factories in the country, domestic demand is growing and is showing no signs of slowing down (Tadesse, 2011)

The most important use of barley throughout the world is as malt for manufacturing beverages or malt enriched food products. It is also used as fodder crop for domestic animals, poultry and human food in the form of preached grain. Beside these, it is used as industrial purposes, such as medicine and manufacturing baby food (FAO, 2002).

Production of malting barley has a very short history it's mainly associated with beer making in Ethiopia, which started in early 1920s with the establishment of the St.George Brewery there are Even though Ethiopia has favorable environment and potential market opportunity, the share of malting barley production is quite low as compared with food barley (Getachew *et al*., 2007).

Malt is the major raw material for both commercial and traditional beer production. The product has an increasing demand with beer production. The practice of traditional barley malt in Ethiopia is different from one place to another but the main processing steps are removing of impurities like sand and stones from the cereals, soaking for 3-4 days depending on the production year of the cereals and also the environment, removing the water by using sieve then cover the cereals by leaf and put inside of the basket and put mud or stone over the leaf in order to produce heat then stay for 3-5 days then remove the leaf from the malt by using hand manually finally, put the malt on the floor or on the roof of the house in order to dry (Addisu,2017).

2.4 Effect of Soil Fertility on Crop Production

In Ethiopia, agriculture still constitutes the major part of the country's economy, yet the agriculture facing a number of problems. Hence farmers are entangled in a vicious circle of ecological degradation, poverty and starvation. The causes to these rooted problem are the land degradation exhibited in form of soil fertility loss as initiated by different factors as deforestation, overgrazing and with a result of soil erosion, sedimentation, pollution, etc (Asefa *et al*., 2014) Soil fertility refers to the inherent capacity of a soil to supply nutrients to plants in adequate amounts and in suitable proportions or the ability of soil to supply and sustain nutrients for healthy plant growth (Gemechu, 2011).

Soil infertility is probably the single most important factor limiting crop yields worldwide for crop growth and development Mineral nutrient supply, availability, absorption, translocation, and utilization of inorganically formed elements from the soil. But essential plant nutrients are highly influenced by the fertility of a soil (Fageria and Baligar, 2006). In sub-Saharan Africa Soil fertility depletion is now increasingly recognized as the fundamental biophysical root cause for declining food security in smallholder farms. No matter how effectively other constraints are remedied, per capita food production in Africa will continue to decrease unless soil fertility depletion is effectively addressed (Sanchez and Jama, 2002).

2.5 Effects of Nitrogen, Phosphorus, Sulfur and Boron on Crop Production

Continuous intensive cropping with unbalanced and inadequate fertilizer use has resulted in depletion of the soil's nutrient. By recognizing this gap, in recent years, this situation is changing and the use of blended fertilizer which is known to be more closely matching with the specific needs of soils and crops in Africa, including Ethiopia, is coming up (Gerstenmier, 2015).From the point of importance, N and P have become increasingly recognized around the world that their sole application are not always sufficient to provide balanced nutrition for optimal crop yields and quality, while application of secondary and micronutrient such as Zn, B, S, and Fe has been made possible, thanks to the availability of the blended fertilizers (Brar and Ludhiana, 2006). Blended fertilizers are known to be not only balanced in terms of nutrient composition but are also the key for sustainable crop production and maintenance of soil health, optimal crop production, better food quality and environmental advantageous (Brar and Ludhiana**,** 2006).

In Ethiopia, nutrient deficiency and unbalanced nutrient supply are the vital yield limiting factors of the country that farmers producing crops using the recommended blanket fertilizer, Urea, DAP fertilizers throughout the years (Asefa *et al*., 2014). The essential micronutrients needed for plant growth and productivity have not been used, and this may be the cause for low crop yield and quality compared to the potential yield of the crop.

It is now well recognized that the use of blended fertilizer is much more preferable as compared to that of blanket recommendation of urea and DAP in that, balanced application of N, P, K, S, Zn, Fe or other micronutrients is essential to maximize crop yields and to optimize nutrient, water and energy utilization. Additionally, balanced nutrient application can substantially reduce accumulation and leaching of Nitrate-N in the soil profile, minimizing the potential for soil and ground water contamination (Malhi and Brandt, 2014).

2.6 Effect of N fertilizer on growth and yield components of barley

Nitrogen is the most limiting nutrient in crop production and is higher in concentration than all other mineral nutrients in most plants (Foth and Ellis, 1997). It is essential for plant growth makes up one to four percent of dry matter of the plants as it is a constituent of all proteins and hence of all protoplasm that are important for plant growth such as proteins and nucleic acid processes including chlorophyll and many enzymes integrate with Nitrogen and important element for their function (Hawkesford *et al.,* 2012). Nitrogen is taken up from the soil in the form of nitrate (NO_3^-) or ammonium (NH_4^+). In the plant N combines with compounds produced by carbohydrate metabolism to form amino acids and proteins. Being the essential constituent of proteins, it is involved in all the major processes of plant development and yield formation. A good supply of nitrogen stimulates root growth and development as well as the uptake of other nutrients (Brady and Weil, 2002).

Nitrogen is an integral component of many compounds essential for plant growth processes including chlorophyll, which is responsible for the dark green color of stems and leaves, which enhances vigorous vegetative growth, plant height, branching and/or tillering, leaf production size enlargement and many enzymes (Gemechu, 2011).Nitrogen also mediates the utilization of potassium, phosphorus and other elements in plants.

Plants obtain readily available N forms from different sources. Nitrogen occurs in organic and inorganic forms, in solution and as a gas, and as cation and an anion. Plant roots absorb only the inorganic forms. Common forms of N contained in fertilizers and fresh manures include ammonia, urea, ammonium and nitrate (Gemechu, 2011). Ammonia (NH^3), a gas, reacts rapidly with soil water to form the positively charged ammonium ($NH^{4+)}$ cation. Urea (CO (NH2)2) is rapidly converted from the solid or liquid form by the urease enzyme to the ammonia form (Hodges, 2009).

Nitrogen application increase spike number, grain weight, grain yield .Amount of nitrogen effect single spike length and the spike weight increase when the amount of nitrogen increase from control level to 200kg/ha (Assefa, 2017).

The application of nitrogen fertilizer significantly increased spike length, number of grains per spike, 1000 grain weight, grain yield and N uptake by the crop (Zebarth *et al*., 2009).

2.7 Effect of P fertilizer on growth and yield components of barley

Phosphorus (P) is classified as the second key plant nutrient required in large quantities for growth and productivity of crops following N. It is known to be involved in many physiological and biological processes of plants (Tisdale *et al*., 2002). It has a role in cell division, stimulation of early root growth, hastening plant maturity and energy transformation within the cell and in fruiting and seed production (Miller and Donahue, 1997). Phosphorus plays an important part in many physiological processes that occur within a developing and maturing plant. It is involved in enzymatic reactions in the plant. It is essential for cell division because it is a constituent element of nucleoproteins, which are involved in the cell reproduction processes and a component of a chemical essential to the reactions of carbohydrate synthesis and degradation (Gemechu, 2011).

Phosphorus is absorbed in the form of H_2PO^{4-} or HPO_4^{2-} ion. This complex does not leach readily from the soil and mobile in the plant once taken up from the soil. P is rapidly fixed with iron and aluminum when applied under acidic soil conditions and fixed as insoluble calcium phosphate in alkaline soils with Ca and unavailable to plants (Flyn, 2010). The role of P in plants, that it is used in dry matter distribution which facilitates plant development. In addition, P is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, and nutrient movement within the plant (Lake, 2018).

Ahn (1993) indicated that P is concentrated in the fast growing parts of the plant and, therefore, it hastens the maturing period of crops. Similar result was also reported by Ottman (2009) who reported that increase in P rate decreased time to heading, anthesis and maturity.

Wakene *et al* (2014) reported that application of P slightly increased plant height. This result also in line with this, Rashid *et al* (2007) indicated that plant height was linearly increased with increasing levels of P fertilization. Similarly, Taye Bekele *et al* (1996) reported that the yield of barley increase with increasing P fertilizer application at many locations. Noori *et al.* (2014) and Wakene *et al.* (2014), report that highest total biomass at the highest P level, used and the lowest biological yield in the control.

Mesfin and Zemach (2015) reported that applications of P fertilizer significantly increase the grain yield of barley. This result was similar to that found previously by Turk *et al.* (2003) and recently by Naceur *et al.* (2017) for barley. This may be due to the fact that the important roles of phosphorus on photosynthesis, respiration and nutrient uptakes (Uchida, 2000).

Plant height was significantly affected by location and P levels. Wakene *et al* (2014) reported that number of productive tillers/plant was affected significantly by P fertilizer application. They indicated that highest number of tillers was recorded at P level of 46 kg ha^{-1} which was not statistically different from P level of 69 kg ha^{-1}. These results also correspond to Sisie and Mirshekari (2011) who showed the increase of wheat tillers with the increase of P fertilizer until optimum rate. Similar results were also reported by Prystupa *et al* (2004) from their research on barley.

Excess P can induce N and micronutrient deficiencies such as Zn, Fe, and Co (Flyn, 2010). Phosphorous deficiency in plants causes too small and short branches, many undeveloped buds and less fruit, intense coloring, browning or purpling of foliage in some plants, thin stems, loss of lower leaves and reduced flowering (Flyn, 2010).

2.8 Effect of S fertilizer on Growth and Yield Components of Barley

Sulfur is one of sixteen essential nutrient elements and fourth major nutrient after NPK, required by plants for proper growth and yield as it is known to take part in many reactions in all living cells (Sud and Sharma, 2002). It is one of the essential nutrients for plant growth and it accumulates 0.2 to 0.5% in plant tissue on dry matter basis. Required in similar amount as that of phosphorus (Ali *et al.,* 2008). It plays an essential role in chlorophyll formation and therefore helps to give plants their green color. Sulfur is known to take part in many reactions in all living cells (Sharma, 2015).

Sulfur also improves milling and baking quality of cereal crops; enhance oil content of oilseed crops; maintain winter hardiness and drought tolerance in plants; controls certain soil borne diseases and decreases fungal diseases in many crops (Haneklaus *et al*., 2007). Its deficiency results in stunted growth, reduced plant height, tillers, spikelet's and delayed maturity. Sulfur deficient plants have also less resistance under stress conditions. Provide a useful explanation of S mobility in barley and how S mobility interacts with N nutrition Eriksen *et al.* (2001).

Sulfur deficiency symptoms are similar to those of nitrogen. However, N deficiency symptoms first appear in the older leaves; generally, while sulfur deficiency symptoms first appear in the younger leaves because S is not easily translocated in the plant (Flaten, 2004). Sulfur-deficient plants lack vigor, are stunted, are pale green to yellow in color, and have elongated thin stems. Sulfur deficiency may delay maturity in grain crops.

2.9 Effect of B Fertilizer on Growth and Yield Components of Barley

Boron (B) is an essential micronutrient for plants and plant requirements for this nutrient are lower than the requirements for all other micronutrients except molybdenum and copper. It is the only non-metal among the micronutrients and also the only micronutrient presents over a wide pH range as a neutral molecule rather than an ion (Epstein and Bloom, 2005).

Boron is needed in the greatest quantity to ensure several key growth processes. It influences root and shoot growth, plant development and pollination. Boron is an important element present in the cell wall. Boron also affects calcium absorption, so supplies are important to ensure a balanced nutrition.

Boron is involved in N and P metabolism, and in plants poorly supplied with B, NO^{3-}, N accumulated in the roots, leaves and stems, showing that NO^{3-} reduction and amino acid synthesis are inhibited. Boron is mainly associated with cell wall pectin and physical characteristics of the growing cell wall were altered under B deficiency (Brown and Hu, 1997).

Boron is the sole element and it has been proved beneficial for the proper growth and development of plant only if it is absorbed and accumulated in required amount. In addition to playing incredible role in the biosynthesis of cell wall and lignifications, boron is also involved significantly in variety of physiological and biological processes such as tissue differentiation, vegetative growth, phenolic, metabolism, and membrane integrity, etc. (Durgesh *et al.,* 2015). Boron is also necessary for nitrogen fixation and nitrate assimilation (Reguera *et al.,* 2010), for oxidative stress and root development (Martin *et al.,* 2011).

3. MATERALS AND METHODS

3.1 Description of the Study Area

The field experiment was carried out at Bule hora woreda at Fesheka kebele on farmers training center (FTC), west Guji zone of the Oromia regional state under rain fed condition. Bulehora town is located at 467 km southwestern of Addis Ababa on the main road to Moyale. The experimental site is located at about 7 km from the town with geographical coordinate of $5^0 35^'$ N and $38^0 15^'$ E, altitude ranging 2200-2600 m.a.s.l. The site receives bimodal rainfall with two distinct rain seasons. The highest mean annual average rainfall of the study area is 1250 mm, whereas the lowest mean average was 600 mm, while the average minimum and maximum temperature of 15°C and 22.8 °C, respectively.

According to the soil map of Bule Hora woreda, the soil types are Black, Red brown and grey. Of these, the first two are the types of soils covering the largest part of the woreda. Red soils are young soils developed in recent alluvial deposits and generally good for agriculture (Adugna, 2015).The spatial coverage of these soils are exactly unknown because all types of soils are found over the total area of the district. However, recent information from Agricultural and rural development office reveals that the percentage coverage of the soil approaches Red 45 %, Brown 22%, Grey 17%, Black 13% and others 3 % (Adugna, 2015). According to the Agricultural Office of the Bule Hora Woreda, some of the dominant crops that are produced in the woreda include maize, teff, barley, wheat, soybean and beans. These crops are used for home consumption. The woreda also produces some cash crops such as coffee, chat, inset and different varieties of fruits (Bule Hora woreda Agricultural Office, 2018).

3.2 Treatments and Experimental Design

The treatment consists of both in 4x4 factorial combination four level of N (0, 23, 46 and 69 kg N ha^{-1}) and four level of NPSB (0, 50, 100 and 150 kg NPSB ha^{-1}). The constituents of fertilizer are; urea (46%N) and NPSB (18.9 N, 37.7 P_2O_5, 6.95 S and 0.1B). There were sixteen treatment combinations, which were assigned to each plot randomly. The treatments were laid in factorial arrangement, using randomized complete block design with three replications. The experimental plot was having an area of 2.4m^2 (2 x 1.2); the space between replications and plots were 1 m and 0.5 m, respectively, with gross experimental area of 260.7m^2 (6.6m*39.5m). Each plot consisted of 10 rows with spacing of 20 cm between rows.

3.3 Experimental Procedures and Field Management

The land was ploughed using oxen and plots were level manually, NPSB was applied at sowing time, while nitrogen fertilizer in the form of urea was added to the soil at the rates of 1/3 at planting time and the other 2/3 was applied at tillering stage to avoid leaching. Malt barely varieties (Holker) was sown at the recommended rate of 125 kg ha^{-1} in rows by using a manual row marker.

3.4 Soil Sampling and Testing

composite soil samples were collected before planting from the experimental site at depth of 20 cm with sampling auger following a zigzag fashion (W-shape) using an auger. Then the collected samples were mixed thoroughly to make one composite sample. Then, one kilogram of composite sample was taken for the final analysis. The soil samples were air dried and grind to pass through 2 mm sieve for physical and chemical analysis of parameters. The collected samples were analyzed for mainly organic matter, total N, soil pH, available phosphorus, available sulfur, available boron, cation exchangeable capacity (CEC) and textural analysis using standard laboratory procedures.

3 .5 Data Collection

Data was collected from the middle eight harvestable rows excluding the two border rows and one plant from the end of harvestable rows in both sides.

3.5.1 Crop phenological data

Days to heading (DH): - was determined as the number of days taken from the date of emergence to spikes emerged in 50% of plants in each net plot.

Days to physiological maturity (DPM): - were also recorded as the number of days after planting to 90% of the physiological maturity, which were indicated by senescence of the leaves as well as free threshing of seeds from glumes when pressed between the thumb and the forefinger.

3.5.2 Growth parameters

Plant height (cm): Plant height measurement was made from the soil surface to the top most growth points of plant part. The measurement was randomly taken from ten plants of eight central rows of each plot at physiological maturity.

Spike length (cm): At maturity, ten spikes from the effective tillers were taken randomly from the net plot area of each plot and measured from the bottom of the spike to the tip of the spike with excluding the awns and then, the mean value spike length were determined in cm.

3.5.3 Yield components and yield

Number of kernels per spike: - was taken from ten randomly selected spikes per net plot at harvest and was averaged to per plant basis.

Number spikelet per spike: - It was taken from ten randomly selected spikes per net plot at harvest and was averaged to per plant basis.

Number of tillers:-The mean numbers of tillers produced per plant was counted in ten randomly selected plants at physiological maturity stage

Number of effective Tillers: - The mean numbers of tillers were determined based on ten random plants of each net plot.

Above ground dry Bio Mass yield (ABM): It was recorded from eight center rows after sun drying to a constant weight.

Grain Yields (GY): - was measured from eight center rows and then moisture content determined by adjusted to 12.5% moisture level.

$$\text{Grain yield in}\frac{\text{kg}}{\text{ha}} = \frac{\text{yield per plot }\left(\frac{\text{kg}}{\text{m}^2}\right)\text{X 10000m}^2}{\text{net plot size m}^2} X\ 0.01$$

Harvest index (%): It was **c**alculated as the ratio of grain yield to above ground dry matter per net plot and multiplied by 100.

$$\text{HI} = \frac{\text{Grain yield}}{\text{Above ground biomass yield}}\text{X 100}$$

Thousand kernel weight (TKW) (g): It was determined based on the weight of 1000 seeds sampled from the bulk grain yield of each treatment by counting on an electronic seed counter and their weight taken with an electronic balance and then adjusted at 12.5% grain moisture content.

3 .6 Data Analysis

The data were subjected to analysis of variance using SAS software version 9.0. Significant treatment differences were separated using the Least Significant Difference (LSD) test at the alpha level of 5 % probability level of significance.

Soil analysis: Organic carbon content was determined by the oxidation of organic carbon with acid potassium di-chromate (K2Cr2O7) medium using the Walkley and Black (1934) method as described by Dewis and Freitas (1970). Total nitrogen was analyzed by Micro-Kjeldhal method (Jackson, 1958). The pH of the soil was determined in 1:2.5 (weight/volume) soils to water dilution ratio using a glass electrode attached to digital pH meter (Page, 1982). Cation exchange capacity was measured after saturating the soil with 1N ammonium acetate (NH4OAC) and displacing it with 1N NaOAC (Chapman, 1965). Available phosphorus was determined using the Olsen method (Olsen *et al*., 1954). Available sulfur was determined using turbid metric method (Chesnin and Yien, 1951). Available boron was determined by Mehlich 3 extracts as the hot water-soluble method.

Hectoliter Weight (HLW): was estimated for each experimental unit following standard procedure (AACC, 2000) on dockage free basis using laboratory standard hectoliter and electronica balance.

Grain protein content: Total nitrogen in the seed was analyzed by wet-oxidation procedure of the modified Kjeldahal procedure (Nelson and Sommers, 1973). Grain protein content was determined by multiplying the N content by the conversion factor of 6.25 according to the standard macro-Kjeldhal procedure (AOAC, 1970).

Economic analysis: The economic analyses were done by using partial budget analysis by CIMMYT (1988).

$NB = (GY \times P) - TCV$

Where NB = Net benefit, GY x P = Gross Field Benefit (GFB), GY = Adjusted Grain yield kg per hectare and P = field price kg of the crop.

$MRR (\%) = \Delta NB / \Delta TVC x100$

Where MRR=%Marginal rate of return ΔNI = Change in Net Income; ΔTVC= change in Total Variable Cost.

4. RESULTS AND DISCUSSION

4.1. Soil Physicochemical Characteristics of the Experimental Site

Physical soil analysis showed that texture of soil was loam with sand, silt and clay percentage of 38%, 40%, and 22%, respectively.

Soil pH, TN and OM of the experimental site was rated and classified according to Tekalign, (1991). On the other hand, available P and OC were rated as per Olsen *et al.* (1954) and Horneck *et al*. (2011) respectively. The analysis result before sowing was 7.21 for pH, 0.024% for total nitrogen (TN), and 0.47% for organic matter (OM) content, 6.00 ppm for available phosphorous (P) and 0.27 for OC. The soil pH was classified as neutral, values of OM and OC content of the soil were rated as very low (<0.86%) and (<4%). While, available P content and TN were low in the soil (Tekalign, 1991; Olsen *et al.*, 1954) pointing to the limited availability of soil nutrients for crop productivity. Thus, addition of single and/or combined fertilizers at the right time and rate might be required whenever there is nutrient deficiency in the study area. The value of EC (1.8 ds/m) was lower considering the standard rate in the literature (Landon, 1991). Soil salinity is not a problem in the study site. Generally, according to USDA soil classification, a soil with electrical conductivity of less than 2.0 dS/m at 25°C and pH less than 8.5 are classified as normal soil. Therefore, the soil of the study area was normal soil. So that the pH level of the study is conducive for barley production as normal soil pH for barley is recorded to be from pH of, 6.25 - 7.5 the pH of the experimental soil is within this range.

The CEC of the site was 65.00-cmol kg^{-1} according to (Landon, 1991) soil having CEC of >40, 25-40, 15-25, 5-15, < 5 cmol kg^{-1} categorized as very high, high, medium, low and very low, CEC of the soil. According to the result obtained from soil laboratory, the value of CEC was in very high which indicates good agricultural soil. Available Boron in the study area was 0.40 mg kg^{-1} (EthioSIS, 2014) critical B value for most Ethiopian soils is 0.8 mg kg^{-1}. This shows that soils of the study area are deficient in B suggesting application of fertilizer, which contains B is essential. Available sulfur value of the study area was 14.00 mg kg^{-1} (Table 3). Based on EthioSIS soil classification for S values lies on low range. The classification is < 9 very low, 10-20 low, 20-80 optimum, and > 80 mg kg^{-1} high. So addition of fertilizer which contains S is relevant. This low in sulfur content of the soil may be due to loss of OM and lack of using S congaing fertilizer. It was also related to continuous cultivation and intensive mining of S from the soil.

Table 1: Selected physico-chemical properties of the experimental site

Soil physical properties	Tested results	Rating	Sources
Sand (%)	38		
Silt (%)	40		
Clay (%)	22		
Soil texture	Loam		
pH (1: 2.5 H_2O)	7.21	Neutral	Horneck *et al*. (2011)
Organic matter content (%)	0.47	Low	Tekalign (1991)
OC (%)	0.27	Low	Horneck *et al*. (2011)
Total nitrogen (%)	0.024	Very low	Tekaligh(1991)
Available phosphorus (ppm)	6.00	Low	Olsen et al. (1954)
Electrical conductivity (ds/m)	1.8	Low	Landon (1991)
Available Boron (Mg/Kg)	0.40	Insufficient	Ethio-SIS (2014)
CEC [Cmol(+)kg-1 soil]	65.00	Very high	Landon (1991)
Available sulfur (Mg/Kg)	14.00	Low	Ethio-SIS (2014)

4.2. Effect of Blended NPSB and N fertilizer on Phenological Parameters of Malt Barley

4.2.1. Days to heading

Result of current study showed that both the main effects and their interaction were significant on the days to heading (Appendix Table 3). The maximum days to heading (83.3 and 83.0 days) was recorded at the interaction of 0 kg NPSB ha^{-1} and 23 kg N ha^{-1} and at 100 kg NPSB ha^{-1} and 69 kg N ha^{-1} respectively. While, the shortest days to heading (77.0 days) was recorded at the control (Figure 1). In agreement with the result, Mekonen (2005) reported that a day to heading was significantly delayed when N fertilizer was applied at the highest rate for wheat and barley production compared to the lowest rate. Rashid *et al*. (2007) also reported that nitrogen application significantly affected days to heading in barley. This is in line with Nakano *et al.* (2008) who reported that plants that received 0.008kg N ha^{-1} at active tillering headed slightly later than those that received 0 kg N ha^{-1}. These results also in line with Bekalu and Mamo (2008) who reported that, N fertilizer rate and blended NPSB rate significantly affected days to heading on wheat and barley production.

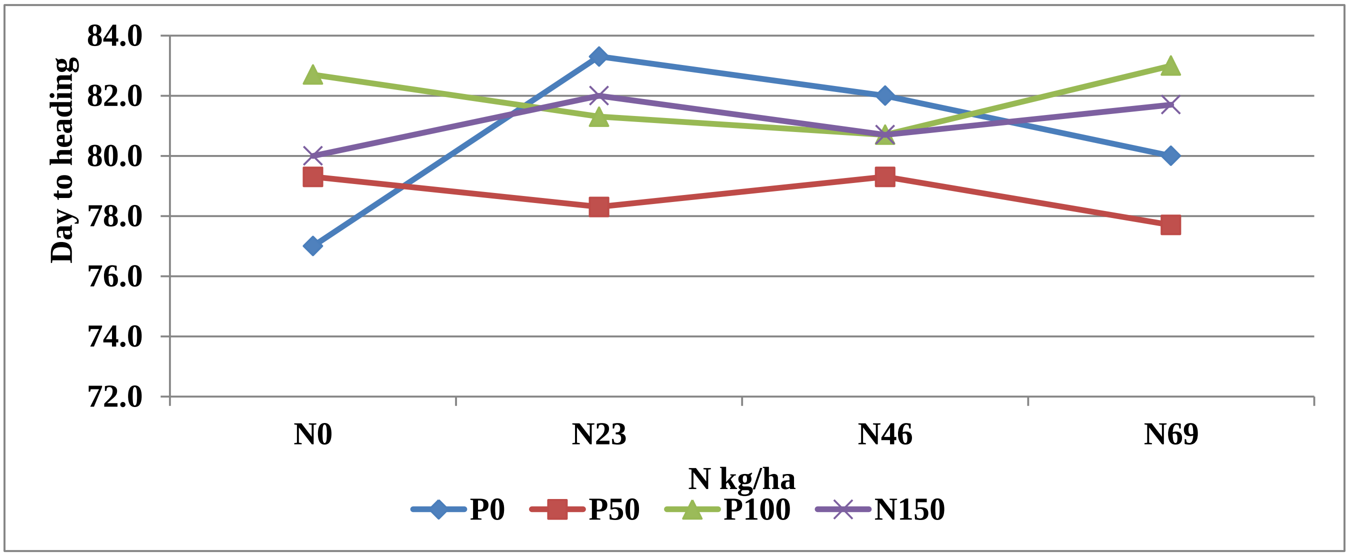

Figure1. Interaction effect of blended NPSB and N fertilizer on Days to heading of malt barely.

4.2.2. Days to physiological maturity

Analysis of variance showed that both the main effects of blended NPSB and N fertilizer rates were highly significantly ($P< 0.01$) on day to physiological maturity. The interaction effect of the two factors was also significant (Appendix Table 3).The maximum days to physiological maturity (140.3 days) and (139.6 days) were recorded at the interaction of 0 kg NPSB ha^{-1} and 23 kg N ha^{-1}and at 100 kg NPSB ha^{-1} and 0 kg N ha^{-1} respectively. While, the shortest days to physiological maturity (133.3 days) was recorded at the combination of 0 kg NPSB ha^{-1} and N at the control from experimental units received neither urea (N) nor NPSB (Figure 2).

In agreement with this result, Wakene (2014) reported that the maturity time of barley was longer at higher rate (120 kg N ha^{-1}) of nitrogen than the control (0 N). These results were in line with Bekalu & Mamo (2008) who reported that, N fertilizer rate significantly affected days to maturity on barley and wheat this might be attributed to the behavior of the fertilizer N which increases vegetative growth of crops there by delaying physiological maturity. The results are similar to (Marschener**,** 2012) who observed when N is applied in excess; the maturity of the crop is delayed by affecting during the critical period of the reproductive phase. Moreover, when N is applied in excess to barley and wheat, the sugar concentration in leaves is reduced during early ripening stage and hence, inhibition occurs in the translocation of assimilated products to spikelet. Under normal condition crops may take long days to maturity to exploit the available moisture and nutrients in the soil. Similarly, Woinshet (2007) reported as high rates of nitrogen prolong days to physiological maturity.

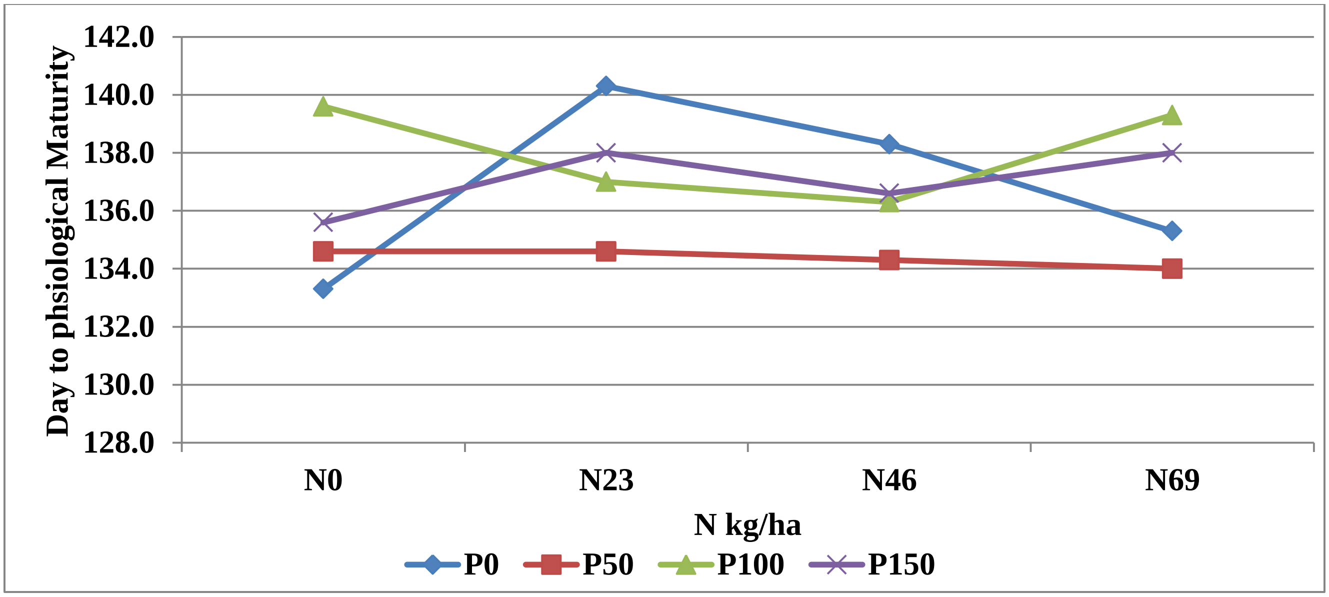

Figure 2. Interaction effect of blended NPSB and N fertilizer on Days to physiological maturity of malt barely

4.3. Effect of Blended NPSB and N Fertilizer on Growth Parameters of Malt Barley

4.3.1. Plant height

Analysis of variance showed that the main effects of blended NPSB and N rates were significant ($P< 0.05$) on plant height. However, the interaction effects of the two factors were not significant (Appendix Table 3).The tallest plant height (90.77 cm) was obtained at the rate of N application 46kg N ha^{-1} and it was at par with plant height (88.5cm) recorded in plants from nitrogen application at rates of 69 kg N ha^{-1}.The shortest plant height (80.48cm) was recorded in unfertilized plot (Table 2). The application of nitrogen fertilizer at 46 kg N ha^{-1} increased the plant height by 11.3% compared to the unfertilized plot. The study also revealed that Maximum plant height (91.15 cm) was observed for 150 kg NPSB ha^{-1} rate; whereas the minimum plant height (83.39 cm) was observed at control. The maximum plant height recorded at 150 kg NPSB

ha^{-1} rate was statistically superior to the control and this was statistically not significant with the rest blended fertilizer rates.

This increment in plant height might be due to the fact that N improves plant height by taking synthesis of macromolecules (proteins, enzymes, pigments, hormones, etc.) and rate of processes like photosynthesis on cell division and cell elongation, and finally internode length. Soil applied with increased rates of N increase internodes length which ultimately resulted in increased plant height also N application enhanced the overall vegetative growth of bread wheat and barley (Saeed *et al*., 2012).

The result showed that plant height increases at an increasing rate of nitrogen levels (Ali *et al*., 2003). (Tayebeh *et al*., 2010) also reported similar results of plant height increment with N rate increase and (Sofonyas, 2016**)** reported significant increments in plant height due to application of high nitrogen rate. This result is in agreement with Minale *et al*. (2011) and Wakene *et al*. (2014) who reported that plant height of barely was increase with increasing rates of N fertilizer. Bereket *et al*. (2014) reported that macro and micro nutrients (Nitrogen, Phosphorous with Sulfur and Born) fertilizers application can increase plant height, increasing doses and combination.

4.3.2. Spike length

Spike length was not significantly ($p < 0.05$) influenced by the main effects of blended NPSB and their interaction rate but was significantly ($p < 0.05$) influenced by the main effects of N (Appendix Table 3). The highest spike length (7.57 cm) was recorded from the plot treated with 46 kg N $ha^{-1}$of application which is statically at par with 69 kg N ha^{-1}.While shortest spike length (7.04 cm) obtained from the control plot. As indicated in (Table 2), increasing nitrogen fertilizer from nil to 46 kg N ha^{-1} increase the spike length 7%. Our result is in agreement with. Laghari *et* *al*. (2010) reported that spike length became higher at the higher doses of nitrogen .Similarly, the reports of Aghdam and Samadiyan (2014) indicated that effect of N on spike length was significant at 1% level which means spike length became higher at higher dose of N possibly due to higher availability of nitrogen. Bekalu and Mamo (2016) reported that optimum amount of fertilizer application has significant effect on spike length growth.

Table 2: Effect of blended NPSB and N fertilizer on growth parameters of malt barley

Treatments	**Rates**	**PH (cm)**	**SL (cm)**
N (kg ha^{-1})	0	80.48^{b}	7.04^{b}
	23	86.75^{ab}	7.38^{ab}
	46	90.77^{a}	7.57^{a}
	69	88.57^{a}	7.48^{a}
	LSD$_{0.05}$	7.01	0.36
NPSB (kg ha^{-1})	0	83.39^{b}	7.33
	50	84.51^{ab}	7.25
	100	87.53^{ab}	7.39
	150	91.15^{a}	7.50
	LSD$_{0.05}$	7.76	NS

* Means in the same column followed by the same letter are not significantly different at $p<0.05$ level of significance.PH= plant height, SL = Spike length.

4.4. Effect of Blended NPSB and N Fertilizer on Yield and Yield Components of Malt Barley

4.4.1. Number of Tillers per plant

The analysis of variance revealed that significant ($p<0.01$) difference was observed on barley number of tillers per plant due to different rates of N. While, blended fertilizer rates and their interaction didn’t show significant variation (Appendix Table 4).The highest (2.76) number of tillers per plant was obtained at 69 kg N ha^{-1} and it was statistically superior to the control and similar with that of the rest rates of urea. On the other hand, the minimum (1.73) number of tillers per plant was obtained at control, which was statistically similar to that of 23 and 46 kg N ha^{-1} urea rates. The lowest numbers of tillers per plant (1.73) were recorded for barley at control plot (Table 3). This might be due to the role of N in accelerating vegetative growth of plants. The highest number of tillers per plant was obtained at 69 kg ha^{-1} urea were improved by 36% as compared to the lowest number of tillers per plant at control. The results were in agreement with that of Abdullatif *et al*., (2010) reported that increasing in the number of tillers with nitrogen fertilization. Bereket *et al*., (2014) and Abdollahi *et al*., (2012) also reported that nitrogen fertilization have significant effect on number of tillers of barley.

4.4.2. Number of Effective Tillers

Analysis of variance revealed that, number of effective tillers was not significantly affected by main effect of N fertilizer rates and their interaction. However, main effect of blended NPSB was significant (Appendix Table 4).

The highest number of effective tillers (1.63) was produced when the crop was fertilized by application of 100 kg blended NPSB ha^{-1} but statistically at par with the rates of 150 kg blended NPSB ha^{-1}. The lowest number of productive tillers (0.81) was recorded from control (unfertilized) plot, which was significantly different from the other rates (Table 3). The highest number of tillers per plant was obtained at 100 kg NPSB ha^{-1} were improved by 50% as compared to the lowest number of effective at control. The results are similar to Assefa *et al*. (2015) reported that application of blended fertilizer resulted in maximum number of effective tillers and increased number of effective tillers by 19.2% as compared to control.

4.4.3. Number of spikelet per spike

The analysis of variance indicated that different rates of N application had significant ($p<0.01$) effect on number spikelet per spike, while the different blended NPSB rates and their interaction

were no significantly ($p>0.05$) influence number of spikelet per spike (Appendix Table 4). The highest (13.58) number of spikelet per spike was obtained at 46 kg N ha^{-1} and it was statistically superior to control (11.79) but was similar with that of the rest N rates (Table 3). Application of fertilizer from control to higher rates of fertilizer increased number spikelet per spike of barley. This result implies that, number of spikelet per spike of barley formation was highly affected by fertilizer (Table 3). This result is in line with of (Tayebeh *et al.*, 2010) who reported that there was variation of number spikelet per spike of barley with application of nitrogen fertilizer rates.

4.4.4. Number of Kernels per Spike

The ANOVA showed that both the main effects of blended NPSB and Urea fertilizers as well as their interaction effect were not significant on number kernels per spike (Appendix Table 4).

Table 3: Effect of blended NPSB and N fertilizer on yield and yield components of malt barley.

Treatments	Rates	NTPP	NKPS	NSPS(cm)	NFT
N (kg ha^{-1})	0	1.73^{b}	21.65	11.78^{b}	0.91
	23	2.21^{ab}	22.73	12.96^{a}	1.21
	46	2.23^{ab}	23.25	13.58^{a}	1.25
	69	2.76^{a}	22.30	12.73^{a}	1.71
	LSD $_{0.05}$	1.00	NS	0.88	NS
NPSB (kg ha^{-1})	0	1.88	22.60	12.85	0.81^{b}
	50	2.15	21.77	12.32	1.10^{ab}
	100	2.50	22.76	13.17	1.63^{a}
	150	2.42	22.80	12.70	1.55^{ab}
	LSD $_{0.05}$	NS	NS	NS	0.81

* Means in the same column followed by the same letter are not significantly different at $p<0.05$ level of significance. NTPP = Number of Tillers per plant, NKPS = Number of Kernels per Spike, NSPS = Number spikelet per spike and NET = Number of Effective Tillers.

4.4.5. Thousand Kernel weight

Thousand kernel weight was highly significantly ($p<0.01$) influenced by the interaction effect and main effect of urea fertilizer rates. However, the main effect of blended NPSB was non-significant (Appendix Table 5). The highest thousand kernel weight (53.20 g) was record at the interaction of 0 kg NPSB ha^{-1} and 23 kg N ha^{-1} which is significantly followed by 0 kg NPSB ha^{-1} and 69 kg N ha^{-1} (51.50 g), 50 kg NPSB ha^{-1} and 0 kg N ha^{-1} (51.20 g), 150 kg NPSB ha^{-1} and 0 kg N ha^{-1} (49.30 g) and 100 kg NPSB ha^{-1} and 0 kg N ha^{-1} (48.9 g). While the lowest thousand kernel weight (33.00 g) was noted at 150 kg NPSB ha^{-1} and 23 kg N ha^{-1}. In general, combined application of blended NPSB with nitrogen fertilizers (0/23 kg ha^{-1}) exceeded the thousand kernel weight by about 37.9% than the lowest treatment (Figure 3). The variation among treatment in response to application of N as well as the interaction of the blended NPSB and N fertilizers on the thousand kernels weight might be due to the contribution of macro and micro nutrient like N, P, S and B contributed to production of more number of kernels per spike hence decreases kernel size might have reduced thousand kernels weight. Thousand kernels weight is negative correlated with kernel size, as large kernels will weigh more than small kernels (Akinci *et al*., 2008).

(Tayebeh *et al*, .2011) reported that number of seeds spike^{-1} and thousands kernel weight were significantly enhanced by increasing nitrogen levels. Higher kernel weight is a reflection of improved nutrient use efficiency as a result of increased application of nitrogen level and blended fertilizer, respectively. This is in line with (Muhammad *et al*,.2009) reported that applying both micro (especially Zn,B) and macro nutrient and when N level application increase there is a positive impact on yield component of wheat and barley crop especially on thousand kernel weight.

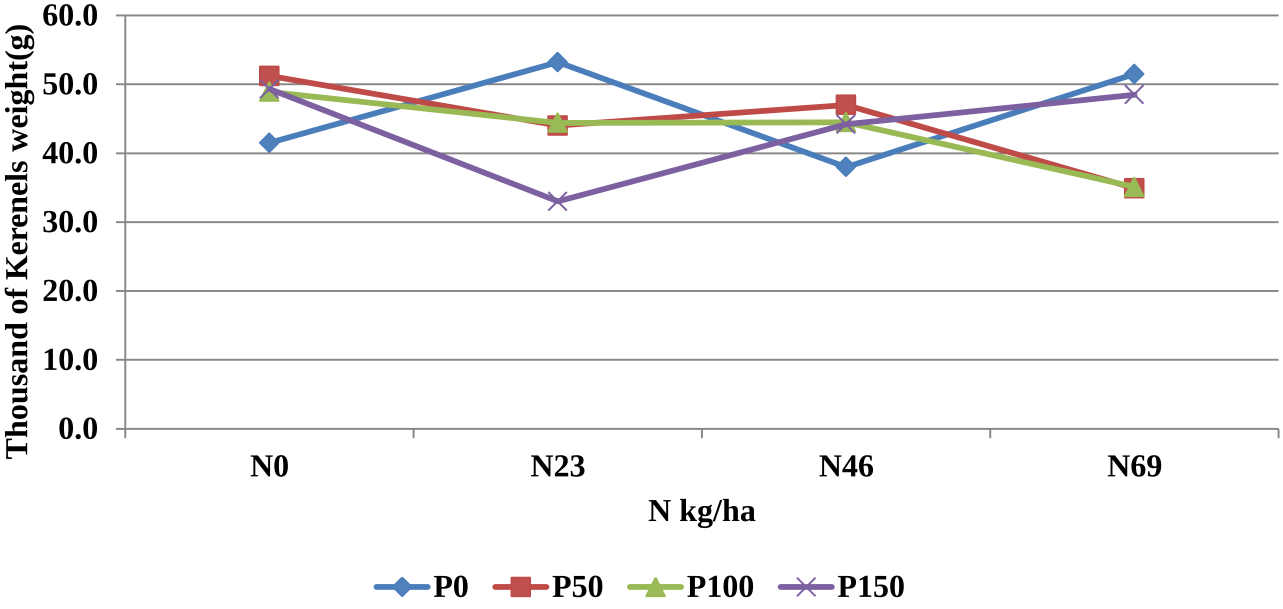

Figure3. Interaction effect of blended NPSB and N fertilizer on thousand kernel weight of malt barely.

4.4.6. Aboveground biomass

The analysis of variance revealed the main effects of NPSB fertilizer rates significantly ($P < 0.05$) influenced the aboveground biomass. However, the main effect of N as well as the interaction effect did not significantly influence this parameter (Appendix Table 5). The highest aboveground biomass (4422.90 kg ha^{-1}) was observed at 150 kg NPSB ha^{-1} which is statically par with100 kg NPSB ha^{-1} (4062.5 kg ha^{-1}). Contrary to this, minimum aboveground biomass (3194.40kg ha^{-1}) was obtained at control (Table 4). The highest aboveground biomass obtained at 150 kg NPSB ha^{-1} lead to an improvement of 27.27 % than the control. This is because adequate supply of nitrogen leads to high photosynthetic activity, vigorous vegetative growth and dark green color and finally improves the utilization of carbohydrates. Sulfur is also reported to enhance the photosynthetic assimilation of N in crop plants (Abdin, 2000). While adequate supply of phosphorus increases tiller emergence especially secondary tillers and their survival, it helps in increasing the biomass yield through proper regulation of carbohydrates translocation (Prasad, 2017). Ample supply of boron facilitates photosynthetic activities and leaf expansion that leads into improved plant growth (Tahir *et al*., 2009).The current finding is in line with Melkamu *et al*. (2019) reported blended fertilizer supply had a marked effect on the aboveground biomass. The maximum aboveground biomass (12.63 t ha^{-1}) was obtained from 200 kg NPSB ha^{-1} of blended fertilizer application. However, the lowest (4.29 t ha^{-1}) aboveground biomass was recorded from control or unfertilized plot. This result also agrees with the finding of Woubshet *et al*. (2017) found that application of 150 kg ha^{-1} NPSB blended fertilizer with compost increased the biomass by 11.5 t ha^{-1}.

4.4.7. Harvest index

Analysis of variance revealed that, harvest index was not significantly affected by main effect of blended NPSB rates and Urea fertilizer rates. Moreover, the interaction effect was not significant on the harvest index (Appendix Table 5).

Table 4: Effect of blended NPSB and N fertilizer on yield and yield components of malt barley

Treatments	Rates	ABM(kg/ha)	HI (%)
N (kg ha^{-1})	0	3423.0	15.35
	23	3569.4	16.39
	46	4084.8	18.49
	69	4126.8	21.49
	LSD$_{0.05}$	NS	NS
NPSB (kg ha^{-1})	0	3194.4^{b}	17.45
	50	3524.3^{ab}	22.26
	100	4062.5^{ab}	15.82
	150	4422.9^{a}	16.15
	LSD$_{0.05}$	927.49	NS

* Means in the same column followed by the same letter are not significantly different at $p<0.05$ level of significance. ABM = above ground biomass per hectare, HI = harvesting index.

4.4.8. Grain yield

Regardless of the degree of significance (level of significance) grain yield was significantly affected by the main effect of N, NPSB and their interaction effects (Appendix Table 5). Accordingly, the highest grain yield (3691kg/ha) was recorded at the combination of 150 kg NPSB ha^{-1} and 69 kg N ha^{-1}; followed by 100 kg NPSB ha^{-1} and 69 kg N ha^{-1} with average grain yield of (2812kg/ha).However, the lowest grain yield (1250 kg/ha) was observed at the interaction of 0 kg NPSB ha^{-1} of and 0 kg N ha^{-1} (control) as illustrated in (Figure 4).

The highest grain yield at the highest NPSB rates might have resulted from improved root growth and increased uptake of nutrients and better growth favored due to the synergistic effect of the four nutrients, which enhanced yield components and yield. Nitrogen affects the vegetative as well as yields whereas phosphorus plays a fundamental role in metabolism and energy producing reaction and can withstand the adverse environmental effects, thus resulting in enhanced grain yield. The increase in grain yield in response to increasing rate of nitrogen could be attributed to enhanced availability of the nutrient for uptake by the plants and increased photoassimilate production that would eventually lead to improved partitioning of carbohydrate to the grains (Gooding and Davies, 1997).

The current finding is in line with Melkamu *et al*. (2019) who reported barley grain yield was increased by 70.4% and 22.4% from recommended NP(100kg/ha) fertilizer and control by application of 200 NPSB kg ha^{-1} blended fertilizers. Moreover, this result agrees with the previous finding of Woubshet *et al*. (2017) who reported that application of 150 kg NPSB ha^{-1} blended fertilizer with compost increase the grain yield by 4.8 t ha^{-1}. Klikocka *et al*. (2016) also found that a positive reaction of N and S fertilization on grain yield, which the highest grain yield (5.40 t ha^{-1}) was obtained due to application of 80 N kg ha^{-1} increasing by 1.30 t ha^{-1} (13.1%) with respect to the control and S fertilization, increased grain yield by 3.58%. Besides, Khan *et al*. (2006) reported 43% raise in grain yield with the addition of 90 kg P and 60 kg ha^{-1} S. Likewise, (Malakouti ,2000**)** repotted that the grain yield increased due to application of boron was also witnessed by the combined application of boron with micronutrients, with the benefits 4 to 11% wheat yield. Bereket *et al*. (2014) also reported that increasing rate of nitrogen fertilization increased grain yield of wheat.

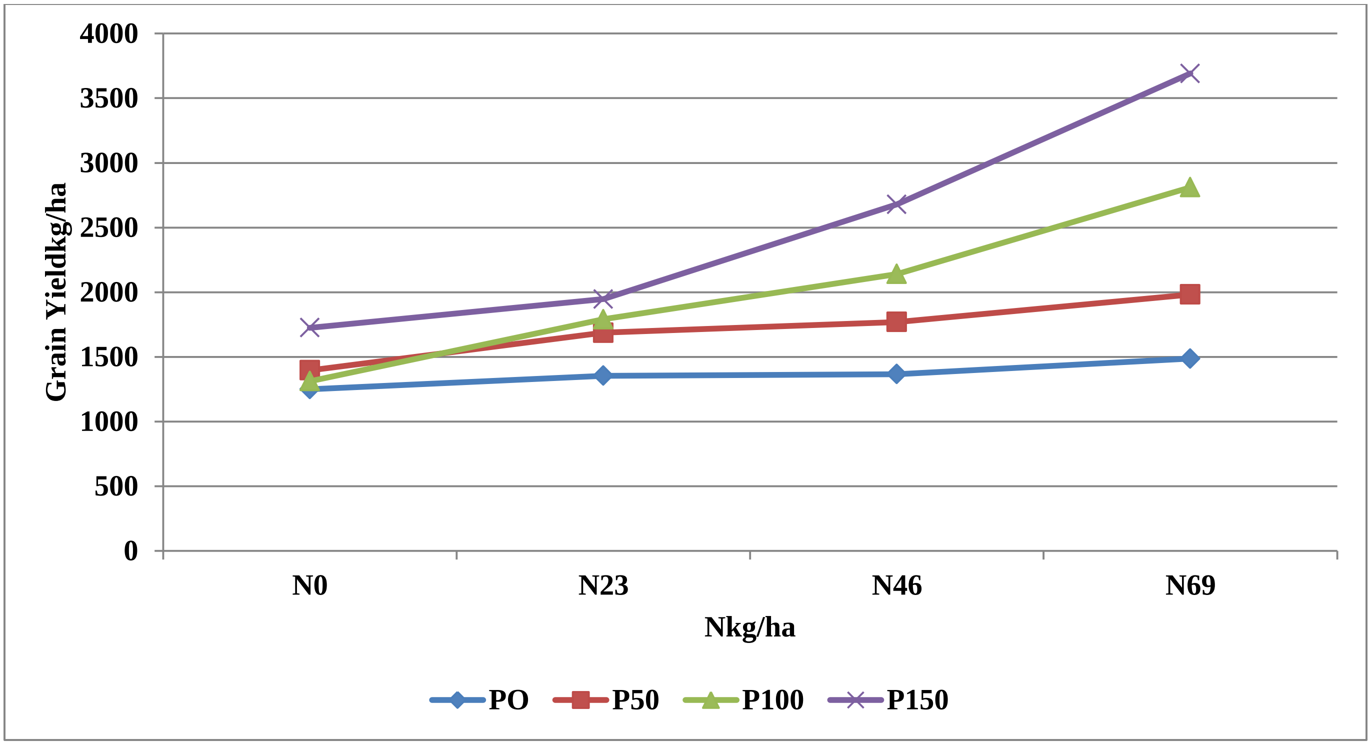

Figure 4. Interaction effect of blended NPSB and N fertilizer on grain yield of malt barely.

4.5. Grain Quality Parameters

4.5.1. Hectoliter weight

The main effect of blended NPSB and N fertilizers application was highly significantly ($P < 0.001$) influenced the hectoliter weight of the malt barley. The two factors also interacted to highly significantly on influence the hectoliter weight of the crop (Appendix Table 6). Accordingly, the highest hectoliter weight (68.56 kg/ha) was recorded at the combination of 150 kg NPSB ha^{-1} and 69 kg N ha^{-1}; followed by 100 kg NPSB ha^{-1} and 69 kg N ha^{-1} with average of 67.90 kg/ha. However, the lowest grain yield (55.06 kg/ha) was observed at the interaction of 50 kg NPSB ha^{-1} and 0 kg N ha^{-1} and control as illustrated in (Figure 5).

In general, there was significant difference in hectoliter weight among the interaction factors, this might be attributed to the difference in their capacity to sink assimilates to the area of grain production and the favorable weather condition during the cropping period (Biruk, 2015).

In agreement with this result Gooding and Davies (1997) also reported slight increase in hectoliter weight response to nitrogen fertilizer application under more favorable growing conditions. The standard value for hectoliter weight is 48-68kg/ha according to the Assela malt factory. Our result is in agreement with, (Biruk, 2016) who reported that, low value of HLW indicates poor grain filling and, therefore, climatic influence leading to grain shriveling which can impair specific weight through reduced packing efficiency.

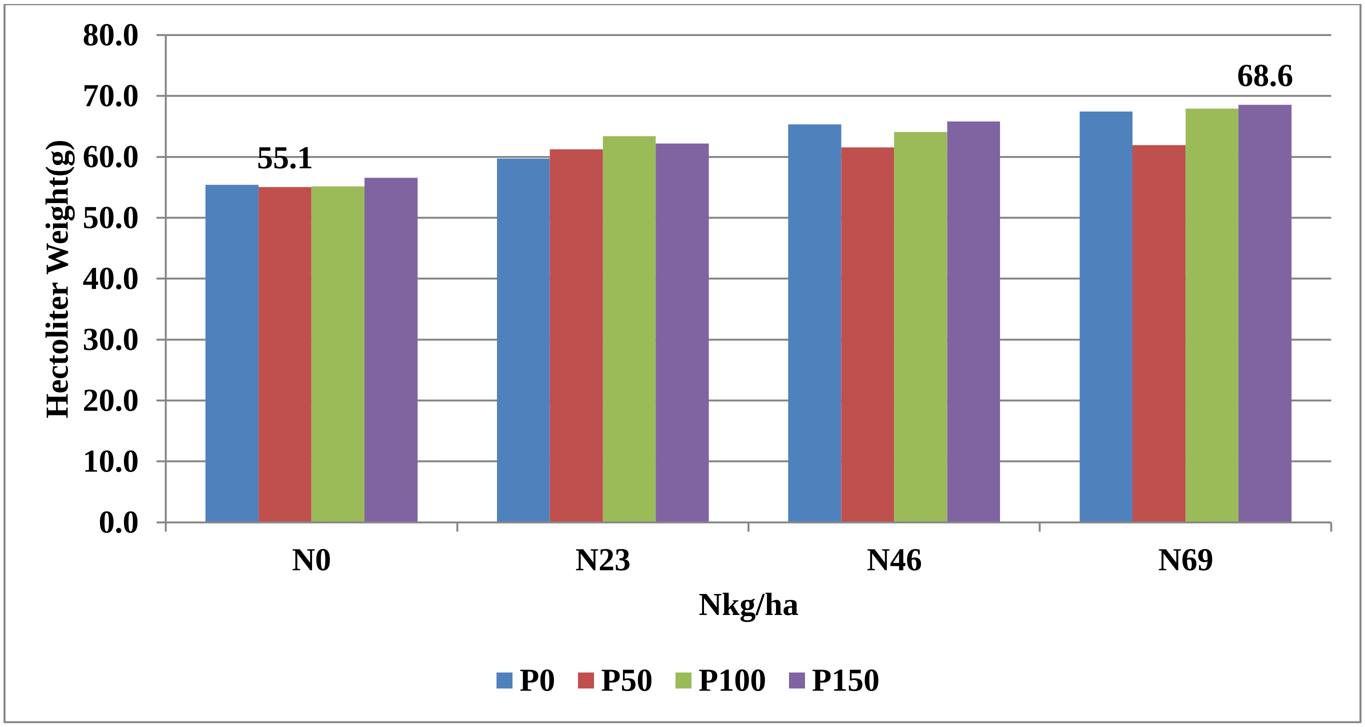

Figure5. Interaction effect of blended NPSB and N on hectoliter weight of malt barely

4.5.2. Grain protein content

The main effect of N highly significantly ($P < 0.001$) influenced the grain protein content. However, the main effect of blended NPSB and the two-factor interaction did not significantly influence the grain protein content of malt barley (Appendix Table 6). Grain protein content increased almost linearly in response to the increased rate of nitrogen fertilizer application. The highest grain protein content (12.7 %) was obtained at the highest rate of N (69 kg N ha^{-1}) which was statistically superior with the rest N rates; whereas the lowest grain protein content (10.8%) was obtained from unfertilized plot (Table 5). Increasing the application of N fertilizers from nil to 69 kg N ha^{-1} consistently increased grain protein contest. Generally, grain protein contents obtained at the application of 69 kg N ha^{-1} exceeded that of the nil N by about 14.9%. The increase in grain protein with increasing nitrogen rate might be due to greater synthesis and accumulation of storage proteins. Nitrogen is the building block of protein in which nitrogen increases the plumpness of the cereal grains and protein content of both seeds and foliage **(**Foth and Ellis, 1997**).**

Adane (2015) found that with low available nitrogen in the soil, malt barley responds well to applied fertilizer, showing increases in both grain yield and protein content. Increasing in protein content may increase steep times, create undesirable qualities in the malt, excessive enzymatic activity and low extract yield **(**Johnston *et al.*, 2007**).** It also slows down water uptake during steeping, potentially affecting final malt quality. According to the Ethiopian standard authority and Asella malt factory (AMF), the protein level of the raw barley quality standard for malt should be between 9-12% **(**EQSA, 2006**).** Both 0 and 23kg N ha^{-1} application of fertilizer rates had grain protein content in the acceptable standard range for malt purpose (Table 5).

Table 5: Effect of blended NPSB and N on grain quality parameters of malt barley

Treatments	**Rates**	**GPC**
N (kg ha^{-1})	0	10.8^{d}
	23	11.5^{c}
	46	12.1^{b}
	69	12.7^{a}
	LSD $_{0.05}$	0.35
NPSB (kg ha^{-1})	0	11.8
	50	11.7
	100	11.8
	150	11.8
	LSD $_{0.05}$	NS

* Means in the same column followed by the same letter are not significantly different at $p<0.05$ level of significance. PC = Grain protein content.

4.6 Partial Budget Analysis of Malt Barely Yield Production

The market price of barley grain was 20.00 Eth-birr kg^{-1} and prices for blended fertilizers NPSB and N were 14.62 and 13.40 Eth-birr kg^{-1}, respectively. While the cost of other production practices like cost of labor, seed and weeding were assumed to remain the same or insignificant among the treatments. Partial budget analysis of the combination of nitrogen levels with different rates of blended fertilizers was presented in (Table 6). Partial budget analysis was done using procedure described by CIMMYT Economics Program (1988) recommendations, which stated that application of fertilizer with the marginal rate of return above the minimum level (100%) is economical.

Information on costs and benefits of treatments is a prerequisite for adoption of technical innovation for farmers. The results in this study indicated that the application of blended NPSB and N fertilizer rate resulted in higher net benefits than the unfertilized/control treatments. As a result, the partial budget analysis revealed maximum net benefit of Birr 63203 ETB ha^{-1} with an acceptable marginal rate of returns (MRR) of 5776 % with the treatment combination 150 kg blended NPSB ha^{-1} and 69 kg N ha^{-1} .However, the lowest mean net benefit (22500 ETB ha^{-1}) was obtained from the control plot (Table 6).Therefore, fertilizer application 150 kg blended NPSB ha^{-1} and 69 kg N ha^{-1} were economical, and uncertainly recommended for production of malt barley in the study area and other areas with similar agro-ecological condition.

Table 6. Partial budget analysis of barely yield production under blended NPSB and N fertilizers rate in Bule Hora District.

NPSB	N	Yield (kg/ha)	Adjusted Yield (kg/ha)	Total Return (Birr/ha)	Total cost (Birr/ha)	Net Income (Birr/ha)	MRR (%)
0	0	1250	1125	22500	0.00	22500	0.00
0	23	1395	1218.6	24372	308.2	24067	508.7
0	46	1366	1229.4	24588	616.4	23972	0
0	69	1487	1338.3	26766	924.6	25842	613
50	0	1396	1256.4	24372	731	23641	0
50	23	1687	1518.3	30366	1039	29327	1846
50	46	1770	1593	31860	1347	30513	385
50	69	1983	1784.7	35694	1655	34039	1145
100	0	1366	1180.8	23616	1462	22154	0
100	23	1791	1611.9	32238	1770	30468	2699
100	46	2141	1926.9	38538	2078	36460	1945
100	69	2812	2530.8	50616	2386	48230	3821
150	0	1725	1552.5	31050	2193	28857	0
150	23	1947	1752.3	35046	2501	32545	1197
150	46	2679	2411.1	48222	2809	45413	4178
150	69	3691	3321.9	66320.4	3117.6	63203	5776

N.B: Prices of Urea: 13.4 birr/kg, NPSB: 14.62, Price of barley: 20 birr/kg in local market.

Family labor cost was not assigned cost because similar labor time was used on each treatment

5. SUMMARY AND CONCLUSIONS

Malt barley is one of most important crop it is used as food and commercial for beer production crop in Ethiopia particularly in Bule Hora woreda. It is produced in rain fed condition in different climatic region of the woreda by farmer and commercial grower in Ethiopia as well as in study area. Productivity of barley is low due to low soil fertility as a result of over exploitation and poor soil fertility management. Hence, a field experiment was carried out in 2019 cropping season to assess response of malt barley to the different rates of NPSB and N fertilizers for malt barley production with, acceptable quality and to determine economically feasible rates. The treatments consisted of four levels of NPSB (0, 50, 100, and 150 kg NPSB ha^{-1}) and four levels of N (0, 23, 46, 69 kg N ha^{-1}) fertilizers. The experiment was laid out in a randomized complete block design in a factorial arrangement and replicated three times.

Accordingly, to the result interaction effect of blended NPSB and N fertilizer rates showed highly significantly ($p<0.001$) differences on days to heading, days to physiological maturity, thousand kernel weight, grain yield, and hectoliter weight, whereas, protein content, number of spikelet per spike, number of tiller per plant and spike length were significantly ($p<0.01$) influenced by the main effect N fertilizer rates. More over blended NPSB significantly affect number of effective tiller and aboveground biomass. The maximum days of heading (83.3 days) were recorded from the combination of 0 NPSB kg ha^{-1} and 23 N kg ha^{-1} fertilizer rates. Furthermore, the maximum days of physiological maturity (140.3) were recorded from the combination of 0 NPSB kg ha^{-1} and 23 N kg ha^{-1} fertilizer rates, the highest thousand kernel weight (53g) were recorded from the combination of 0 NPSB kg ha^{-1} and 23 N kg ha^{-1} fertilizer rates, while the highest grain yield (3691 kg ha^{-1}) was recorded at combination of 150 NPSB kg ha^{-1} and 69 N kg ha^{-1} and highest hectoliter weight (68.5kg ha^{-1}) were recorded at fertilizer rate

150 NPSB kg ha^{-1} and 69 N kg ha^{-1}, the maximum spike length (7.57cm) number of spikelet per spike(13.5cm),number of tiller per plant(2.23) were recorded at fertilizer rate 46 kg N ha^{-1} and protein content(12.7%) were recorded 69 kg N ha^{-1}.

Plant height (PH) were significantly ($P<0.05$) affected by the main effect of N and NPSB fertilizers the highest plant height (90.7 cm and 91.1) was recorded at 46 kg N ha^{-1} and 150 kg NPSB ha^{-1}. The result of economic analysis showed that combined application of 150 kg NPSB ha^{-1} and 69 kg N ha^{-1} gave economic benefit of 63203 ETB ha^{-1} with acceptable marginal rate of return (5776%).

Thus, at fesheka farmers training center site and for the surrounding farmers in Bule Hora and other areas which have similar agro-ecological conditions, application of 150 kg NPSB ha^{-1} and 69 kg N ha^{-1} recommended obtaining maximum economic return.

Grain quality, especially with respect to protein content, is highly influenced by N fertilizer application. The determination of a specific N application rate for malt barley is essential to the production of malt barley grain of acceptable quality.

Fertilizer application rates 23 kg N ha^{-1} for the varieties of holker acceptable grain quality for fesheka kebela in bule hora woreda. 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 verity. Therefore, it is advisable to undertake further research across soil types, season and locations involving more than one verity to draw sound recommendation on a wider scale and for longer duration and variable cropping systems.

6. REFERENCES

AACC(American Association Cereal Chemists).2000.Approved Methods of the American Association Cereal Chemists. American Association of Cereal Chemists,*Inc.,St.Paul* Minnesota.

Abdin, M.Z. 2000. Effect of sulfur application on lipid, RNA and fatty acid content in developing seeds of rapeseed (*Brassica campestris* L.). *Plant Science*, 150: 71-76.

Abdollahi GJ, Hashemi-majd K, Mosavi SB, Feiziasl V, Jafarzadeh J. (2012) Effects of fall nitrogen rates on rainfed bread wheat yield and yield components in drought condition. Int Res *J Applied Basic Sci* 3(11): 2195-2204.

Abdullatif M, Asmat UM, Sattar A, Fiaz Hussain, Abbas G. (2010) Response of growth and yield of wheat to NPK fertilizer. *Sci Int* (Lahore) 24(2): 185-189

Addisu Alebie. 2017. Comparative study of aflatoxine level between traditional and industrial barley malt in Ethiopia Msc thesis submitted to the faculty of the center of food science and nutrition, Addiss Abeba University.

Adugna Babu.2015.Assessment of Challenges and Opportunities of Wetlands Management In Bule Hora Woreda, Guji Zone,Southern Ethiopia.Science ,Technology and Arts Research Journal report.4(2) :99-111.

Aghdam, S. M. and Samadiyan, F. 2014. Effect of Nitrogen and Cultivars on Some Traits of Barley (*HordeumVulgar*e L.) M.Sc. Plant Breeding, Faculty of Agriculture, University of Tabriz, Tabriz, Iran. *International journal of Advanced Biological and Biomedical Research*. 2(2), 295–299.

Agriculture Office of the Bule Hora Woreda .2018.The annual report production of crops.

Ahn P.M. (1993). Tropical soils and fertilizer use. Long man group, UK. Alam M.Z., Hider S.A. Paul N.K. (2007) Yield and yield components of barley (*Hordeum valgare* L.) cultivars in relation to nitrogen fertilizer. J Appl Sci Res 3: 1022-1026.

Akinci, C., Mehmet, Y. and Bahar, B. 2008. The effects of seed size on emergence and yield of durum wheat. *Journal of Food, Agriculture and Environment*, 6 (2): 234-237.

Ali S., Riaz K. A., Mairaj G., Arif M., Fida M., Bibi S., 2008. Assessment of different crop nutrient management practices for yield improvement. *Australian Journal of Crop Science*, 2(3): 150157.

Ali, M. A., Tariq, N.H., Ahmed, N., Abid, M. and. Rahim, A. 2013. Response of wheat (*Triticum aestivum* L.) to soil applied Boron and Zinc fertilizers under irrigated conditions. *Pakistan Journal Agricultura,* 29 (2): 114-125.

Almaz MZ,Hider SA.Paul NK(2007) yield and yield components of barley (Hordeum valgareL.) Cultivar in relation to nitrogen fertilizer. *J Appl Sci* Re 3:1022-1026.12

Amare Aleminew and Adane Legas. 2015. Grain quality and yield response of malt barley varieties to nitrogen fertilizer on *Brown Soils* of Amhara Region, Ethiopia. *World Journal of Agricultural Sciences*, 11 (3): 135-143.

AOAC (Association of Official Analytical Chemists). 1970. Official methods of analysis, 11th ed. Association of Official Analytical Chemists, Washington, D.C.

Asefa F., Mohammed M. and Debela A., 2014. Effects of Different Rates of NPK and Blended Fertilizers on Nutrient Uptake and Use Efficiency of Teff [*Eragrostis Tef* (*Zuccagni*)

Trotter] in Dedessa District, Southwestern Ethiopia. *Journal of Biology, Agriculture and Healthcare*, 4(25): 254-258.

Ashraf, A., Khaid, A. and Ali, k. 1999. Effects of seeding rate and density on growth and yield of rice in saline soil. *Pakistan Journal of Biological Science*, 2(30): 860-862

Assefa Fenta,Maqsood,M.,Akbar,M. and Yousaf,N.2017.Effects of urea fertilizer on growth response of food barley. *International of Journal Agriculture Biology*, 1:36-36

Assefa Menna, Johnson, Semoka, M.R., Nyambilila Amuri and Tekalign Mamo. 2015. Wheat Response to Applied Nitrogen, Sulfur and Phosphorous in three Representative Areas of the Central Highlands of Ethiopia. *International Journal of Plant and Soil science*, 8 (5): 1–11.

Badr A,Muller K,Schafer-Pergl R,El Rabey H,Effgen S,Iberhim HH,Pozzi C,Rohde W,Salamini.2000. On the origin and domestication history of Barley (*Hordeum vulgare* L.) *Molecular Biology and Evolution*.17 (4):499-510.Doi 10.1093/*oxford journals.molbev*. a026330. PMID 10742042

Bekalu Abebe, Mamo Manchore .2016. Effect of the rate of N fertilizer application on growth and yield of wheat (*Triticum aestivum* L.) at Chencha, Southern Ethiopia. *International Journal of Plant, Animal and Environmental Sciences* 6(11): 111-122.

Belay Simane, Tanner, D.G., Amsal Tesfaye and Asefa Taa. 1999. Agro-ecological decision support systems for wheat improvement in Ethiopia: climatic characterization and clustering of wheat growing regions. *African Crop Science Journal*, 7(1): 9-19.

Bereket Haileselassie, Dawit Habte, Mehretab Haileselassie and Gebremedhin Gebremeskel. 2014. Effects of Mineral Nitrogen and Phosphorus Fertilizers on Yield and Nutrient Utilization of Bread Wheat (*Tritcum aestivum* L.) on the Sandy Soils of Hawzen District, Northern Ethiopia. *Agriculture, Forestry and Fisheries*, 3 (3):189-198.

Berhan Abayu. 2012. Agronomic and Economic Effects of Blended Fertilizers under Planting Method On Yield And Yield Components of Tef: M.Sc Thesis, Mekelle University, Mekelle, Ethiopia.

Berhan Getie, 2017: Yield and Quality Response of Malt Barley (Hordium Dischiton L.) to Applied Levels of N Fertilizer and Seed Sources on Luvisol of Farta District South Gonder Zone, Ethiopia: *Journal of Biology,Agriculture and Health care* 7(1):1-8

Biruk Gezahegn and Demelash Kefale. 2016. Effect of Nitrogen Fertilizer Level on Grain Yield and Quality of Malt Barley (*Hordeum vulgare* L.) Varieties in Malga Woreda , 52, 8–16.

Botella, M.A., Cerda, A.C. and Lips, S.H. 1993. Dry matter production, yield and allocation of carbon-14 assimilate by wheat as affected by nitrogen source and salinity. *Agronomy Journal,* 35(5):1044-1049.

Brady N. C. and R.R. Weil. 2002. *The nature and properties of soils. Thirteenth edition*. Pearson Education Asia. Delhi, India. 960p.

Brar M. S. and Ludhiana P., 2006. Balanced Fertilization for Sustaining Crop Productivity. *In: Proceedings of the International Symposium held at Punja*b. Ludhiana, India, 22-25 November 2006. *International Potash Institute Volume I*: Invited Papers

Brown, P. H. and Hu H. 1997. Does boron play only a structural role in the growing tissues of higher plants. *Plant and Soil,* 196:211–215.

Chapman, H.D. 1965. Cation-exchange capacity. In: C.A. Black (ed.). Methods of soil analysis Chemical and microbiological properties. Agronomy 9:891-901. .

Chesnin, L. and Yien, C.H. 1951. Turbidimetric determination of available sulfates. *Soil Science Society of America Journal,* 15: 149-151.

CIMMYT. 1988. from Agronomic Data to Farmer Recommendations: An Economics Training Manual. Completely revised edition. Mexico, DF. 79p.

CSA (Central statistical agency) agricultural sample survey. 2018. Report on are and production of major crops (private peasant holdings, Meher season). Volume I, *Statistical bulletin,* Addis Ababa, Ethiopia, p10-12.

CSIOF (Current Situation, Investment Opportunities and Future).2013.outlooks of malt barley Cultivars. International Journal of Biology Sciences, 3(9):298-303.

Dai F,Nevo E,Wu D, Comadran J,Zhou M,Qiu L(October 2012).Tibet is one of the center of domestication of cultivated barley. Proceeding of the National Academy of Science of the United State of America.109 (42):16969-73

Dewis, J. and Freitas, P. 1970. Physical and chemical methods of soil and analysis. FAO Bulletin No. 10. Rome. 175p..

Dimenstein L, N Lisker, N Kedar and D Levy. 1997. Changes in the content of steroidal glycol alkaloids in potato tubers grown in the field and in the greenhouse under different conditions of light, temperature and day length. *American Journal of Physiology and Plant Pathology*, 150: 391-402.

Durgesh, K., Tripathi, D. K., Chauhan, N.K., Dube, S., and Singh, S. 2015. Micronutrients and their diverse role in agricultural crops: Advances and future prospective. *Acta Physiology Plant*, 37:139-145.

Epstein, E. and Bloom, A.J. (2005). Mineral Nutrition of Plants: Principles and Perspectives. (Eds.) Sinauer Associates Ltd., Sunderland. 170pp.

EQSA (Ethiopia Quality Standards Authority). 2006. Malting Barley Specification. Addis Ababa, Ethiopia.

Eriksen, J., Olesen, J.E., and Askegaard, M.2001. Sulfate leaching and sulfur balances of organic cereal crop rotation on three Danish soils. *European Journal of Agronomy*,17: 19

EthioSIS (Ethiopian Soil Information System) (2014) Soil Fertility and Fertilizer Recommendation Atlas of EthioSIS (Ethiopian Soil Information System). Soil analysis report Agriculture Transformation Agency (Unpublished).

Fageria, K., Baligar, V. C.and Clark, R. B. (2006). Physiology of Crop Production. The Haworth Press Ltd., NewYork.92pp.

FAO (Food and Agriculture Organization of the United Nations). 2016. Global production of barley. *Faostat*.

Fekadu, A., Berhanu, B., Fekadu, F., Adisie, N. and Tesfaye, G. Malting barley breeding. Pp 24-33. In: Hailu Gebre and Joop van Leur. (eds.) 1996. Barley research in Ethiopia: Past work and Future prospects. Proceedings of the First Barley Research Review Workshop, 16-19 October 1993, Addis Ababa: IAR/ICARDA Addis Ababa, Ethiopia.

Flaten, Don. 2004. Effects of Sulfur Nutrition on Grain Quality of Wheat. Manitoba Agriculture, Food and Rural Initiatives.

Flyn R., 2010. Introduction to Soil Salinity. Mexico State University Gardening Advisor. IE, pp.1-8.

Food and Agricultural Organization FAO, 2002.Views-Food crops and Shortages. No.1: 1-10.

Foth, H. D. and Ellis, B. G. 1997. *Soil Fertility, (2nded.).* Lewis Publishers, Boca Raton, Florida. 290p. fungi on yield and yield components of wheat. *International Journal Agri. Biosci.*, 6(1): 21-24.

Franklin, O., Cambui, C. A., Gruffman, L., Palmroth, S., Oren, R. and Näsholm, T. 2017. The Carbon bonus of organic nitrogen enhances nitrogen use efficiency of plants, 8(1):25– 35.

Gebrekidan H, Seyoum M (2006) Effects of mineral N and P fertilizers on yield and yield components of flooded lowland rice on vertisols of Fogera plain, Ethiopia. *Journal of Agriculture and Rural Development in the Tropics and Subtropics* 107: 161-176.

Gemechu Geba. 2011.influence of nitrogen and phosphorus fertilizer on seed yield and quality of maize (*zea may L.*) at beadle south-western Ethiopia Msc thesis submitted to the faculty of the department of plant science, school of graduated studies and Haramaya university Ethiopia.

Gerstenmier A., 2015. Agricultural Input Supply. Abdou Diouf International Conference Center, Dakar Senegal, 21-23 October 2015.

Getachew, Alemu and Tekalign Mamo, 2003. Response of barley to nitrogen and phosphorus application in Wello highlands of Ethiopia: II. Nutrient uptake and use efficiency. Ethiopian *Journal of Natural Resources*, 5: 39-56.

Getachew, L., Sintayehu, D., Tolosa, A. (2007). Assessing uncooperative advantage of malt barley production in Ethiopia. African crop science conference proceedings, 8:1227-1230. Egypt

Gooding, M.J. and Davies, W.P. 1997. Wheat Production and Utilization. CAB International, Wallingford, UK. *Journal of Agriculture*. 26(4): 489-497.

Grando S, HG Macpherson (eds.) (2005). Food Barley: Importance, Uses and Local Knowledge. Proceedings of the *International Workshop on Food Barley Improvement*, 14 -17 January 2002, Hammamet, Tunisia. ICARDA, Aleppo, Syria, x+156 pp.

Haneklaus, S., Bloem, E. and Schnug, E. 2007. Sulfur and plant disease. In: Mineral nutrition and plant disease, L. E. Datnoff, W. H. Elmer, and D. M. Huber, Eds., 101–118. St. Paul, MN: The American Phyto pathological Society.

Hasegawa T, Koroda Y, Seligma NG, Horie T (1994) Response of spikelet number to plant nitrogen concentration and dry weight in paddy rice. *Agronomy Journal* 86: 673-676.

Hawkesford, M., Horst, W. , Kichey, T., Lambers, H., Schjoerring, J., Møller, I. S. and White, P. 2012. Functions of Macronutrients. pp. 135-189. *In*: Marschner, P. (eds.), *Marschner's Mineral Nutrition of Higher Plants.* Elsevier Ltd., USA.

HBRC (Holleta barley Research Center). 2012. Annual research report 2010/11. EIAR- HBRC Holleta, Ethiopia. p154.

Hodges, C.S., 2009. Soil Fertility Basics. Nc certified crop advisor training. Soil Science *In: Soil Fertility and Fertilizers 5th eds.* Prentice Hall India, New Delhi. pp. 230-265.

Horneck D. A., Sullivan D. M., Owen J. S., and Hart J. M., 2011. Soil Test Interpretation Guide. EC 1478. Oregon State University Extension Service.

Hue, Y., Ye, X., Shi, L., Duan, H. and Xu, F. 2010. Genotypic differences in root morphology and phosphorus uptake kinetics in *Brassica napus* under low phosphorus supply. *Journal of Plant Nutrition*, 33: 889-901.

ICARDA (International Center for Agricultural Research in Dry Areas) .2008. Barley improvement production, Allepo, Syria53

Jackson, M.L. 1973. Soil chemical Analysis Printice Hall. Ind, Englewood, chiffs N.J. USA. 284p.

Jafar-Jood, S., A.H. Shiranirad, J. Daneshian and A. Rokhzadi, 2013. Effects of nitrogen application and spraying of boron and manganese on growth trails of two potato cultivars. *International Journal of Biology Sciences*, 3(9): 298-303.

Johnston, A., Murrel, S. and Grant, C. 2007. Nitrogen fertilizer management of malting barley: Impacts of crop and fertilizer nitrogen prices, 21-24.

Jones Martink.,Kovaleva,Olga(18 July 2018).Barley heads east: Genetic analyses reveal routes of spread through diverse Eurasian landscapes PLOS ONE.13(7):e0196652.

Kamiyama M,Shibamoto T(June 2012).Flavonoides with potent antioxidant activity found in young green barley leaves. *Journal of Agricultural and Food Chemistry*.60 (25):6260-7 doi:10.1021/jf301700j.PMID 22681491

Kelea Kena, Tadesse Yohannes and Tesfa Bogale. 1993. Influence of fertilizer and its related management practices on maize grain yield in major maize producing areas of Ethiopia *In* Tolessa Ransom J.K.(eds.). Proceeding of the first national workshop of Ethiopia, EIAR/CIMMYT, Addis Ababa, Ethiopia.

Ketema Nugusie and Mulatu Kassaye. 2018. Response of Food Barley (*Hordeum vulgare* L.) Varieties to Rates of Nitrogen Fertilizer in Limo District, Hadiya Zone, Southern Ethiopia. *Journal of Natural Sciences Research*, 8: 17-31

Khan M.S.I., Roy S.S. and Pall K.K., 2010. Nitrogen and phosphorus efficiency on the growth and yield attributes of capsicum. *Academic journal of plant Sciences* 3(2): 71-78.

Khan, M.J., M. H. Khan, and R. A. Khattak. (2006). Response of Maize to different levels of Sulfur. *Soil Sci and Plant Anal*, 37:41-51.

Klikocka, H.,Cybulska M., Barczak B., Narolski B., Szostak B., Kobiałka A., Nowak A., and Wojcik. E. (2016). The effect of Sulfur and nitrogen fertilization on grain yield and technological quality of spring wheat Plant Soil Environ. *Journal of Natural Science Research*.7 (1):31-47

Laghari, G.M., Oad, F.C., Tunio, S.D., Gandahi, A.W., Siddiqui, M.H., Jagirani, A.W. and Oad, S.M. 2010. Growth yield and nutrient uptake of various wheat cultivars under different fertilizer regimes. *Sarhad Journal of Agriculture*. 26(4): 489-497.

Lake Mekonnen and Bezabih W/Kiros, 2018.Response of Food Barley (Hordeum Vulgare L.) to Various Levels of P Fertilizer. *International Journal of Research in Agriculture and Forestry*. vol. 5, no. 2, pp. 21-26, Lake Mekonnen.2018.Effects of seed and N rate on grain yield and yield components of barley. *Journal of Natural Science Research*, 8(3):10-15

Landon, J. R. 1991. Booker tropical soil manual: *A* Handbook for Soil Survey and Agricultural Land Evaluation in the Tropics and Subtropics. Longman Scientific and Technical, Essex, New York. 474p.

Lapitan NLV, Hess A, Cooper B, Botha AM, Badillo D, Iyer H, Menert M, Close T, Wright L, Hanning G,.2009. Differentially expressed genes during malting and correlation with malting quality phenotypes inbarley (*Hordeum vulgare* L.). *Theoret Appl* Genet. 118:937–952.

Lemlem Aregu, Temesgen Adenew, and Likyelesh Gugsa.2002. To ward farmers participatory research: Attempts and achievements in the central high land of Ethiopia. Proceeding of client-oriented research evaluation work shop, 16-18 October 2001. Holetta Agricultural research Center, Holetta, Ethiopia.

Malakouti, M.J. (2000). Balanced nutrition of wheat: approach towards self-sufficiency and enhancement of national health. “A compilation of papers”. Ministry of Agriculture, Karaj, Iran. 544 pp.

Malhi S. S. and Brandt S. A., 2014. Importance of Balanced/Appropriate Fertilization on Crop Martin-Rejano, E.M., Camacho-Cristobal, J.J., Herrera-Rodriguez, M.B., Rexach, J., Navarro-Gochicoa, M.T. and Gonza lez-Fontes, A. 2011. Auxin and ethylene are involved in the responses of root system architecture to low boron supply in Arabidopsis seedlings. *Physiology Plantarum,* 142:170 -180.

Marshner, P. 2012. Mineral Nutrition of Higher Plants, third edition. London, UK: Academic.

Masresha Mitiku (2014) Response of Maize (Zea mays L.) to Application of Mineral nitrogen fertilizer in Tigray, Northern Ethiopia, a thesis (M.Sc.), The School of Graduate Studies, Alemaya University, and Ethiopia, pp: 45.

Mather D, Tinker N, LaBerge D, Edney M, Jones B, Rossnagel B, Falk D. 1997. Regions of the genome that affect grain and malt quality in a North American two-row barley cross. Crop Sci. 37:544−554.

Mekonnen Asrat. 2005. Response and uptake of barley (Hordeum irregulare *L*.) to different rates of Orga-P And nitrogen fertilizers on *Nitisols* of Gozamin District, Ethiopia. MSc Thesis, Haramaya University, Ethiopia.

Melesse Harfe. 2017. Response of bread wheat (*Triticum aestivum* L.) varieties to N and P fertilizer rates in Ofla district, Southern Tigray, Ethiopia. *African Journal of Agricultural*, 12(19):1646-1660.

Melkamu H, Gashaw M, Wassie H (2019) Effects of different blended fertilizers on yield and yield components of food barley (hordeum vulgare l.) on nitisols at hulla district, southern Ethiopia. Academic Ethiopia: Acad. Res. *J. Agri. Sci. Res*. 7(1): 49-56.

Melle Tilahun, Asfaw Azanaw and Getachew Tilahun. 2015. Participatory evaluation and promotion of improved food barley varieties in the highlands of north western Ethiopia. Wudpecker *Journal of Agricultural Research,* 4(3): 050 – 053.

Mesfin Kassa and Zemach Sors, 2015. Effect of Nitrogen and Phosphorus Fertilizer Rates on Yield and Yield Components of Barley (*Hordeum Vugarae L.*) Varieties at Damot Gale

District, Wolaita Zone, Ethiopia. *American Journal of Agriculture and Forestry*. 3(6): 271-275.

Miller,R.W. and R.L. Donahue. (1997). Soil in Our Environment. 7th(ed) Prentice Hall Inc. New Jersey, USA.649p.

Minale Liben, Alemayehu Assefa and Tilahun Tadesse, 2011. Grain yield and malting quality of barley in relation to nitrogen application at mid- and high altitude in Northwest Ethiopia. *Journal of Science and Development*, 1(1): 75-88.

Ministry of Agriculture (MoA) and Agricultural Transformation Agency (ATA). to NPK fertilizer. *Sci Int* (Lahore) 24(2): 185-189.

Mohammed H, Legesse G. 2003.Overview of malt barley production and marketing in Arsi. Proceedings of the workshop on constraints and prospects of malt barley, production, supply and marketing; 2003 Mar 15. Asella: Asella Malt Factory and Industrial Projects Service, p. 1–25.

Muhammad T, Asefa T, Tajamol H, Wasoya A (2009) Yield response of wheat to Boron application. *Pak J Life Soc Sci* 7(1): 39-42

Muluken Bantayehu, 2013: report on malting barley genotypes under diverse agro ecologies of North western ethiopia:adet *agricultural research center*, bahirdar, ethiopia.

Naceur A.B., hamed H.C., Jaime A., Silva T., Abdelly c., Naceur M.b. (2017). The response of two naked barley varieties (*Hordeum vulgare* L.) to four phosphorus fertilizer levels. Journal of Agricultural and Crop Research. 5(2):17-24.

Nakano H., Satoshi Morita & Osamu Kusuda. 2008. Effect of Nitrogen Application Rate and Timing on Grain Yield and Protein Content of the Bread Wheat Cultivar ‘Minaminokaori’ in Southwestern Japan, *Plant Production Science*, 11(1): 151-157

Nandwa S.M. 2003. Perspectives on Soil Fertility in Africa. *In*: Gichuru M.P., Bationo A.,Bekunda M.A., Goma H.C., Mafongonya P.L., Mugendi D.N., Murwira H.M., Nandwa S.M., Nyathi P., and Swift M.J. (eds). *Soil fertility management in Africa: A regional perspective*. Academy Science Publishers (ASP) and Trop. *Soil Biol. And Fert.* (TSBF) of *CIAT*, Nairobi, Kenya.

Nelson, D.W. and L.E. Sommers.1973. Determination of total nitrogen in plant material. *Agro. J.*, 65:109-112.

Noori M., Adibian M., Sobhkhizi A., Eyidozehi K. (2014). Effect of phosphorus fertilizer and mycorrhiza on protein percent, dry weight, weight of 1000 grain in wheat. Int. J. Plant, Anim. Environ. Sci. 4(2):561-564.

Olsen, S. R., Cole, C.W., Watanabe, F.S. and Dean, L.A. 1954. Estimation of available phosphorous in soils by extraction with sodium bicarbonate. *Soil Science,* 96: 308-312.

Onasanya, R.O.,O.P. Aiyelari, A. Onasanya, F.E. Nwilene and O.O. Oyelakin.2009.Effect of different levels of nitrogen and phosphorus fertilizers on the growth , yield of maize (*Zea mays L.*) in Southwest Nigeria. *Institutes Journal of Agricultural Research*, 5:193-203.

Ottman MJ (2009). Response of wheat and barley varieties to phosphorus fertilizer. University of Arizona, USA.

Prasad, S. 2017. Effect of sowing time and nutrient management on growth and yield of heat tolerant varieties of wheat. College of Agriculture, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, PhD. Thesis.

Prystupa P., G. Slafer, A. Savin (2004). Leaf appearance, tillering and their coordination in response to NxP fertilization in barley. Springer, Netherlands.

Rashid, A., Khan, U.K. and Khan, D.J. 2007. Comparative effect of varieties and fertilizer levels on barley (*Hordeum vulgare* L). *Pakistan Journal of Soil Science*, 1: 1-13.

Reguera, M., Wimmer, M., Bustos, P., Goldbach, HE., Bolanos, L. and Bonilla, I. 2010. Ligands of boron in Pisum sativum nodules are involved in regulation of oxygen concentration and rhizobial infection. *Plant Cell Environment*, 33(6):1039–1048.

Rick Graham, Ian Menz, Nick Moody and Neroli Graham, 2014. Western Australian malting barley varietal recommendations.

Saeed, B., Gul, H., Zaman, K .A. and Parveen, L. 2012. Growth factors and straw yield of wheat cultivars in relation with nitrogen and sulfur fertilization. Asian Research Publishing Network (ARPN). *Journal of Agricultural and Biological Science*, 7(1): 1103-1109.

Sanchez, P.A. and Jama, B.A. 2002. Soil Fertility Replenishment Takes Off in East and Southern Africa. In Vanlauwe,B., Diels,J. Sanginga, N. and Merckx, R. (eds.), *Integrated Plant Nutrient Management in Sub-Saharan*, CAB International, Wallingford.

Shahidur Rashid, Gashaw Abate, Solomon Lemma, James Warner, Leulsegged Kasa and Nicholas Minot. 2015. Barley value chain in Ethiopia: Research for Ethiopia's agriculture policy (reap): *Analytical Support for the Agricultural Transformation Agency*.

Shahraki, H., Mobasser, H.R., and Ganjali, H.R. 2017. Effect of nitrogen fertilizer and mycorrhizal fungi on yield and yield component of wheat. *International Journal of Agriculture and Biosciences,* 6 : 21-24.

Sharma D.2015. Effect of Sulphur on Growth, Yield and Economic of Potato Cultivar. *Annals of Plant and Soil Research,* 17 (1): 45-49.

Shiferaw Temeteme. 2017.Investgation of hybrid maize (*zea may L.*) response to different rates of N and P fertilizers on nitiosols at yeki woreda Msc thesis submitted to the faculty of the department of plant science, school of graduated studies and Haramaya university Ethiopia.

Shuaib K, Muhammad A, Anjum MA, Ahmad S, Ghulam A, et al. (2009) Effect of phosphorus on the yield and yield components of wheat variety under rain fed conditions. Sarhad *J Agri* 25(1): 21-24.

Simson S. P. and Straus M. C., 2010. Basics of Horticulture. Oxford Book Company.

Sinebo, W., Gretzmacher, R. and Edelbauer, A. 2003. Environment of selection for grain yield in low fertilizer input barley. *Field Crops Research*. 74 (3-4): 151-162.

Sisie S.A., Mirshekari B (2011). Effect of phosphorus fertilization and seed bio fertilization on harvest index and phosphorus use efficiency of wheat cultivars. J. Food Agric. Environ. 9(2):388-391.

Sofonyas Dargie .2016. Response of bread wheat (*Triticum Aestivum* L.) to application of slow releasing nitrogen fertilizer in Tigray, Northern Ethiopia, a thesis (M.Sc.), The School of Graduate Studies, Alemaya University, and Ethiopia, pp: 45.

Sud, K.C. and Sharma R.C. 2002. Sulphur Needs of Potato under Rainfed Conditions in Shimla Hills. In: Potato Global Research and Development, Paul Khurana, S.M.,

Tadesse K. 2011. Malting barley marketing and malt production from barley in Ethiopia. pp.327-337. In: Mulatu, B. and Grando, S. (eds.) Barley Research and Development in Ethiopia. Proceedings of the 2nd National Barley Research and Development Review Workshop. 28-30 November 2006, HARC, Holetta, Ethiopia. ICARDA, PO Box5466, Aleppo, Syria. pp xiv + 391.

Tahir, M., Tanveer, A., Shah, T., HFiaz. N. and Wasaya, A. 2009. Yield response of wheat (*Triticum aestivum* L.) to boron application at different growth stages. *Pakistan Journal Life Social Sci*ence, 7(1): 39-42.

Tantawy, E. and E.M. El-Beik and A.K. El-Beik, 2009. Relationship between growth, yield and torability of onion (*Allium cepa* L.) with fertilization of nitrogen, Sulphur and copper under calcareous soil conditions. *Research Journal of Agriculture and Biological Science,* 5:361-371.

Taye Bekele, Yeshanew Ashagrie, Balesh Tulema, Girma Gebrekidan (1996). Soil fertility management in barely. In: Hailu and Joop van Leur (eds). Barely research in Ethiopia: past work and future prospects. Proceedings of the first barely research review workshop, 16-19 October 1993, Addis Ababa: IAR/ICARDA, Addis Ababa, Ethiopia. pp. 92-99

Tayebeh A, Abbas A, Seyed AK .2011. Wheat yield and grain protein response to nitrogen amount and timing. *AJCS* 5(3): 330-336.

Tekalign Mamo. 1991. Soil, Plant, Water, Fertilizer, Animal Manure and Compost Analysis Manual. Plant Science Division Working Document 13, *ILCA*, Addis Ababa, Ethiopia.

Tisdale, S. L., Nelson, W., Beaton, J. D. and Havlin, J. L.1995. *Soil fertility and fertilizers. 5th edition*. Macmillan, New York.

Tisdale, Samuel, Nelson., WL, Beaton, JD. and Havlin, JL, 2002. Fundamental of fertilizer application. *In*: *Soil fertility and fertilizers 5th edition*. Pp 462-508.

Tolessa Debelle, Tesfa Bogale, Wakene Negassa, Tenaw Worayenu, Minale Liben, Tewoddros Mesfin, Burtukan Mekonen and Waga Mazeengia, 2002. A Review of Fertilizer Management Research on Maize in Ethiopia. *In* Mandefro Nigussie, Tanner, D. and Twumasi-Afriyie S. (Eds.), 2002. *Enhancing the Contribution of Maize to Food Security in Ethiopia, Proceeding of the 2nd National maize workshop Ethiopia 12-16 November 2001. Addis Ababa, Ethiopia*. Addis Ababa, Ethiopia: Ethiopian Agricultural Research Organization (EARO) and International Maize and Wheat Improvement Center (CIMMYT). 46-54p.

Turk MA, Tawaha AM, Taifour H, Al-Ghzawi A, Musallam IW, Maghaireh GA and Al-Omari Y (2003). Two row barley response to plant density, date of seeding, rate and application of phosphorus in absence of moisture stress. Asian J. Plant Sci. 2(2):180-183.

Uchida R. 2000. Essential nutrients for plant growth: nutrient functions and deficiency symptoms. Plant nutrient management in Hawaii's *Soils,* 31-55.

USDA (United States Department of Agriculture). 2018. Ethiopia Grain and Feed Annual Report Global Agricultural Information Network (grain) Report ET-1503.

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

Walker K., Booth E.J. 1994. Sulphur deficiency in Scotland and the effects of Sulphur Supplementation on yield and quality of oilseed rape. *Norway Journa Agricultural Science Supply,* 15: 97-104.

Walkley, A.J. and Black, I.A.1934. Estimation of soil organic carbon by the chromic acid titration method*. Soil Sci*., 37: 29-38.

Wiedenhoeft AC (2006) The Green world: Plant Nutrition. Chelsea house publisher, NY, USA.

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

Woubshet D., Selamyihun K. and Cherukuri V. (2017). Effect of integrated use of lime, blended fertilizer, and compost on productivity, nutrient removal and economics of barley (*Hordeum vulgare* L.) on acid soils of high lands in West Showa Zone of Ethiopia. *Int. J. of Life Sciences*, 2017, Vol. 5 (3): 311-322.

Zebrath, B.J. and Sheard, R.W. 1992. Influence of rate and timing of nitrogen fertilization on yield and quality of hard red winter wheat in Ontario. *Canadian Journal of Plant Science*, 72:13-19.

Zohary D, Hopf M (2000). Domestication of Plants in the Old World: The Origin and Spread ofCultivated Plants in West Asia, Europe, and the Nile Valley (3rd Ed.). *Oxford University Press*. pp. 59–69. ISBN 978-0-19-850357-6.

7. APPENDICES

Appendix A: Lists of Appendix in Tables

Appendix Table 1. List of treatments and elemental compositions of the treatment

Treatment	Description	N	P_2O_5	S	B
T1	Control (0 kg NPSB ha^{-1} , 0 kg N ha^{-1})	0	0	0	0
T2	50 kg NPSB ha^{-1} + 0 kg N ha^{-1}	9.45	18.85	3.47	0.05
T3	100 kg NPSB ha^{-1} + 0 kg N ha^{-1}	18.9	37.7	6.95	0.1
T4	150 kg NPSB ha^{-1} + 0 kg N ha^{-1}	28.35	56.55	10.4	0.15
T5	0 kg NPSB ha^{-1} ,23 kg N ha^{-1}	23	0	0	0
T6	50 kg NPSB ha^{-1} + 23 kg N ha^{-1}	32.5	18.85	3.47	0.05
T7	100 kg NPSB ha^{-1} + 23 kg N ha^{-1}	42	37.7	6.95	0.1
T8	150 kg NPSB ha^{-1} + 23 kg N ha^{-1}	51.3	56.55	10.4	0.15
T9	0 kg NPSB ha^{-1} ,46 kg N ha^{-1}	46	0	0	0
T10	50 kg NPSB ha^{-1} + 46 kg N ha^{-1}	55.5	18.85	3.47	0.05
T11	100 kg NPSB ha^{-1} + 46 kg N ha^{-1}	65	37.7	6.95	0.1
T12	150 kg NPSB ha^{-1} + 46 kg N ha^{-1}	74.3	56.55	10.4	0.15
T13	0 kg NPSB ha-1 ,69 kg N ha-1	69	0	0	0
T14	50 kg NPSB ha^{-1} + 69 kg N ha^{-1}	78.4	18.85	3.47	0.05
T15	100 kg NPSB ha^{-1} + 69 kg N ha^{-1}	88	37.7	6.95	0.1
T16	150 kg NPSB ha^{-1} + 69 kg N ha^{-1}	97.35	56.55	10.4	0.15

Appendix Table 2. Description of variety Holker

Year of release	1979
Altitude	2500-3000
Maturity days	139-145
Yield on research site	2400-3100 kg/ha-1
Yield on farmers site	1800-2500 kg/ha-1
Seed rate	125-150 kg/ha-1
Seed germination	91%

Appendix Table 3. Mean square values of phenology and Growth related traits of malt barley as influenced by blended NPSB and N fertilizers rate.

		Mean Square			
Source of vibration	DF	Days to heading	Days to maturity	Plant Height	Spike Length
Replication	2	4.937	0.083	168.477	2.543
NPSB rate	3	22.798^{**}	29.020^{**}	144.863^{*}	0.134^{ns}
Nitrogen rates	3	4.576^{*}	5.743^{*}	235.039^{*}	0.627^{*}
NPSB*N	9	8.780^{**}	11.909^{**}	87.256^{ns}	0.167^{ns}
Error	30	1.093	3.461	70.780	0.189
CV(%)		1.29	1.36	9.70	5.91

NS= Non-significant; * significantly different at 5% and **, significantly different at 1%; CV = coefficient of variation.

Appendix Table 4. Mean square values of yield and yield related traits of malt barley as influenced by blended NPSB and N fertilizers rate.

		Mean Square			
Source of vibration	DF	Number of spikelet/spike	Number of tiller per plant	Number of Effective tiller	Number of kernel/spike
Replication	2	2.885	6.532	2.910	21.713
NPSB rate	3	1.482^{ns}	0.936^{ns}	1.778^{*}	2.791^{ns}
Nitrogen rates	3	6.674^{**}	2.138^{*}	1.310^{ns}	5.552^{ns}
NPSB*N	9	1.119^{ns}	0.957^{ns}	0.715^{ns}	3.932^{ns}
Error	30	1.106	1.440	0.958	5.03
CV(%)		8.21	6.34	9.20	9.97

NS= Non-significant; * significantly different at 5% and **, significantly different at 1%; CV = coefficient of variation.

Appendix Table 5. Mean square values of yield and yield related traits of malt barley as influenced by blended NPSB and N fertilizers rate.

		Mean Square			
Source of vibration	DF	Aboveground biomass	Harvest index	Thousands kernel weight	Grain yield
Replication	2	413572	52.001	8.578	49994
NPSB rate	3	3598731^{*}	106.334^{ns}	17.867^{ns}	122416^{*}
Nitrogen rates	3	1532874^{ns}	88.095^{ns}	68.967^{**}	318982^{**}
NPSB*N	9	2098334^{ns}	42.545^{ns}	169.960^{**}	106018^{**}
Error	30	1237484	92.481	6.926	32997
CV(%)		29.2	3.6	9.70	5.91

NS= Non-significant; * significantly different at 5% and **, significantly different at 1%; CV = coefficient of variation.

Appendix Table 6. Mean square values of Quality parameters of malt barley as influenced by blended NPSB and N fertilizers rates.

		Mean Square	
Source of vibration	DF	Hectoliter weight	Protein content
Replication	2	4.062	52.001
NPSB rate	3	24.979**	106.334ns
Nitrogen rates	3	266.195**	88.095**
NPSB*N	9	7.477**	42.545ns
Error	30	0.708	92.481
CV(%)		1.35	3.6

NS= Non-significant; * significantly different at 5% and **, significantly different at 1%; CV = coefficient of variation.

Appendix B: Lists of Appendix in Figures

Figure 1. Layout preparation of the experimental field.

Figure 2. Filed performance of a trial at 45 days after planting (on the application of urea).

Figure 3. Evaluation of field management and performance of a trial.

Figure 4. Sample collection, harvesting and Preparation under field condition.

BIOGRAPHICAL SKETCH

The author was born on August 19, 1990 at Wonji, district in East Showa Zone, oromiya National Regional State, Ethiopia. He attended his Elementary School education at Wonji number one school, and completed his junior and high school at Wonji Secondary and Comprehensive Preparatory School. After passing the Ethiopian Higher Education Entrance Examination, he joined Arba Minch University, School of Agriculture in 2009 and graduated with B.Sc. degree in Plant Science on June 30, 2011 G.C. In December 2011, he was employed at Bule woreda Office of Agriculture and served up to December. In January 2016, he joined Ethiopia Commodity Exchange (ECX).

In September 2017, the author joined the graduate program of Hawassa University to pursue his M.Sc. study in Agronomy.