GROWTH AND YIELD RESPONSE OF FOOD BARLEY (*Hordeum vulgar* L.) VARIETIES TO NPSB BLENDED FERTILIZER RATES AT ENDEGAGN WOREDA OF GURAGE ZONE SOUTHERN ETHIOPIA

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WOLKITE UNIVERSITY, WOLKITE, ETHIOPIA

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This is to certify that the thesis entitled **"Growth and Yield Response of Food Barley (***Hordeum vulgar* L**.) Varieties to NPSB Fertilizer Rates at Endegang Woreda of Gurage Zone Southern Ethiopia",** submitted in partial fulfillment of the requirements for the degree of Masters of Science in **Agronomy,** Department of Plant Science, College of Agriculture and Natural Resource, Wolkite University and is a record of original research carried out by Firew Belete Melise, under our supervision, and no part of the thesis has been submitted for any other degree or diploma. Therefore, we recommend that the student has fulfilled the requirements and hence hereby can submit the thesis to the department.

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Stamp of SGS

DEDICATION

I dedicate this thesis to my beloved wife Mesert Erbalo and all my lovely family for the all smoothed and unrestricted support rendered to me for the betterment of my life.

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First, I would like to thank God, who helped me in each aspect of my life giving me strength and wisdom including this thesis work.

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STATEMENT OF THE AUTHOR

By my signature under, I announce and affirm that this thesis work is my own work. I have followed all ethical and technical values of scholarship in the preparation, data collection and data analysis compilation of this thesis. Every scholarly matter that is incorporated in the thesis has been given all the way through citation.

This Thesis is submitted in partial fulfillment of the requirements for a Master of Science degree in Agronomy at Wolkite University. The thesis is deposited in Wolkite University library and is ready accessible to borrowers under the rules and regulation of the library. I seriously declare that thesis has not been submitted to any other institution anywhere for the reward of any academic degree or diploma.

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BIOGRAPHICAL SKECH

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LIST OF ABBREVATION AND ACRONOMY

ANOVA	Analyses of variance
ATA	Agricultural Transformation Agency
CSA	Central Statistical Agency
ETB	Ethiopian Birr
EATA	Ethiopia Agricultural Transformation Agency
EWAOAR	Enedegang Woreda Agricultural office annual report
FAO	Food and Agricultural organization
FTC	Farmer Training center
GFB	Gross field benefits
HARC	Holletta Agricultural Research Center
ICARDA	International Center for Agricultural Research in the Dry Areas
LSD	Least significance difference
M.a.s.l.	Meter above sea level
MOA	Minister of Agriculture
MRR	Marginal rate of return
OC	Organic Carbon
NPSB	Nitrogen, Phosphorus, Sulfur, Boron
RCBD	Random Complete Block Design
SAS	Statically analysis' system
SNNPRs	South, Nation, Nationality, people, Regional, state
WARC	Werabe Agricultural Research Center
USDA	United States Department of Agriculture

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Growth and Yield Response of Food Barley *(Hordeum Vulgar L.)* Varieties to NPSB Blended Fertilizer Rates at Endegang Woreda of Gurage Zone Southern Ethiopia.

Firew Belete (B.Sc.), Wolkite University, Ethiopia

ABSTRACT

Barley is one of the major cereal crops grown in Ethiopia. Due to lack of improved varieties and lack of site specific recommended NPSB fertilizer rates its productivity is lower at Endegagn District. A field experiment was conducted in 2022 main cropping season at Endagagn District to evaluate the effect of NPSB fertilizer rate on yield and yield components of food barley varieties. *Factorial combinations of four NPSB fertilizer rates* (0, 50, 100 and 150 kg ha^{-1}) and four varieties of food barley (HB1307, HB1966, Cross41/98 and local variety) *were laid out in randomized complete block design with three replications. Data was collected on growth and yield and yield components Data were analyzed using SAS (version 9.3).Treatments mean were compared us LSD at 5% level probability. The result showed that NPSB blended fertilizer levels and varieties were significantly affected majority of the parameters. The highest day's to 50% heading (107) was recorded due to the use of 150kg of NPSBha^{-1} for variety HB1966. The highest days to physiological maturity (139), plant height (128) and lodging percent (14.2%)were recorded due to application 150kg of NPSBha^{-1} for variety HB1966 while the highest spike length(8.2),total number of tiller(12),number of kernel per spike (70), above ground dry biomass(15502kgha^{-1}) , grain yield (57933 kgha^{-1}) and harvest index (37.9%) were recorded due to the application of 150 kgha^{-1} NPSB blended fertilizer with variety cross41/98. Net benefit of 156,397.3birrha^{-1} was provided from the treatments combination of 150kgha^{-1} blended NPSB fertilizer levels with cross41/98. Based on the result of this research use of 150kgha-^{1} blended NPSB fertilizer rate on cross41/98 variety gave highest grain yield and maximum net benefit in the study area. At the conclusion the result obtained from the study was show that, the interaction effect of NPB fertilizer rates and varieties was highly significantly influence on number of number of kernel per spike, a above ground dry biomass, harvest index, plant height and total number of tiller significantly effect on grain yield Therefore, farmers in the study area and areas with similar agro ecology and soil category can be advised to apply cross41/98 variety with 150 kgha^{-1} blended NPSB fertilizer to enhance the production, and productivity of food barley. However, to get better conclusive result and sound full recommendation the experiment has to be done across location and season.*

Key words: food barley, blended NPSB fertilizer varieties and yield

1. INTRODUCTION

Barley (*Hordeum vulgare L.*) is one of the most important cereal crops produced in the world and it is one of the most ancient cereal crop and has played major function in the development of agriculture in the world (Alnarp,2013). It is a useful grain crop in Ethiopia (Muluken, 2013). Ethiopia is the second leading producer of barley in Africa, following Morocco, covering for regarding 25% of the entire barley production in the continent (FAO, 2014) In Ethiopia, area coverage and total production of barley during 2020/21 cropping season was about 926,106.90 ha and 23391098.80 quintals (CSA, 2021).

Balanced fertilization is the solution to sustainable barley production and maintenance of soil health. For the last five decades Ethiopian farming based on imported fertilizer products; solely urea and DAP as source of N and P, accordingly but currently, it is recognized that the production of most cereal crops can be limited by lack of S and other nutrients (Assefa *et al*, 2015). Most Ethiopian farmers have been applied different levels of fertilizers. Yet the blanket recommendation of urea and DAP were 100 $kgha^{-1}$, which farmer in most parts of Ethiopia including study area were applying without considering soil fertility status (ATA, 2013). This fertilizers (urea and DAP) only including N and P that may not enough for the nutrient supply of crops, which decline yield and yield components of food barley in Ethiopia. In order to solve these constraints the Ministry of Agriculture of Ethiopia introduced a new in-organic fertilizer (NPSB) including nitrogen, phosphorous, sulfur and born (MoANR, 2013). However, lack of site specific and optimum soil fertilization are among the most important bottlenecks for production of barley in Ethiopia (Chala and Tesfaye, 2017).

Despite its wide spread cultivation and uses, average yield of the crop in the country under farmer's condition is 2.56t ha^{-1} (CSA, 2021), area coverage and productivity of barley in the study area 358ha and 8572 quintal and productivity 2.4tone ha^{-1} which is far below the average potential yield under improved management conditions (6 t ha^{-1}) (Habtamu *et al*., 2014). Low soil fertility, lack of nutrient supply, and shortage of improved varieties are causes for the yield gap among others. Moreover, in study area soil acidity, poor soil

fertility, lack of improved varieties, pests and poor management system are the main challenges for barley production (ICARDA, 2008). Moreover, as per soil fertility map of SNNPRS which was developed by (ATA,2016), most soils in the study area (Endegagn district) are categorized under strong to moderate acidity with a deficiency of both macro (N, P and S) and micro (Zn and Bo) nutrients that contradict the requirement of the crop. Hence there is a need for both site and crop specific fertilizer recommendation to suitable varieties to improve productivity of barley for small-scale farmers residing in the study area. There is no specified variety for high productivity and there is no site specific fertilizer application used for barley production.

Information on the use of blended fertilizer (NPSB) rate particularly for released food barley varieties is scanty in the study area. But, to improve food barley productivity and grain yield, it is important to decide the optimal blended NPSB fertilizer levels for the study area. The production of barley in the study area under main cropping season is well known; since there is high demand grain for food, income generation and straw for animal feeds. Barley yield is low in Endegagn district because most of the farmers in the study area with respect to barley production is thus farmers in study area produced barley with low productivity compare with its potential to minimized these gap research is necessarily. (EWAO, 2022). Therefore, this research was implemented with the following objectives

Major Objective

- ✓ To evaluate the effect of NPSB fertilizer rate on yield and yield components of food barley and recommend economically optimum rate for the study area.

Specific objectives

- ✓ To determine effect of NPSB rates on yield and yield components of food barley
- ✓ To determine effect of varieties on yield and yield components of barley.
- ✓ To investigate the interaction effect of NPSB fertilizer and varieties on barley yield.
- ✓ To determine economic feasibility rates of NPSB fertilizer yield of barely varieties

2. LITERATURE REVIEW

2.1.Description of Barley

2.1.1. Origin and Distribution of barley

Barley belongs to the genus (*Hordeum vulgare* L. the clan Triticale of the family Phocaea. Barley grains found at archaeological sites in the Fertile Crescent show that about 10,000 years ago the crop was domesticated there from its wild virtual Hordeum spontaneous (B adr *et al*, 2000). It was maybe originated from Asia and Ethiopia with centers of diversity that means north-east Africa and Mountainous regions of Abyssinia and south-east Asia, China and Japan contiguous regions of Tibet. Occidental types are attributing's by broad empty glumes two rows with empty spikelets, pubescent palea and coloured stem. Oriental types are attributes by naked or hooded barley with struggle to some races of mildew and possess extreme earliness or lateness (Ahlawat, 2012). Barley is attention to have originated in the fertile form that is rounded broad at the center and tip at two ends area of the Near East from the wild progenitor Hordeum natural.

2.1.2 Environmental and Agronomic Requirements of Barley

Barley is a crop of cool climate and can also be grown effectively in tropical and sub-tropical region. There are winters and spring types of barley. Winter types need verbalization for completion of the life sequence (Ahlawat, 2012). It can grow from near sea level to an elevation up to 4500 meter above sea level. It achieves better in areas of relatively high rain fall, low relatively humidity and cool temperature at maturity A mean daily temperature of 12-15^{0}c and 30^{0}c during growth and ripening stage respectively are better for barley production (Ahlawat, 2012). Generally, barley is cool season crop that will yield the better under conditions in which the vegetative and early reproductive growth coincide with moderate temperature (Oser, 2015). It can grow under rain fed and drought prone conditions. A well distributed 200-250mm rainfall can support barley crop , but, the crop does better with 400-500mm annual rain fall. Barley being along day plant would prefer a photoperiod of 10-12 and 12-14 hours during vegetative and reproductive phase

respectively (Ahlawat, 2012). Ethiopia is considered as a center of diversity for barley, it can be refined at altitudes between 1500 and 3500m, but the mainly appropriate areas for the crop are those with altitudes ranging up to 2200 to 3000m.a.s.l (Lakew *et al*, 1996). According to Kaso and Guben (2015), barley is a main food crop for many Ethiopians; mainly for highlanders and it is also talented to grow at all elevation, and cultivated by small holders in every region of Ethiopia. But, it performs better at the maximum elevation in the northern and central regions of the country. It is frequently cultivated in strained area where soil erosion, irregular drought or frostiness limits the capacity to grow other crops (Berhane *et al*, 2005). The crop is grown worldwide with most attention in temperate areas and high altitudes of tropics and sub tropics. The maximum diversity of food barley in expressions of morphological types, genetic races, disease resistance lines and endemic morph types exist in Ethiopia.

2.1.3. Growth and Development of barley

Barley plant is growth and development are influenced by both environmental and genetic factors (Arisnabarreta and Miralles, 2008). A good empathetic of growth and development can help producers implement right management practices and obtain higher yields.

Consideration to plant phenology can help guide the timing of N side dressing to stimulate growth and decrease fertilizer N losses additional, an understanding of the crop growth cycle in a given agro -ecological region can support the producer schedule planting to avoid drought and possible adverse effects of low and high temperatures. Knowledge of growth phases is also useful in arrangement tissue sampling at different locations. In addition to visual morphological

Observations simulations of Phenological development of barley have been developed (Jamieson *et al*, 2006).

Plant growth and development are difficult procedures, based on many factors both internal and external. They can be considered to begin with germination, followed by a large complex series of morphological and physiological events that are called growth and development (Fageria *et al*, 2009).

Growth is also a quantitative aspect of development, expressive an increase in the number and size of cells, and differentiation is the qualitative aspect of development (Fageria *et al*, 2009). It is usually measured in terms of increase in volume or weight of the crop plant or its organ.

2.1.4 Economic use of food barley

Agriculture in country occupied up to 46% of GDP, and 80% of sell abroad earning 80% (EATA, 2013). The global production of barley amounted to about 145.9 million metric tons in the 2021/2022 crop year. Barley is grown as a commercial crop in some one hundred countries world -wide and is the 4^{th} most useful cereal crops next to wheat, rice and maize of the world's total cereals production. Barley is the most useful food crop in the high land area of Ethiopia. It is useful cereal crop grown by survival farmers on small level farmers (Ejigu, 2012). Barley is important in many recipes that have deep roots in traditional and culture. Various recipes like Basso (fine flour of healthy roosted barley grain moistened through water, butter) Chuiko, Genfokolo and Kinch are the majority can made by solely barley with other cereal flours. Surrounded by local beverages, Tella and Borde are prominent, and better prepared from barley grain (Grando, 2005)

Most of the farmers produce barley for many reasons. Among those reasons that make barley use for the farmers are resistance to high altitude, relatively performs better than other crops, good sources of energy and strong barley food gives better body strength, medicinal purposes like gastritis. The food products accumulate better than other crops and

for income generation and good cash crops as it is highly demanded for local beverages made in towns for sale. (Haile and Peter, 2011)

2.1.5 Current status of food Barley Production in Ethiopia

Our country Ethiopia is ranked twenty-first in the world in barley production by distribute of 1.2% of the world total production (USDA, 2014). USDA suggested that assessments of commodity and trade, barley cultivation are broadly disseminated across country on more than 1,000,000 hectares of land and by more than 4,000,000 smallholder farmers. It is high opportunity crop, by vast room for beneficial expansion, mostly when linked by the country commercial brewing and value added industries. Barley is 5^{th} useful cereal crop in Ethiopia after wheat, tef, corn, and sorghum (CSA, 2021).

CSA suggested that Ethiopia area harvested of barley is enhancing between 2010/11 to 2014/15 as a result of the well-organized consumption of inputs such as blended fertilizer rates and use right agronomic practice and used improved varieties. Ethiopia 2^{nd} biggest producer of barley in Africa following to Morocco, accounting for concerning 26% of the total barley production in the continent (Shadidur *et al*,2015). This show, about 4.5 million smallholders grow barley on more than 1,000,000 hectare of land. The overall production has been enhancing progressively more than the past decade. It has raised from 1.1mollion metric tons in 2003/4 to 1.9 million tons in2013/14, which is corresponding to an annualized growth rate of 6% per year. It is cultivated by small holders in every region of Ethiopia, since it is able to grow at all elevations, but it performs best at the higher elevations in the northern and central regions of the country (www.daff.gov.za, 2012).

Barley is grown as a 'meher' (rain season) crop in the higher altitudes of Dega regions. It is grown mainly in Arsi, Bale, Shoa, Welo, Go- jam and Gondar. It is also widely cultivated as a crop in many areas. The annual cultivated area is estimated at 881,680 hectares and production at 999,610 tons, representing 18.7 % of the cultivated area and 18.3 % of the total cereal production. Average yield varies between 10 and 13 quintals per hectare. Barely variety has also play an important role in producing better yield, seed quality and different agro-ecological adaptation. Growing of different barley variety with wider

adaptability and responsive to inputs has opened a new avenue for exploiting higher grain yield potential the identification of high yield responsive varieties is considered to be the first and the most important steep the development of production technology. The yield potentialities of barley varieties are realized extent when they are grown under optimum agro-climatic environment (Singh *et al*, 2009).

This is primarily due to the low yielding ability of farmers' cultivars, which are the principal varieties in use the influence of several biotic and a biotic stresses and the minimal promotion of improved barley production technologies. Several a biotic and biotic factors have involved to this low productivity, such as poor agronomic crop management practices; the use of low yielding cultivars; the inadequate availability of the few maintained cultivars released; diseases, insects and weed; and the inherently low yield potential of the prevalent local varieties (Bayeh and Stefania, 2011).

Barley is grown in different rain-fed agro-ecological zones of Ethiopia characterized with a wide range of climate. In terms of altitude, barley grows well from 1800 to 3000 m.a.s.l. At the highest elevations, it is often the only crop grown that provides food, beverages and other requirements to many millions of people. Barley 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. Over 98% of total area and production of barley is determined in four regions namely: Oromia, Amhara, Tigray, and Southern Nations, Nationalities, and People's Region (SNPPR) while small amount of barley is also produced in the Harari and BenishangulGumz regions.

Food barley is the second useful crop in Endegang followed by wheat and the fourth important crop in area converge followed by wheat, pea and bean. Even though the productivity of food barley is low 2.4 tons per hectare the great potential of barley in highlands of study area. (EWAOAR, 2021)

2.1.6 Challenges and opportunities of barley production in Ethiopia

Agriculture in country occupied up to 46% of GDP, and 80% of sell abroad earning 80% (EATA, 2013). It is one of the useful cereal crops among cultivated in Ethiopia. Low soil fertility, lack of improved varieties, weed competition, insects, and water stress and soil erosion are the most important challenges of barley production in Ethiopia.

The major problems that decline yield of barley in Ethiopia are poor soil fertility, soil pH, insect, diseases, and weed (ICARDA, 2008). Scarcity of soil fertility and soil acidity are the major problem that threatens barley production in Ethiopia. Barley production is constrained by both a biotic and biotic factors such as low soil fertility, weed, diseases, insect pests, poor management practices, in adjustable barley cultivars with durable resistance to diseases, inappropriate sowing patterns, lack of improved variety, rate of fertilizers, climatic condition, sowing time. Among the several factors responsible for low yield in study area, use of unbalanced rate of fertilizers and inappropriate use of variety are important agronomic practice and research on these limiting factors will enhance yield (FAO, 2017).

Some of the problems are in appropriate crop management, lack of improved varieties, barley yellow dwarf virus, net blotch and injury diseases and the little availability of the extremely few improved cultivars released, weed, insect and the inherently low yield potential of the past local varieties (Bayehe and Stefania, 2011). Low –yield capacity of farmers in adequate supply of improved barley seed and varieties adapted to the different production system and different agro- ecological zones. Shortage of appropriate production system biotic stresses like disease, insect pest, weed declined grain yield by 21-67% and 25-34%respectively (Bekele,1983).Barley shoot fly may decline yield by more than 56% and aphids may cause 4% to79% (Haile and Ali 1986) loss even 100% crop failure, a biotic stresses like as poor soil fertility, low soil organic matter. Ethiopia is deliberated as a center of diversity for barley, it can be cultivated at altitudes between 1500 and 3500m, but the most suitable areas for the plant are those with altitudes ranging from 2200 to 3000 m.asl (Lakew *et al*., 1996). According to Kaso and Guben (2015), barley is a main food crop for many Ethiopians, mainly for highlanders and it is also able to grow at all

elevations, and cultivated by small holders in every region of Ethiopia. But, it performs greatest at the higher elevations in the northern and central regions of the country

2.2 Effect of Fertilizer Application on food Barley

Enhancing agricultural productivity is one of the main problems of achieving food safety and poverty decrease in Ethiopia. In sustainable barely production the efficiency of fertilization, could be increased by using variety-specific fertilization diverse works done on Nitrogen use and genetic variation showed that efficient use of N in crop plant requires adequate genetic variability for character that determines N- use efficiency suggested that, because of a negative correlation, the possibility of selecting varieties that exhibit high yielding and high grain N concentration is slight (Arega *et al*, 2013).

Barley variety is one of the most staple food in Ethiopia particularly at low rain fall area, even if barley is used the source of food still to obtained yield is low because farmers cultivated local variety, less resistances of disease and also hybrid lines which released from different research center hadn't been evaluated along wider environment especially at low rain fall area. Testing of different variety of barley at different agro-ecology can increase the yield capacity of barley (Abdi, 2011).

Selection of variety is important and selection is based on different personality such as quality production, bio yield, and the main factor is adaptability to environment (Alam *et al*, 2002). Low yield in our country and in our state is attributing to different factor such as low quality seeds, low yielding varieties, plant protection measures, chemical fertilizers and improper seed rates levels. Different varieties are selected on the basis of different characteristics like disease resistance, quality production and seed production, full of life development and spike length, however no variety contains every one of the qualities or requirement to fulfill the demands. Because different varieties give different result at different location due to it is genetic variation but best choice in selection of varieties is based on higher yields, more tolerance and resistance to unwanted conditions and shorter maturity (Kumar *et al*, 2013).

Application of fertilizer containing N and P began in the late 1960s, producing increase in the yield of many crops (Wassie and Tekalign, 2013) the other macro and micro nutrients do not have given attention due to these unbalanced fertilization and poor nutrient management and decreased crop quality (Sheleme, 2011).Nitrogen is the major nutrient input for achieving higher yield of barley. Barley is very responsive to insufficient nitrogen and very responsive to nitrogen fertilization (Alam *et al*, 2007). Similarly, (Sinebo*et al*. 2003) also reported that about 65% of grain yield variability in barley was characteristics to nitrogen stress. The most useful role of nitrogen in the plant is its presence in the arrangement 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 (Bereket *et al*, 2014) who reported that macro and micro nutrients such as N, P, S and B fertilizers use can raised plant height with increasing amount and combination. (Woubshet *et al*, 2017) who reported that combined used of NPSB fertilizer levels raised grain yield of barley. (Wakene *et al*, 2014). Who reported that number of productive tillers was affected widely by phosphorus fertilizer.

Nitrogen increased leaf area, tiller formation, leaf area index and leaf area duration and this increasing is led to much greater production of dry matter and grain yield (Franklin *et al*, 2017).Among the plant nutrients, nitrogen plays an extremely important role in crop productivity (Worku *et al*,2007). Although careful dose of nitrogen elevates the yield and quality of variety but too much dose causes the economic loss as well as decreased yield and quality of barley varieties. Barley farmers in Ethiopia have not completely adopted modern inputs like fertilizer and modern varieties that help improve production (CSA, 2014).

To supply sulfur commercial fertilizer, DAP is replaced by NPSB. Since, the composition of newly introduced fertilizer differ from that of familiar fertilizer (DAP), the appropriate rate is not determined for barley production in the study area as decline nutrient stage in the soil (Diriba *et al*, 2013). Decline soil fertility decreased crop yield as result increased food insecure people. The barley productivity is problem by poor yield-potential of varieties, diseases, poor soil-fertility, soil acidity, insects, water logging and weeds

It is apparent that still currently, the use of commercial fertilizer in Ethiopia has been agreement with the economy of the farmers mainly since farmers were not using the fertilizers based on soil type and crop requirement at the same time, the yield return from the applied fertilizer was reduced. The reason was blanket application of DAP and Urea was not based on the recommendation of crop requirement, soil nutrient and agro ecological factors (Abreha and Yesuf,2008).which leads either nutrient shortage or toxicity (Ray *et al*,2000).Even though such as using solely NP is, essential nutrients like S,B and K are getting low attention the current studies show that nutrients such as N,P,S and B are becoming shortage symptoms are being observed on major crops in different areas of the country (ATA,2016).

Many studies indicate that elements like N, P, K, S and Zn levels as well as B and Cu are becoming depleted and lack symptoms were being indicated on major crops in diverse areas of the country (ATA, 2013). Several research studies show that most Ethiopian soils are shortage in-macronutrients (N, P, K and S) and micronutrients (Cu, B, and Zn) (EthioSIS, 2014). Macro nutrients as well as micronutrients are of primary importance in our agriculture system but due to unawareness of the farmers about importance of applying micronutrients and unavailability, the soils are becoming deficient in micronutrients (Muhammad *et al*, 2009). Micronutrients are essential for plant growth and play a vital role in increasing crop yields as they develop plant nutrition and increase soil efficiency (Hamzeh and Florin, 2013).

The main macro-nutrients such as nitrogen, sulfur, magnesium and calcium, phosphorus, potassium which are required in large amounts, have to applied if the soil is lack of in one or more than two. The micronutrients are the main substances in plant growth and are comparable with the vitamins in human nutrition their gap of optimal supply is small (FAO, 2009). Blended (NPSB) fertilizers made by physical combing different fertilizer materials to give the requires grade. Each particles remain divide in the combing, and inclined may happen. This challenge can be declined by using materials with similar particle size. The quality of the blended (NPSB) fertilizer particularly inclined each fertilizer materials could be important factor in selecting a fertilizer (Dilipkumar and

Mitalimanual, 2015). Reported that soil in the highlands of Ethiopia usually have low levels of essential plant nutrients and low

2.3.1 Effect of nitrogen fertilizer on food barley

Nitrogen is the majority plentiful mineral nutrient in crops. It constitutes 2-4% of plant dry matter (FAO, 2006). It is main nutrient input for achieving higher yield of food barley. Barley is extremely responsive to insufficient nitrogen and very quick to respond to nitrogen fertilizer. It plays key role in pant biochemistry. Low supply of N has a profound effect on crop growth and may lead to highest loss in grain yield (Ottman, 2009).

Exposed that the use of nitrogen fertilizer significantly adds spike length, number of grains spike per grain volume and grain yield on barley. (Zebarthet *al, 2009*) When plants are shortage in N, they become underdeveloped and yellow in appearance. Nitrogen lack in cereals is attributed by poor till ring and number of spikes per unit area and also the number of grains per spike is decreased (Mengel and Kirkby, 1996). The grains are small, but always relatively high in protein content, due to reduce in the import of carbohydrate in to grains during the later level of the grain filling. Most Ethiopian soils are in nutrients, especially nitrogen and phosphorus and fertilizer application has significantly increased yield of crops (Tekalign *et al,* 2001). Nitrogen nutrition influenced crop potential through its effects on photosynthetic capacity.

Barley was improved with increasing N- fertilization. (Moselhy, 2002) They added appropriate application of nitrogen fertilizer highly increased spike length, number of grains spike per, 1000 grain weight, grain yield and N up take by the crop (Wakene *et al,* 2014).The rate of nitrogen increased the plant height increased with each increment of nitrogen rate from control to the highest rate. the plant height increased with increased N-fertilizer increment of plant height along with increase of N-fertilizer rate might be related to the effect of nitrogen which promotes vegetative growth as other growth factor are in combination.

Melle *et al, (2015*) report that plant height of barley was increased with increasing levels of N-fertilizer. The number of grain per spike are important structural elements for grain yield of cereals means that the N-fertilizer rates increased from 0 to18 and 36kg N per hectare the grain yield was mobilized by 30.7 and 39.8%in that order, show increasing response with increasing N fertilizer rates and also increases in grain yields of barley crop with increasing levels of N-fertilizer (Amare *et al*, 2015).

2.3.2 Effects of Phosphorus fertilizer on food barley

Phosphorus has huge use in plant nutrition. It involves in the processes of power transformation, genetic heritage, and protein synthesis and cell division. In addition to that it is increasing root development and make stronger of seed formation, and crop physiological maturity. Similar to this ease of use of phosphorus in the soil, it is influenced by many factors such as soil reaction and also climatic factors. In contacts of our country phosphorus use as fertilizer is useful in enhancing crop production of barley. Depend on the pervious result of P fertilizer finding the yield and yield mechanism of barley and were increasing with increasing P fertilizer use levels. (Wakene *et al*,2014) reported that request P- fertilizer rate increases plant height as p-rate increases, the plant height linearly increased with increasing levels of phosphorus fertilizer the same to that the biomass of barley very a lot increased with increasing application of phosphorus fertilizer rates the highest rate of phosphorus fertilizer applied to provide highest biomass whereas the low rate of phosphorus fertilizer rate applied to obtained least biomass the same to us grain yield of barley increased with increasing level of phosphorus rate (Wakene *et al*,2014)

Phosphorus is categorized as the 2nd most useful nutrient for crop production .It is known to be included in several biological and physiological processes of plant (Tisdale *et al*, 2002).Phosphorus is an essential nutrient needed by the plant for normal growth in the different agro ecological regions. More than 80% of added p to such soil will be predetermined, and only a part of it get dissolved in the soil solution which may be either taken up by plants or precipitates The output of (Alam *et al*,2007) reported that the plant height necessarily increased with increasing of application levels of phosphorus fertilizer to the soil. They found that 1000 grain amount of barley increased significantly with

increasing P rate function (Rahim *et al,* 2010) and also similar result was shows (Mesfine and Zemach, 2015) reported that application of p fertilizer highly increased the grain yield of barley. One of the most useful yield determinations is the number of spike per meter which is influenced by several factors like balanced nutrition they found that the chlorophyll contents were increased in fertilized soil by the different levels of phosphorus fertilizer use to the soil. Similar results were provided by. (Wakene*et al,* 2014) provided the highest total biomass at the highest p level, used and the lowest biological yield in the controls.

Increase in phosphorus application rate up to 30 $kgha^{-1}$ phosphorus lead to reduction in the number of days required to heading of barley (Dejene *et al*, 2014).The largest days of heading were recorded with control $kgha^{-1}$ whereas minimum days of heading were recorded with highest rate of phosphorus application. The role of phosphorus for plant mobilized plant growth and early maturity of plant became fast. Application of phosphorus rate increased with increasing number of tiller for plant (Amare *et al*, 2015).

2.3.3 Effect of sulfur containing fertilizer on food barley

Sulfur is an important plant nutrient in crop production needed for protein and enzyme synthesis and also it is component of several of the amino acid (Scherer, 2001). It is the largest part important nutrient for plant growth and development Sulfur is an important the second plant nutrient, plays a fundamental function in biosynthesis of major metabolites for improving yield and value of crops and for accruing better yield below reasonable fertilization (Anwar *et al*,2002).Application of S is reasonable strategies to hold back the uptake of toxic elements (Na and Cl) because of the negative relationship its use is significant not only for rising crop production and quality of the produce but also maintained soil situation for healthy crop growth(Zhang *et al*,1999).

The shortage of S in soil is partly exacerbated by the reality that the Ethiopian agriculture mainly attention on the important of high analysis NP fertilizers that include little available S follow up mono cropping only application of organic wastes, and the total removal of crop residues. (Singh, 2006) As result, the lower the organic matter content of the soil the

more likely S lack is to happen. In terms of disease protect foliar application of S increased the effectiveness of fungicide (Zahid and Leitch,2005).Sulfur lack reduced grain size and baking quality because of formation of disulfide bonds formed from the sulfhydryl groups of cysteine. This affects the visco-elasticity of dough.

Melkamu *et al,* (2019), reported that the rates of sulfur fertilizer increased to provide maximum barley yield whereas the low application of S-fertilizer was applied to obtained least yield of barley crop. The plant height increased as increased application of S- increased the maximum plant height obtained from the highest rate of S- per hectare Sulfur is one of the essential nutrients for plant growth and it stored 0.2 to 0.5% in plant tissue on dry matter basis. It is needed in relatively similar amount as that of phosphorus (Ali *et al*, 2002).Sulfur shortage plants have also low struggle under stress situation (Duke and Reisenaue, 1986). The absence of adequate S, crops cannot addressed their full potential in terms of yield .It is needed for synthesis of S including amino acid like cysteine and methionine. Their lack out-put in stunted growth, reduced plant height, tillers spikelet and slow maturity. Sulfur lack plants have also low resistance under stress situation (Doberman and Fairhurst, 2000).Its fertilization supports enhancing the uptake of NPK and Zn in the plant. Due to its positive effect, the efficiency of these elements is enhanced which output in increased crop productivity. Similarly its shortage out come in stunted growth, decline plant height, tillers, and spikelet's and slow maturity. (Eriksen *et al*, 2001).obtained important explanation of S mobility in barley and how S mobility involves with N nutrition.

2.3.4. Effect of boron containing fertilizer on food barley

Boron is one of the mainly crucial micronutrients, also called trace elements, needed for the normal growth of plants (Barker and David, 2007). Plant requires boron nutrient in lower amount than the requirements for all other nutrients not including molybdenum and copper. It is the nonmetal element among the micronutrients and also the only micronutrient present over a wide pH range as a neutral molecule rather than anion (Fageria, 2009)

Plant can absorb boron in the form of H_3BO_3, and it moves to plant root mainly by mass flow and diffusion. Boron is an enzyme activates and is interact in the production of starch needed for the production of cellulose. The essentiality of B for growth and development of higher plants has been earlier demonstrated Boron plays an important role in the movement and metabolism of carbohydrate in the plant, synthesis of plant hormones and nucleic acids, pollen germination, flowering and fruiting, water use, nitrogen assimilation and generative growth of plants. It also functions in lignin formation of cell wall synthesis, cell division, differentiation, membrane functioning, root elongation and salt absorption (Anonymous, 2007).

The most important functions of boron in barley plants are thought to be its structural role in cell wall development and stimulation or inhibition of specific metabolism pathways (Ahmad *et al*, 2013).

2.3.5 Characteristics of improved food barley varieties

Improved variety means plant varieties that have been genetically modified to provide higher yields as well as to increase resistance against diseases, insect pests, drought, parasitic weeds, and other environmental conditions. The main features of improved food barley varieties they offer much higher yields, better quality, more stable production and higher tolerance to diseases(Lakew,2003

3. MATHERIAL AND METHODS

3.1 Description of the Study Area

The experiment was conducted during the main cropping season of, 2022 at Gomira Farmers Training Centre (FTC) site of Endegagn District, Gurage Zone, SNNPR. The experimental site is located 231 km away from Addis Ababa and 240 km from Hawassa and 73 km from Gurage Zone Wolkite at. The area has an altitude of 2603 m.a.s.l and located between geographic coordinates of 37^0 76' 14'' E Longitude and 86^0 21' 12'' N latitude. It receives adequate rain fall in main rainy season from May to September, on the rest of the months receives small amount of rainfall and are entirely dry months.

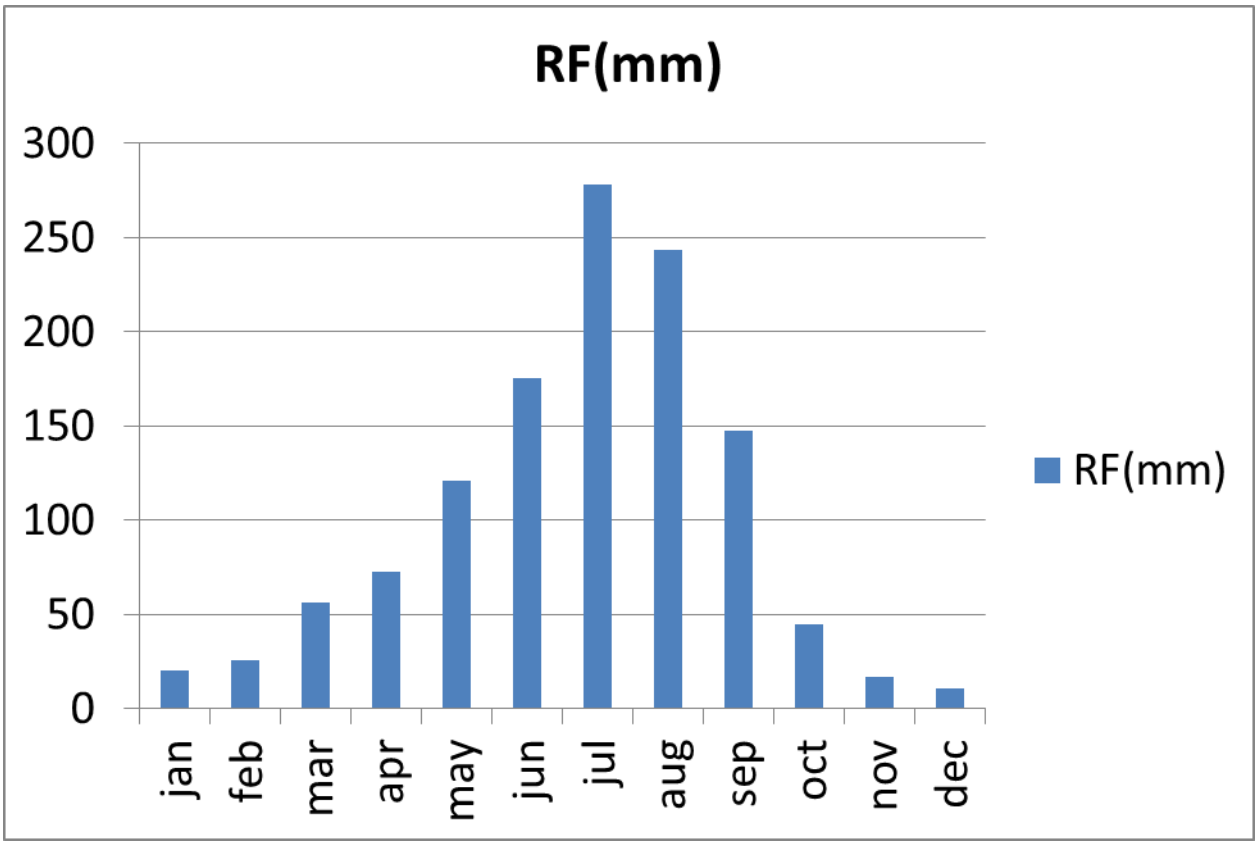


Figure 1 Rainfall (mm) condition of experimental area

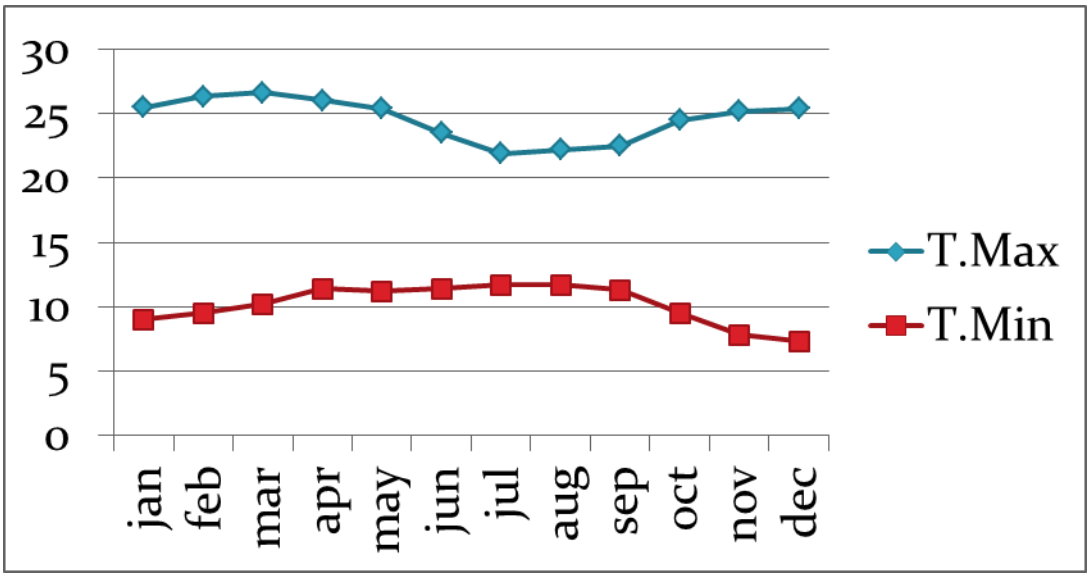


Figure 2 Max and Min Temperature (^{0}c) of experimental area

Dry months with precipitation less than 100mm and applicable for annual crops (FAO, 2006).The rain fall ranges between 1100-1200mm and the annual average minimum and maximum temperatures 12.2 and 24.6 C respectively (EWAOAR, 2022). The District is bordered by Mierabe-Azerint Berbere District at the East, Ameka District at south and Enore-Aner at north and west direction.

The study site is located at 10.5km east of Dinkula capital town of Endegagn District. The soil of the experimental area is categorized as Niti-sol (Semu *et al*, 2022).In study area major dominated crops are wheat, bean, pea, barely, tef (EWAOAR, 2022).

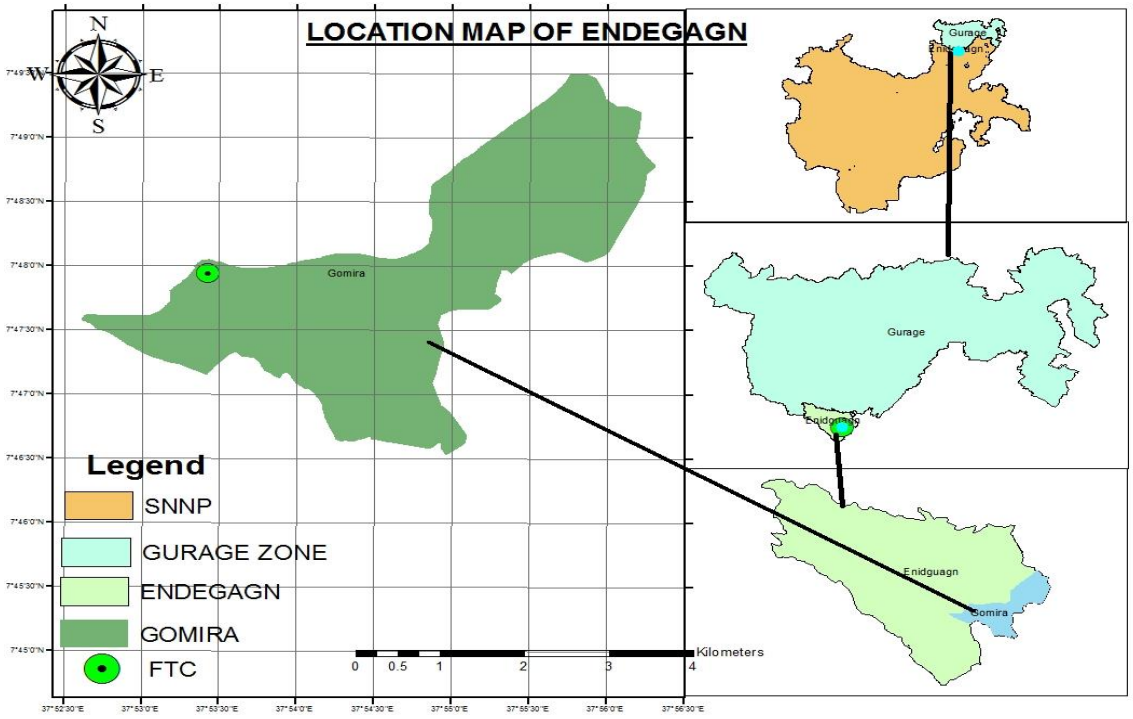


Figure 3 Map showing the study area of Endegagn District, Gurages Zone, South Central Ethiopia.

3.2 Soil Sampling and Analysis

To evaluate the soil fertility status of the study site, a composite soil samples was collected from 10 spots of the experimental site in zigzag pattern before planting, at a depth of 0-30 cm using a soil auger. Then, the samples were dried in the oven and crushed with mortar and allowed to pass through a sieve size of 2 mm, particle size distribution (soil texture), soil pH, Cation Exchange Capacity (CEC) (Cmol)(+)kg), organic carbon (%), available phosphorus[mg/kg(ppm)], total nitrogen% ,available sulfur (ppm) and available boron (ppm) were analyzed at Wolkite and Areka soil laboratories.

The soil pH was determined by a 1:2:5 soils to water ratio using a glass electrode attached to a digital pH meter. The soil textural class was determined by the Bouyoucos hydrometer method (Bouyoucos, 1962). The organic carbon of the soil is also determined by the volumetric method based on the oxidation of organic carbon with an acid potassium dichromate medium using the (Walkely and Black, 1934) method.

Total nitrogen was determined according to the modified kjeldahl method with acid by (Dewise and Freitas, 1954). Available phosphorus (ppm) was determined by Olsen's method (Olsen, 1954). Available sulfur (meq/ls_20_4) was determined by the turbdimeteric phosphate extraction method (Aaron *et al*, 2008), and available boron was determined using the dilute hydrochloric acid method (pannamperuma *et al*, 1981). CEC is determined titrimetric ally by distillation of ammonia that has been displaced by sodium (Na) (Sahlemedhin and Taye, 2000)

3.3. Experimental Materials

3.3.1. Plant material

Three **f**ood barley varieties, (HB 1307, Cross 41/98 and HB1966) were obtained from Holeta Agricultural Research Centre (HARC) and the Local (landrace) was obtained from Woreda Agricultural Office.

Table 1 General description of planting material

Variety	Year of release	Breeder	Maturity (days)	Yield t/ (ha)	
				Farmers	On station site
HB13-07	2006	HARC	137	3.5	3.5-5.0
HB1966	2017	HARC	137	3.0-4.0	3.5-5.4
Cross41/98	2012	HARC	137	2.0-3.8	2.5-5.6
Locale	-	-	124	1.4-2.1	-

MoANR, (2016) and HARC, (2019)

3.3.2 Fertilizer materials

Blended NPSB blended fertilizer was applied as inorganic fertilizer. The nutrient composition of NPSB is (18.9 N, 37.7 P_2O_5, 6.9 S and 0.1 B) and the fertilizer was obtained from Endegagn Woreda agricultural office.

3.4 Treatments and Experimental Design

The experiment was consisted of factorial combination of four levels of blended NPSB fertilizer rates 0, 50, 100 and150 kg per ha and four varieties of food barley HB1307, HB 1966, Cross41/98 and local variety. The sixteen treatments combination were arranged in Randomized Complete Block Design (RCBD) with three replication.. The gross size of each plot was 2m x3m ($6m^2$) consisting of ten rows and 3m length each. The distances between adjacent plots and blocks were 0.5m and 1m respectively. The net plot size was 1.6m x 2.6 m ($4.16m^2$) consisted of eight rows and 2.6m length each. The outer most rows on both sides of each plot were considered as border effect.

3.5 Experimental Procedures and Field Management

The experimental field was ploughed to depth of 25- 30cm, with oxen plough to affine filth 4-times and the plots were leveled manually. The site was cleared from unnecessary materials and plant residues. The experimental field was divided in to three blocks, with sixteen (16) plots in each replication. Based on the design, a field lay out was made and each treatment was assigned randomly to the experimental units within a block. Seeds were sown as pre planned varieties on respective plots in rows of 20cm spacing manually by drilling in July, 18, 2022. The first weeding was done after one month after planting and the second weeding done before flowering. All necessary agronomic management practices were carried out uniformly and properly for each plot on right time and right place starting from the field preparation to harvesting. Harvesting was done when the crop reached at physiological maturity on December 4, 2022 manually.

3.6 Crop data collected

3.6.1 Crop Phenologies

Days to 50% heading (DTH): The number of days of 50% heading was determined by visual observation by counting the number of days from sowing to the time when 50% of plants were headed.

Days to 90% maturity (DM): This was determined as the number of days from sowing to the time when 90% of the plant in the plots reached physiological maturity, and when straw is turned to yellow and no green color remained on glumes and panicles of the plant.

3.6.2 Growth parameters

Plant height per plant (cm): plant height was determined from ground level to the top of the spike do not include the awns on ten randomly selected plants from the net plot area at physiological maturity.

Spike length (cm): spike length was measured from bottom of the spike to the tip of the spike not including the awns from ten randomly selected plants from the net plot at physiological maturity.

Lodging percent (LP): The degree of lodging was assessed immediately before the time of harvest by visual observation based on the scale of 1-5 where 1 (0-5) shows no lodging, 2 (15-30) shows 25% lodging, 3 (30-40) shows 50% lodging, 4(45-60) shows75% lodging, 5 (60-90%) indicates 100% lodging (Donald., 2004). The scales were described by measuring the angel of inclination of the main steam from the vertical line to the base of steam by visual observation.

3.6.3 Yield component and yield

Number of total tillers per plant: number of tillers per plant was counted for ten randomly selected plants at physiological maturity.

Number of productive tillers per plant: number of tillers bearing spikes was determined by counting productive tiller from ten randomly selected plants of each net plot at physiological maturity and then the mean was determined.

Number of kernel per spike: Ten selected plants were taken randomly from net plot area of each plot and number of kernels per spike was counted carefully and then the mean was determined.

Thousand kernels weight (g): thousand kernels weight was determined based on the weight of 1000 kernels sampled from the grain yield of each harvested area or net plot by counting using electronic seed counter and the weight measured with sensitive balance at12.5 moisture content.

Above ground dry bio-mass (kgha^{-1}): This was determined from the total part of plants harvested from the net plot area when it was reached maturity and then drying obtain a constant weight and expressed in kg per hectare

Straw yield (kgha^{-1}):- After threshing and measuring the grain yield, the straw yield was measured by subtracting the grain yield from the total aboveground dry biomass.

Grain yield (kgha^{-1}):-It was obtained from each net plot to calculating grain yield in kg per hectare. It was adjusted to 12.5% moisture content and weighed by the following formula. Adjusted grain yield (kgha^{-1}): at 12.5% moisture based= yield obtained (kgha^{-1}) x (100-%MC/ (100-12.5)

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

$$HI\ (\%) = \frac{\text{Grain yield}}{\text{AGDBM}} \times 100$$

3.7 Partial Budget Analysis

An economic analysis was done Appling partial budget method described by CIMMYT (1988). The prices of NPSB and labor costs incorporated in the application of the fertilizer were considered as variable costs. The net benefits and other economic analysis parameters were calculated by means of the formula developed by CIMMYT (1988) and give as follows.

Adjusted grain yield (AGY) (kgha^{-1}): AGY is the average yield adjusted declined by 10% to reflect the gap between the experimental yield and the yield for farmer.

Gross field benefit (GFB) (ETBha^{-1}): is computed by multiplying the field per farmer entry price that farmer receives for the crop when they sell it as adjusted yield.

GFB= AGY x farmer gate price of the crop.

Total variable cost (TVC) (ETBha^{-1}) : is calculated by adding up the costs that vary involving the cost of NPSB fertilizer at the time of planting and, according to Enedegn , farm daily payment of labor cost for application NPSB, weeding, land preparation, planting, and harvesting, were measured the same for all plots

Net benefit (NB): is calculated by subtracting the total variable costs from gross field benefit for each plot

3.8 Data Analysis

The data's collected measured parameters from the experiment were subjected to statistical analysis Software (SAS version 9.3) using ANOVA. The mean separation of significant treatment means was approved out using the least significant difference (LSD) test at 5% level of probability (Gonez and Gomez, 1984). In the same way, simple linear correlation analysis was considered out between growth and yield parameters

4 .RESULTS AND DISCUSSION

4.1. Soil physico-chemical properties before sowing

The pre-planting soil analysis' result shows that the soil of the trial area contains 32% clay, 32% silt and 36% sand textural class clay loam. According to (Tekalign, 1991) pH values categorized as less than 4.5 very strongly acidic, 4.5 up to 5.2 strong acid,5.3 up to5.9 moderately acidic,6 to6.6 slightly acidic and6.7 up to7.3 is neutral. Therefore the pH of the study area is strong acid p^H with a value of 5.12. The organic carbon in study area 2.84% (Table1),which is medium according to the scaling of (Tekalign,1991).who rated soils having organic carbon value in the scale of 2-3% show that medium possible of the soil to supply nitrogen to the crops through mineralization of organic carbon. The medium value of soil organic carbon might be as a result of medium addition of plant residues as smallholders farmers bring into play the biomass of barley for animal feed in the study area. Moreover, (Tekalign, 1991) also categorized soil total N content <0.05% as very low, 0.05-0.12% low, 0.12-0.25 medium and also>0.25 as high. Based on this care gory, the soil samples was establish to have moderate level of total nitrogen (N) (0.19 %) which shows that the nutrient to be a limiting factor for barley production in the study area.

Available phosphorus content of the experimental filed was 8.13 Depend on this, the available phosphorus of study site is low and required phosphorus fertilizer. This low phosphorus content is as result of exhaustive mining of the farm filed and fixation by heavy metal captions (Masresha, 2014) and also reported low value of P satisfied on soils which are cultivated frequently as result of p fixation and p mining. Available sulfur value of the experimental site was 13.5 ppm which is at low range according to (EthioSIS, 2014) Available Boron amount of experimental site was 0.43ppm which is at low range.

Cation exchange capacity (CEC) of the experimental site was (21.68 $cmolkg^{-1}$) (Table 2). (London *et al*,1991) report that soils having CEC of greater than 40 very high, between 25-40 high 15-25 medium, 5-15 low and less than 5 very low. Hence, result obtained from soil analysis, for CEC was in medium range.

Table 2 Selected physic-chemical properties of the soil of the experimental site during 2022 main cropping season

Soil properties	Results	Rating	Reference
Soil particle size			
Clay (%)	32		
Silt (%)	32		
Sand (%)	36		
Textural class	Clay loam		
Soil pH (1:2 H_2O)	5.12	highly acid	Tekalign 1991
Organic carbon (%)	2.84	High	Bary-Kurtz (1945),
Organic matter (%)	4.89	High	Bary-Kurtz (1945),
Total Nitrogen (%)	0.19	Medium	Kjeldhal(Jackson,1970)
CEC (meq/100g soil)	21.68	Medium	Lando(1991)
Available Phosphorus (mg/kg)	8.13	Low	Bary-Kurtz (1945),
Available Sulphur SO_4 (ppm)	13.5	low	Ethio-SIS(2014)
Available Boron (ppm)	0.43	low	Havlin *et al*,(1999)

4.2 Phenological and Growth Parameters

4.2.1. Days to 50% heading

The main effects of NPSB blended fertilizer rate and varieties had a significant effect on days to 50 % heading. The analysis of variance also indicate that the interaction of varieties and NPSB blended fertilizer rates had highly significantly ($p<0.01$) effect on days to 50% heading (Appendix Table 1)

The highest days to 50% heading (107days) was recorded by the interaction of variety HB 1966 with the highest levels of blended NPSB 150 kg ha-1 which however was statistically at par with that obtained from Croos41/98 grown with the application of the same amount

of NPSB. In contrast, the shortest (61) days to 50% heading was recorded from local variety in the with control plot (Table 3). Significant difference in days to 50% head initiation were observed between tested varieties of food barley with increased application rates of NPSB fertilizer and this could be attribute to the inherent genotypic difference of the varieties to respond in differently at different rates of N fertilizer. In general, days to 50% heading of barley grown on NPSB treated plots were delayed as compared barley grown with control plot NPSB application. This might be due to increment of nitrogen fertilizer rates which is known to delay the time to heading through providing extended vegetative growth and photosynthesis.

The result of the current finding was in line with the finding of (Ketema and Mulatu, 2018). who report that days to 50% heading was significantly late by highest NPSB fertilizer levels related to the lowest rate of NPSB fertilizer on barley crop, Because the role of nitrogen fertilizer that encourage vigorous vegetative growth and development of the plant possibly as result of the availability of sufficient nutrient in the soil for plant up take.

Table 3 Interaction effects of varieties and NPSB rates on day's to 50% heading of food barley during 2022 main cropping season

	NPSB rates (kg/ha)			
Varieties	0	50	100	150
Croos41/98	63.33^{fg}	73^{e}	87^{c}	102.67^{a}
HB13-07	64.67^{fg}	71.33^{e}	82.33^{cd}	97.3^{b}
HB1966	68.33^{ef}	83.67^{cd}	93.67^{b}	107.3^{a}
Local	61^{g}	63.33^{fg}	79^{d}	86^{c}
LSD(0.05)		5.2		
CV (%)		3.89		

LSD (0.05) = Least significant difference at5% level; CV (%) =Coefficient of variation Means followed by the same letter are not significantly different at 5% level of significances.

4.2.2 Days to 90% physiological maturity

The analysis of variance indicate that the day to 90% physiological maturity was highly significantly ($p<0.01$) influenced by the main effects of NPSB blended fertilizer rates and varieties while their interaction did not show significant effects on days to 90% physiological maturity (Appendix table1).

The longest days (144 days) to attain 90% physiological maturity was obtained from the highest level of NPSB fertilizer rate 150 kg ha^{-1} with HB 1966 whereas the shortest days (114 days) were obtained from plots without NPSB (Table 4). The delayed physiological maturity at the highest rate of NPSB fertilizer application might be due to the effect of individual nutrients such as N, P, S and B to trigger the photosynthesis of the crop for the extended period of time (Wosene and Berhane, 2015).

High NPSB rate applied treatments has delayed the maturity of the food barley varieties due to the fact that it extended vegetative growth instead of reproductive growth because of the N role on vegetative growth of the crop. Thus, plants treated with the highest level of N endured slightly green duration while those plants without N showed yellow spike, leaf and stem and this enforce them to early maturity physiology which might have been due to depression of cytokines synthesis or increased production of abscisic acid (ABA) under low N supply (Bishaw *et al*, 2014). These variations on date of maturity of barley might be, due to shoots maturity which can be directly affected by the rate of fertilizer application. The main effect of varieties had also a significant effect on days to 90 % maturity. The highest days to maturity of 139 was recorded from HB1966 variety which was statistically at par with that obtained from Crosse41/98. The lowest value of this parameter was scored from the local variety (Table 4). This might be attributed to the genetic difference among the varieties.

Current finding in lined with (Wakene *et al*, 2014) revealed that late in 90% physiological maturity point of barley was maximum at higher level of N. Similarly, this is in consistent with this the finding (Wosene and Berhane, 2015) who revealed that delay in maturity time of barley was greater at higher rates of nitrogen fertilizer than the other treatments (Legesse

,2004) reported that N fertilization late the physiological maturity of tef outstanding to comprehensive vegetative growth instead of reproductive growth

4.2.3 Spike Length per plant (cm)

The analysis of variance indicate that, the main effect of blended NPSB fertilizer level and varieties were highly significant ($P<0.01$) whereas the interaction of varieties and NPSB fertilizer level did not significantly influenced spike length (Appendix table 2).

The highest spike length (8.1) cm was obtained from the variety cross 41/98 and lowest spike length (5.6 cm) was scored from the local variety. However, an HB13-07 and HB1966 variety was statistically at par (Table 5). Different varieties have shown different performance on their spike length and this could be due to the genotype potential during their growth and overall developmental stages (Jemal and Aliyi, 2021). And also similar result was reported by (Ketema and Mulatu, 2018) who reported that barley varieties have shown significant difference for their spike length and cell expansion.

The main effect of NPSB fertilizer had also a significant effect on spick length of barley. An increased in application of NPSB fertilizer from 0 to 150 kg ha^{-1} has enhanced the spike length of barley crop. The increment was from 5.9 to 8.2 with the percentage of 28.05% with increasing the NPSB fertilizer rate from 0 to 150 kg ha^{-1}. The highest spike length (8.2cm) was produced from the application of highest level of NPSB fertilizer rate of 150 kg ha^{-1} whereas the shortest spike length (5.9) was recorded from unfertilized plot (Table 5). This could be due to the role of nitrogen and phosphors which promote the cell elongation, division and expansion when applied in optimum manner for crops. The current finding is similar with result of (Diriba *et al*, 2019)

4.2.4 Lodging percent (%)

Lodging refers to the permanent displacement of the plant shoot from its normal upright position. This usually occurs as a combined effect of insufficient anchorage strength of the crop and influence of adverse weather conditions like rain, wind and hailstorm (Khobra et al., 2019).

The main effects of variety and NPSB fertilizer had a significant effect ($p < 0.01$) on lodging percent however, their interaction was not significantly affected this parameter (Appendix table 2).

Both HB1966 and local variety had greatest lodging (%) percentage (11.7%) while, the lowest lodging % (10%) was recorded from variety cross 41/98 (table 4). The highest logging percentage obtained at both HB1966 and local varieties and the least from cross 41/98 variety could be due to the potential difference to resist the logging, length, stem size and the growth performance of the varieties even at the same soil condition. As increased application of NPS fertilizer rates, the lodging tendencies have been also increased (Table 4). This may be due to increasing rate of total nitrogen that achieved better fast vegetative growth, plant height, spike length, seed per spike and stem elongation of barley. Which in turn increases the weight of the stem otherwise, increase lodging percent of barley. This might be due to varieties diverse in number of leaves and tillers. Huge gap amongst barley varieties were practical for lodging inclination. This was also supported by the finding of tiller (Laghari *et al*, 2010) who reported that, lodging percent is generally varied from variety to variety because of their genetic potential difference. And similarly, increasing the rate of NPSB fertilizer from zero to 150 kg ha^{-1} has shown significant ($P<0.01$) difference of the percentage of logging at barley crop. The highest lodging % (14.2 %) was attained from the plots which were treated with the highest rate of 150 kg NPSB ha^{-1} whereas, the lowest percentage at the crop logging was obtained from lowest rates of 0 to 100 kg NPSB ha^{-1} and there is no significant variation in the percentage of logging at rates of 0 kg ha^{-1}, 50 kg ha^{-1} and 100 kg ha^{-1} and these are at par. Yet, the increment at percentage of logging in the highest rate of NPSB fertilizer ha^{-1} could be due to greatest NPSB fertilizer that achieved fast vegetative growth, plant height, spike length, total tillers and productive tillers.

The current finding in lined with (Berry *et al*,2003) reported that the influence of fertilizers, the maximum lodging percent was recorded in the plot treated with highest level of NPSB fertilizer rate whereas minimum lodging percent was obtained from control plot. The highest lodging percent at the maximum level of blended NPSB could be as result of huge

nitrogen fertilizer uses which show key role of nitrogen in vegetative growth and cause for increase number of tillers as well as leaves. Lodging percent is generally supposed that high rates of N rise lodging by making plants taller (Laghari *et al*, 2010).

Table 4 Main effects of varieties and NPSB fertilizer rates on days to days to physiological maturity, spike length and lodging of food barley during 2022 main cropping season

Varieties	Days to 90% physiological maturity	Spike length	Lodging percent
HB13-07	128.58^{bc}	7.2^{b}	11.6^{a}
HB1966	139^{a}	6.97^{b}	11.7^{a}
Crosse41/98	135.08^{ab}	8.1^{a}	10^{b}
Locale	122.42^{c}	5.6^{c}	11.7^{a}
LSD(0.05)	6.89	0.75	0.24
NPSB rates (kg ha^{-1})			
0	114.25^{c}	5.9^{c}	10^{c}
50	127.33^{b}	6.4^{c}	10^{c}
100	139.17^{a}	7.3^{b}	10.8^{b}
150	144.33^{a}	8.2^{a}	14.2^{a}
LSD(0.05)	6.89	0.75	0.24
CV (%)	6.3	12.91	25.8

Means followed with the same letter (s) in the are significantly different at 5%;
CV%=coefficient of variation' Ns=Non significant Difference at5%level

4.2.5 Plant height per plant

The analysis of variance showed that the main effects of NPSB fertilizer rates and varieties significantly influenced ($P<0.01$) plant height of barley. Moreover, the interaction of blended NPSB fertilizer rate and varieties was also significantly influenced this parameter ((Appendix table 2).

Variety HB1966 has scored the highest plant height (128 cm) with the application of 150 kg NPSB ha^{-1} whereas the shortest plant height of 69.13 cm was recorded from local variety when it grows without NPSB application (Table 5).

Plant height of all varieties increased with an increase in NPSB rates from 0 to 150 kg ha^{-1}. This might be due to the fact that increased as rate of nitrogen; phosphorous, sulphur and boron supply may have played an essential role in plant growth and development (Jemal and Aliyi, 2021). An increase in plant height of crop by blanced N, P, S and B -supply has been reported (Haftom *et al*, 2009).

The result is in lined with the finding of (Bereket *et al*,2014) who reported that macro and micro nutrients such as N, P, S and B fertilizers use can raised plant height with increasing amount and combination (Khan *et al*, 2000). Who reported that raising the rate of N increased the plant height. Moreover, (Melle *et al*, 2015) report that plant height of barley increased with increasing rates of N-fertilizer. An increase in plant height with an increase in NPSB rate has been reported by (Melkamu, 2018)

Table 5 Interaction effects of variety and NPSB fertilizer rates on plant height of food barley during 2022 main cropping season

	NPSB rates (kg ha^{-1})			
Varieties	**0**	**50**	**100**	**150**
Croos41/98	78.33^{f}	92.47^{e}	112.5^{cd}	126.4^{ab}
HB13-07	73.3^{f}	91.43^{e}	117.37^{bcd}	126.6^{ab}
HB1966	91.17^{e}	108.33^{d}	121.77^{abc}	128.77^{a}
Local	69.13^{f}	72.67^{f}	72.67 ^{f}	74.47^{f}
LSD (0.05)		10.9		
CV(%)		6.72		

Means followed by the same letter (s) in the column are significantly different at 5%; CV%=coefficient of variation' Ns=Non-significant Difference

4.3 Yield Components and Yield Parameters

4.3.1 Total number of tillers per plant^{-1}

Total number of tiller was significantly ($p<0.01$) influenced by the main effects of NPSB fertilizer rates and varieties. The interaction effects of the main factors had also a significant ($p < 0.01$) influence on total number of productive tillers per plant (Appendix table 3)

The highest number of total tillers of food barley (12 tillers per plant) was recorded from cross 41/98 barley variety with the combined application of the highest rate of 150 kg ha^{-1} NPSB blended fertilizer whereas the lowest number of total tillers per plant (2 number of tillers per plant) was obtained from the local variety which is grown without fertilizer. An increase in NPSB application from 0 to 150 kg ha^{-1} on barley increase total number of tiller regardless of the variety (Table 6). This increment in total tiller number at different varieties of the barley crop with an increased application of NPSB fertilizer might be due to the role of nitrogen, phosphorous and sulfur to enhance carbohydrates production and consequently increased tiller number.

The current finding is in agreement with the result of (Wakjira, 2018) who suggested that total number of tillers was increased by increased application of blended NPS fertilizer levels. And also similar with the result of (Ahmad *et al*, 2000) and also (Hossain and Akhtar, 2014) reported increased number of tillers per plot area with rising NPSB rate.

Table 6 Interaction effects of varieties and NPSB fertilizer rates on number of total tillers on food barley during 2022 main cropping season

	NPSB rates (kg ha^{-1})			
Varieties	**0**	**50**	**100**	**150**
Cross41/9	3.33^{hij}	7^{cd}	9.33^{b}	12^{a}
HB13-07	3.0^{ijk}	4.67^{fg}	7.33^{c}	9.0^{b}
HB1966	2.67^{jk}	4.33^{fgh}	5.33^{ef}	6.0^{de}
Local	2.0^{k}	2.67^{jk}	3.0^{ijk}	4.0^{ghi}
LSD(0.05)		1.02		
CV(%)		11.39		

Whereas, Means followed by the same letter (s) are significantly different at 5%; CV%=coefficient of variation' Ns=Non-significant Difference at 5% level

4.3.2 Number of productive tillers per plant^{-1}

NPSB fertilizer rates and varieties significantly influenced number of productive tiller of barley. Moreover analysis of variance revealed a highly significant ($p<0.01$) interaction effect on number of productive tiller (Appendix table 3).

The highest mean number of productive tillers (9.3) per plant was obtained from cross 41/98 variety of barley with the combined application of 150 kg ha^{-1} blended NPSB fertilizer levels whereas the least number of productive tillers per plant (1.3) tillers per plant was recorded from the local variety which is treated without NPSB application (Table 7).

All NPSB treated varieties have shown an increment on the number of productive tiller with the highest increment at the rate of 150 kg NPSB ha^{-1}. This increment in the number of productive tillers with increasing blended NPSB fertilizer application levels might be due to the role of nitrogen and phosphorus is known with raising the number as well as the size of productive tillers (Wakene *et al*, 2014).

The current finding in lined with the finding of (Wakene *et al*, 2014) who reported that number of productive tillers was affected extensively with the effect of different rates of phosphorus fertilizer. Our result is also similar with (Wakjira,2018) who reported total number of tillers increment response to increasing the level of blended NPSB fertilizer from zero to120 kg ha- It is also comparable with the finding of (Alam *et al,*2007) who reported that nitrogen increase number of productive tillers per plant irrespective of cultivars

Table 7 Interaction effects of varieties and NPSB fertilizer rates on number of productive tillers on food barley during 2022 main cropping season

	NPSB rates (kg ha^{-1})			
Varieties	**0**	**50**	**100**	**150**
Cross 41/98	2.6^{fgh}	5.67^{c}	7.67^{b}	9.33^{a}
HB13-07	2.33^{ghi}	3.67^{de}	5.33^{c}	7.33^{b}
HB1966	1.7^{ij}	3.00^{efg}	3.33^{def}	4.0^{d}
Local	1.3^{j}	2.00^{hij}	2.33^{ghi}	3.0^{efg}
LSD (0.05)		0.85		
CV(%)		12.54		

Whereas, means followed by same letter (s) in the column are significantly different at 5%; CV%=coefficient of variation'

4.3.3 Number of kernels per spike

Number of kernels per spike significantly ($p<0.01$) influenced by the main effect of NPSB fertilizer rate and varieties. The interaction effect of variety with NPSB fertilizer was also significantly influenced this parameter (Appendix table3).

The maximum kernels number per spike of 70.8 was observed from croos41/98 variety when it was grown with the application of 150 kg ha^{-1} NPSB, which however is statistically similar with that scored from HB 1307 barley varieties when it grows with 150 NPSB kg ha^{-1}. The lowest value of number of kernels per spike(19.6) were obtained from local

cultivar which was sown without NPSB fertilizer (Table 8).Barley varieties showed an increase in number of kernel per spike with an increase in NPSB fertilizer rate from zero to 150 kg ha^{-1}. However, response of varieties varies with a similar rate application of NPSB fertilizer. This could be due to the fact that different varieties might have different uptake and utilization efficiency of nutrient so that they might have different number of kernel per spick. In addition an increase in of N, P and S in an increasing NPSB rate can contribute to cell expansion and development.

The current result in lined with the study of (Melkamu, 2018) who reported that the kernel number per spike increased with an increase in NPSB rate. Moreover, (Habtamu,2019) reported that the highest number of kernel per spike was recorded at maximum application 200 kg ha^{-1} of NPSB blended fertilizer whereas lowest number of kernel per spike also recorded control plot.

Table 8 Interaction effects of varieties and NPSB fertilizer rates on kernel per spike of food barley during 2022 main cropping season

	NPSB rates (kg ha^{-1})			
Varieties	**0**	**50**	**100**	**150**
Cross41	42.16^{fg}	56.03^{cd}	64.9^{ab}	70.8^{a}
HB 1307	28.9^{h}	47.8^{ef}	60.47^{bc}	65.7^{ab}
HB1966	45.46^{efg}	41.9^{fg}	51.77^{de}	61.43^{bc}
Local	19.66^{i}	39.53^{g}	39.63^{g}	46.33^{efg}
LSD (0.05)		8.06		
CV (%)		10.04		

Whereas, means followed with the same letter (s) i are significantly different at 5%; CV%=coefficient of variation' Ns=Non-significant Difference at 5% level

4.4.4 Aboveground dry biomass (kg ha^{-1})

Analysis of variance show that the above ground dry biomass was highly significant ($P<0.01$) affected the main effect of variety, NPSB fertilizer and their interaction (Appendix Table 4).

Variety cross41/98 scored the highest aboveground dry biomass yield of 15,502 kg ha^{-1} when it grows with the application of 150 kg ha^{-1} NPSB followed by HB 1307 variety grown on the same fertilizer rate. In contrast the lowest value of this parameter was scored from local variety grown without NPSB fertilizer (Table 9).

As NPSB increased the total biomass has also shown an exponential increment across variety. However, different varieties respond differently to the same amount of fertilizer rate. This increment might be due to the fact that different variety might have different ability to absorbed available essential element as from the soil and produce different amount of dry matter per mole of a nutrient absorbed. In addition, the role of the individual effects of Nitrogen, Phosphorous and Sulfur contributions on dry matter accumulation in plant tissue and they can promote the vegetative growth of plant at a higher amount by providing the better condition on the photosynthesis of the crop. Furthermore, the significant increment in spike length, number of kernel per spike, number of productive, vegetative part and non-productive tillers and grain yield by might contribute for the significant increment in total biomass.

The current result was in agreement with (Ghimire *et al*, 2017) who reported that above ground dry biomass of barley was significantly increased with increasing use of phosphorus fertilizer rates.

Table 9 Interaction effects of variety and NPSB fertilizer rate on above ground dry bio mass of food barley during 2022 main cropping season

	NPSB rates (kg ha^{-1})			
Varieties	0	50	100	150
Cross 41/98	7360^{ghi}	12610^{bc}	13538^{b}	15502^{a}
HB 1307	6127^{ijk}	8412^{fg}	11851^{cd}	13732^{b}
HB 1966	5626^{jk}	7493^{ghi}	9452^{ef}	10965de
Local	4909^{k}	5640^{jk}	6682^{hij}	8118^{fgh}
LSD(0.05)	1586.4			
CV(%)	10.28			

Whereas, means followed with the same letter (s) are significantly different at 5%; CV%=coefficient of variation' Ns=Non-significant Difference at 5% level

4.4.5 Thousand grain weight (g)

The main effect of NPSB rate and variety significantly influenced thousand grain weights. The interaction of variety with NPSB had also a significant ($p<0.01$) effect on this parameter (Appendix table 3).

Variety Cross 41/98 with application of 150 kg ha^{-1} of NPSB fertilizer resulted in significantly highest thousand grain weight (61.18g). The lowest thousand grain weight (18.94g) was recorded in local variety when received 0 kg ha^{-1} NPSB fertilizers however, it did not significant difference from HB1966, which received similar amount of NPSB fertilizer (Table.9). The increase thousand grains weight with rising NPS kg ha^{-1} blended fertilizer levels might be due to high assimilation of phosphors and sulfur during grain satisfying stage.

The current study was similar with the findings of (Melkamu *et al*, 2019) who reported that, the application of different blended fertilizers on yield and yield components of food barley variety produced the highest thousand grain weight from the use of high blended NPSB blended fertilizer levels while the lowest thousand grain weight was provided from 0

kg ha^{-1} NPSB. Similarly (Asghari *et al*, 2006) reported that increasing levels of nitrogen use was raised thousand grain weigh. (Biruk and Demelash, 2016) reported that thousand grain weight of barley variety also significantly raised with increasing rates of fertilizers compared to unfertilized plot.

Table 10 Interaction effects of variety and NPSB fertilizer rate on thousand grains Weight (g) of food barley during 2022 main cropping season

	NPSB rates(kg ha^{-1})			
Varieties	0	50	100	150
Cross 41/98	26.49^{fg}	40.02^{d}	48.44^{c}	61.18^{a}
HB 1307	23.44^{gh}	36.39^{d}	46.35^{c}	55.3^{b}
HB 1966	22.3$^{h\ I}$	30.97^{e}	39.25^{d}	44.5^{c}
Local	18.94^{i}	24^{gh}	29.79^{ef}	37.93^{d}
LSD(0.05)		4.12		
CV(%)		6.75		

Whereas, means followed with the same letter (s) in the column are significantly different at 5%; CV%=coefficient of variation' Ns=Non-significant Difference at 5% level

4.4.6 Grain yield (kg ha^{-1})

The analysis of variance revealed that, the grain yield was highly significant ($p<0.01$) influenced by NPSB rate, varieties and their interaction (Appendix table 4).

The highest grain yield (5793.3 kg ha^{-1}) was obtained from cross 41/98 variety with the application of 150 kg ha^{-1} NPSB blended fertilizer rates whereas the lowest grain yield (788.8 kg ha^{-1}) was recorded from local variety with grown without NPSB blended fertilizer (Table 10). And the increase in grain yield of with the application of NPSB fertilizer might be due to the role of N, P and S fertilizers to contribute for grain filling, cell expansion and overall photosynthetic activities. Increasing NPSB level might enhanced

root growth and increased uptake of nutrients and improved growth preferential outstanding to the synergetic effects of both nutrients which better yield mechanism and yield.(Gooding and Davies, 1997).

The result was in agreement with the finding of (Woubshet *et al*, 2017) who reported that combined use of NPSB fertilizer levels raised grain yield of barley (Mesfin and Zemach 2015) reported that the use of phosphors fertilizer significantly raised the grain yield of barley. Significant increase in grain yield in response to the raised use of nitrogen fertilizer could be ascribed to improved ease of use and up take of nitrogen by the roots of food barley crop. Report that application of nutrients like S and B application in experiments significantly increased grain yield and yield components of barley compared to the control plot.

Table 11 Interaction effects of varieties and NPSB fertilizer rates on grain yield of food barley during 2022 main cropping season

	NPSB rates(kg ha^{-1})			
Varieties	**0**	**50**	**100**	**150**
Cross41/98	2538.5^{f}	3403.9^{d}	4378.2^{b}	5793.3^{a}
HB13-07	2275^{fg}	3122.6^{de}	4018.2^{bc}	4213.1^{b}
HB1966	1338.2^{hi}	2592.1^{ef}	3535.2^{cd}	4056.9^{bc}
Local	778.5^{j}	1226^{ij}	1813.3^{gh}	2380.6^{f}
LSD (0.05)		538.94		
CV (%)		10.9		

Whereas, means followed with the same letter (s) are significantly different at 5%; CV%=coefficient of variation' Ns=Non-significant Difference at 5% level

4.4.7 Straw yield (kgha^{-1})

Straw yield was significantly ($p < 0.01$) affected by the main effect of NPSB fertilizer rate and varieties. The interaction effect of variety with NPSB fertilizer was also significant ($p < 0.01$) (Appendix table 4).

Variety cross41/98 with application of 150 kg ha^{-1} NPSB fertilizer resulted in significantly highest means of straw yield (9708 $kgha^{-1}$) which however was statistically similar with that obtained from the same Varity grown with the application of 50 and 100 kg ha^{-1}. The lowest straw yield (4120 kg ha^{-1}) was recorded from local grown without NPSB (Table 11) significant increment in the straw yield due to the application of NPSB across barley variety might be due to the synergetic roles of N, P, S and B nutrients

The current result is in agreement with that of (Teferi *et al*,2019) who report that the highest straw yield of food barley was 10500 kg ha^{-1} obtained from application of 150 kg ha^{-1} blended NPSB fertilizer rate whereas the lowest straw yield of food barley 5380 kg ha^{-1} straw yield found form the control. This finding also in lined with finding of (Woubshet *et al*, 2017) who suggested that the use of 150 kg ha^{-1} blended NPSB fertilizer rates with manure increase straw yield by 5900 kg ha^{-1}

Table 12 Interaction effects of variety and NPSB fertilizer rate on straw yield of food barley during 2022 main cropping season

	NPSB rates (kg ha^{-1})			
Varieties	0	50	100	150
Cross 41/98	4821.4^{efg}	9205.8^{ab}	9160.1^{ab}	9708^{a}
HB 1307	3851.6^{g}	5289.7^{efg}	7832.3^{bc}	9518.6^{a}
HB 1966	4288.1^{fg}	4901.3^{efg}	5916.4^{de}	6908.2^{cd}
Local	4120.6^{g}	4414.2^{efg}	4868.9^{efg}	5737.6^{def}
LSD(0.05)		1565.7		
CV (%)		14.94		

Whereas, means followed with the same letter (s) in the column are significantly different at 5%; CV%=coefficient of variation' Ns=Non-significant Difference at 5% level

4.4.8. Harvest Index (HI)

Harvest index was significantly ($p<0.01$) affected by the main effect of Varity and NPSB rate. The interaction of varieties and NPSB fertilizer rate was also significantly affected of harvest index (HI) ($p<0.01$) (appendix table 4).

Cross41/98 which received 150 kg ha^{-1} NPSB fertilizer resulted in highest harvest index of 37.94%. The lowest harvest index was resulted from local variety with 0 kg ha^{-1} NPSB fertilizer (16.11%) however; it was not significantly difference from local grown 50 kg ha^{-1} NPSB (21.79%) (Table13). This could be due to more vegetative dry matter production under increasing NPSB fertilizer rate application than under smaller fertilizer rates. In the varieties the highest harvest index (37.94%) was observed from Cross41/98, whereas the lowest harvest index (16.11%) was obtained from local variety (Table 13). The variety that have most harvest index was able to be seen its tendency to working productively with the minimum nutrients distribute the dry matter gained to drop organ distinguished to other varieties. Nearby, the variety that have highest harvest index might be due to most photosynthetic absorbed and changed into grain yield than vegetative growth. This result is followed by (Ketema et al., 2018; Mekuan *et al* and Kiya, 2020). Highest harvest index with the application of fertilizer might be attributed to the synergetic effects of nutrients in the NPSB blended fertilizer. Harvest index as quantitative features is display of plant efficiency to allocate dry matter in grain yield (Shahryari and Mollasadeghi, 2011). (Riggs *et al,* 1981) suggested that the high significant and constructive relation between harvest index and grain yield in food barley. Higher harvest index implies upper partitioning of dry matter into seed.

Current result is supported by the finding of (Lake ,2018) who suggested that, highest harvest index was obtained when nitrogen was used at high which was statically at par to all treatments except including 0 kg^{-1} application of nitrogen which gave the lowest value of harvest index. Moreover, (Tahir *et al,* 2009) reported that the maximum barley harvest index with raised fertilizer rates and attribute this to might be higher transfer of assimilates to the grain (Melkamu,2018) also reported that maximum harvest index was recorded from plots applied with highest blended NPSB fertilizer rates.

Table 13 Interaction effects of variety and NPSB fertilizer rate on harvest index of food barley during 2022 main cropping season

	NPSB rates (kg ha^{-1})			
Varieties	0	50	100	150
Cross41/98	34.62^{ab}	27.16^{cde}	32.62^{abc}	37.94^{a}
HB 1307	37.70^{a}	37.15^{a}	34.22^{ab}	30.21^{bcd}
HB 1966	23.86^{de}	34.50^{ab}	37.58^{a}	37.87^{a}
Local	16.11^{f}	21.79^{ef}	27.14^{cde}	29.33^{bc}
LSD(0.05)		6.4		
CV(%)		12.28		

Whereas, means followed with the same letter (s) in the column are significantly different at 5%; CV%=coefficient of variation' Ns=Non-significant Difference at 5% level

4.**4 Result of the Partial Budget Analysis**

The partial budget analysis was engaged to estimate the gross benefit, total variable costs, net benefits' and marginal rate of return that could be gained from various different treatments. The partial budget analysis indicates also level of effectiveness and helps to decide whether to adopt a new technology or not. The interest of producers use of NPSB fertilizer rate applying and food barley varieties is not limited to, increasing yield only, yet also to make a profit out of it. Towards highest profit, different barley varieties and blended NPSB fertilizer rate application they used as well as the cost of seed, fertilizer and the price of yield are decide factors. To identify treatments with the balanced return to the farmer investment, marginal analysis was performed on non-dominated treatments. For a treatment to be considered as wealth whereas to farmers between 50% and 100% (MRR) was minimum adequate rate of return (CIMMYT, 1988). of the 16 treatments is described as follow in table (16) depend on this result, the highest net benefit of 156537.9 birr per hectare was obtained from the treatment combination of 150 kg NPSB fertilizer rate per hectare use for variety cross41/98 followed by cross41/98 combination of 100kgha^{-1} followed by HB 13-07 the treatment combination of HB13-07 with 150kg /ha NPSB blended fertilizer 106,698.7 birr/ha. However, the lowest net benefit 4884.8 birr ha^{-1} was obtained from variety local with 0 kg/ha NPSB blended fertilizer levels (table16). As a

result, the most productive and gorgeous variety with NPSB fertilizer application levels for producers with higher net benefit was cross 41/98, with the use 150kgh^{-1} fertilizer application rate. The contrast is important to farmers because they are interested to compare the increase in costs needed to gain increased in net benefits. Therefore, the net positive benefit gained with application of 150 kg NPSB ha^{-1}with cross41/98 variety was economically gainful application rates and responsive variety that can be recommended for farmers in the study area and other areas with similar agro-ecological and edaphic conditions. In lined with this finding of (Kasim, 2021) obtained the highest net benefit of 125531 Birr with the application of 200kg ha^{-1} NPSB for food barley and also similar with Bekalu and Mamo (2016), the application of the highest rate of nitrogen fertilizer is effective in attaining the higher yielied anet benefit of wheat and barley.

Table 14 Results of the Partial budget analysis

Varieties	Fertilizer NPSB ha^{-1}	Average Yield kgha^{-1}	Adjusted yield kgh^{-1}	SY	GY Etbha^{-1}	SY	GFB Etbha^{-1}	TVC Etb/h	NB Etbha^{-1}
Cross41/98	0	2538.5	2284.65	4821.4	79962.75	1687	81649.8	21300	60349.8
	50	3403.9	3063.51	9205.8	107222.8	3222	110444.8	21743	88701.8
	100	4378.2	3940.38	9160.1	137913.3	3206	141119	25546	115573
	150	5793.3	5213.97	9708	182488.9	3398	185886.9	29349	156537.9
HB13-07									
	0	2275	2047.5	3851.6	71662.5	1348	73010.5	21300	51710.5
	50	3122.6	2810.34	5289.7	98361.9	1851	100212.9	21743	78469.9
	100	4018.2	3616.38	7832.3	126573.3	2741	129314.3	25546	103768.3
HB1966	150	4213.1	3791.79	9518.6	132712.7	3332	136044.7	29346	106698.7
	0	1338.2	1204.38	4288.1	42153.3	1500	43653.3	21300	22353
	50	2592.1	2332.89	4901.3	81651.2	1715	83366.2	21743	61623.2
	100	3535.2	3181.68	5916.4	111358.8	2071	113429.8	25546	87883.8
Local	150	4056.9	3651.21	6908	127792.4	2418	130210.4	29346	100864.4
	0	778.5	700.65	4120	24522.8	1442	25964.8	21080	4884.8
	50	1226	1103.4	4414.2	38619	1545	40164	21523	18641
	100	1813.3	1631.97	4968.9	57118.9	1739	58857.9	25326	33531.9
	150	2380.6	2142.54	5737	74988.9	2007	76995.9	29126	47869.9

Where; GY=grain yield, ST =straw yield, GFB=Gross field benefit, TVC=total variable cost, NB= Net benefit and ETB=Ethiopian Birr cost of NPSB=37.26 ETBkg^{-1} Urea 38.80 ETBkg^{-1} barely seed 38 ETBkg^{-1} Labor cost=120ETB day^{-1}

5. SUMMARY, CONCLUSSION AND RECOMMENDATION

Barley yield in Ethiopia and the study area is due to shortage of adaptable varieties, lower soil fertility and lack of site specific fertilizer recommendation. Thus, afield experiment was conducted during the 2022 main season to evaluate the growth and yield response of food barley varieties to blended NPSB blended fertilizer rates at Endegagn district, Gurage Zone of southern Ethiopia. The experiment was arranged in factorial combination four food barley varieties (cross41/98, HB13-07, HB1966 and locale) and four blended NPSB fertilizer levels (0, 50,100 and 150) $kgha^{-1}$ and laid out in randomizer complete block design with three replication.

The result showed that almost all parameters were affected by the interaction effect of NPSB fertilizer rate and barley varieties. Days to 50% heading, plant height, number of total tillers, number of productive tillers, number of kernel per spike, thousand seed weight, grain yield ,straw yield and harvest index highly significantly ($p<0.01$) affected due to the interaction of both factors while, days to 90% physiological maturity, spike length and lodging percent had did not significant effects.

Resulted in the highest days to 50% heading (107), 90% physiological maturity (144) for variety HB 1966. Maximum number of total tillers (12), productive tillers number of spike per kernel (8.2), above ground dry biomass, grain yield and straw yield (9708) for variety cross41/98, thousand grain weight (61.8g) and grain yield (5793.3) were recorded from variety cross41/98 with 150kg $NPSBha^{-1}$ fertilizer rates. The majority of the crop parameters indicated significantly and positively correlated with one another the partial budget analysis indicates that the highest net benefit of 156537.9 birr ha^{-1} was provided from the treatment combination of 150kg ha^{-1} blended NPSB fertilizer levels for variety cross41/98.

Based on the result of this research use of 150kgha-^{1} blended NPSB fertilizer rate on cross41/98 variety gave highest grain yield and maximum net benefit in the study area. Therefore, farmers in the study area and areas with similar agro ecology and soil category can be advised to apply cross41/98 variety with 150 $kgha^{-1}$ blended NPSB fertilizer to

enhance the production, and productivity of food barley However, for strong and sound recommendation this experiment needs to be repeated across location and season.

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7. APPENDIX TABLE

7.1 List of Table in Appendix

Appendix Table 1. Mean squares of analysis of variance for phonological and growth parameters of food barley affected by NPSB fertilizer levels and varieties

		Mean squares	
Sources of variation	DF	DH	PH
Replication	2	15.40	521.76
Variety	3	514.74**	3494.79**
NPSB fertilizer rates	3	2639.63**	3149.6**
Variety x NPSB rates	9	30.52 **	354.8**
Error	30	9.73	42.73
CV (%)		3.98	6.7

DF=degree of freedom, ns=non-significant, *significant at 5% level of significance, e**=significant at1% level of significance, DH=days to50% heading PH= plant height.

Appendix Table .2 Mean squares of analysis of variance for days to physical maturity and growth Parameters of food barley affected by NPSB fertilizer levels and varieties

		Mean squares		
Sources of variation	DF	DPM	SL	LOG (%)
Replication	2	66.6	0.88	0.0625
Variety	3	639.58**	12.5**	0.083**
NPSB fertilizer rates	3	2152.7**	11.8**	0.47**
Variety x NPSB rates	9	57.32ns	0.74 ns	0.102 ns
Error	30	68.45	0.80	0.084
CV (%)		6.30	12.91	25.3

DF=degree of freedom, ns=non-significant, *significant at 5% level of significance, e**=significant at1% level of significance, DPM= Days to 90% physiological maturity SL= spike length and LOG= lodging percent.

Appendix Table 3 Mean squares of analysis of variance for yield components of food Barley affected by NPSB fertilizer levels and varieties

		Mean squares			
Sources of variation	DF	NTT	NPT	NKPS	THW
Replication	2	0.083	0.146	271.5	7.87
Variety	3	54.077**	40.97**	1346.12**	619.39**
NPSB fertilizer rates	3	55,2**	33.14**	1697.33**	1583.77**
Variety x NPSB rates	9	5,095**	3.387**	71.94**	32.42**
Error	30	0.37	0.257	23.39	6.10
CV (%)		11.39	12.54	10.04	6.75

DF=degree of freedom, ns=non-significant, *significant at 5% level of significance, e**=significant at1% level of significance, NTT=number of total tillers NPT= number of productive tillers NKPS =number of kernel per spike THW= thousand grain weight.

Appendix Table 4 Mean squares of analysis of variance for yield components of food barley affected by NPSB fertilizer levels and varieties

		Mean squares			
Sources of variation	DF	GY	ST	ABGDM	HI
Replication	2	70521	7869175	9361086	63.889
Variety	3	1.33**	2.694**	7.54**	319.65**
NPSB fertilizer rates	3	1.27**	2975**	8.126**	83.175**
Variety x NPSB rates	9	394920 **	3551859**	3967149**	82.58**
Error	30	104458	881598	905131	14.73
CV (%)		10.89	14.94	10.28	2.04

DF=degree of freedom, ns=non-significant, *significant at 5% level of significance, e**=significant at1% level of significance, GY=grain yield ST= straw yield AGDBM= above ground dry biomass HI= harvest index.