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Growth and Yield Response of Malt Barley (Hordeum Vulgare L.) to NPSB and Nitrogen Fertilizers Application in Southern Ethiopia

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ABSTRACT

Barley is one of the most staple food and economically important widely used cereal crop in Ethiopia. A field experiment was conducted under main season conditions to investigate the effects of blended (NPSB) and nitrogen fertilizer rates on growth and yield of malt barley (Hordium vulgare L.) at Bule Hora, Southern Nations Nationalities, and Peoples Regional State of Ethiopia. Factorial combination of both four level of urea (0, 23, 46 and 69 kg ha^{-1}) and NPSB (0, 50, 100 and 150kg ha^{-1}) with three replications were used as two factors to evaluate the yield and yield component including economic analysis of malt barley in randomized block design. Results indicated that different rates of blended fertilizers had highly significant ($p<0.001$) effect on day to heading and day to physiological maturity. Different rates of blended fertilizers used significantly ($p<0.05$) affected plant height, Number of Effective Tillers, Number of Tillers per plant, above ground biomass per hectare, grain yield per hectare and harvesting index. While, application of blended fertilizer had an on-significant effect on spike length, Thousand-kernel weight, Number of Kernels per Spike, Number spikelet per spike. Moreover, malt barley growth, yield and yield components were highly significantly ($p<0.01$) influenced due to different nitrogen rates used except Number of Kernels per Spike and above ground biomass ($p>0.05$). Significantly a higher growth, yield and yield component of malt barley was recorded due to 150 kg ha^{-1} and 100 kg ha^{-1}NPSB than the rest NPSB rates. Highest yield was scored (72.01 quintal/ha) from 150 kg ha^{-1} NPSB. Moreover, higher growth, yield and yield components were obtained due to 69 kg ha^{-1} rates of nitrogen than the rest rates of nitrogen. Maximum grain yield (83.69 quintal/ha) obtained at 69 kg ha^{-1} rates of nitrogen. The partial budget analysis revealed maximum net benefit of Birr 127426.80 ha^{-1} with an acceptable marginal rate of returns (MRR) of 2850.18 % with the treatment 150 kg blended NPSB ha^{-1}. While, maximum net benefit of Birr 149686.38ha^{-1} with an acceptable marginal rate of returns (MRR) of 8637.45 % with the treatment 69 kg N from urea ha^{-1}. Therefore, the present study suggests that, fertilizer application of 150 kg NPSB ha^{-1}and 69 kg N ha^{-1} were economical, and uncertainly recommended for production of malt barley in the study area and other areas with similar agro-ecological condition and soil type.

Keywords: *Malt barley, yield, blended fertilizer and nitrogen fertilize*

INTRODUCTION

Barley (Hordeum vulgare L.) is one of the most staple food and economically important widely used cereal crop in Ethiopia next to teff, maize, wheat, and sorghumit is an important grain crop in Ethiopia and has diverse ecologies being grown from 1800 to 3400 masl altitude in different seasons and production systems (27).

Malt barley is largely a commercial crop produced for the market both for industrial malt grain production and for cottage local beer and liquor production (9). Barley has been used as animal fodder, as a source fermentable material for beer and certain distilled beverages, and as a component of various health foods. It is used in soups and stews, and in barley bread of various cultures. Barley (Hordeum vulgare L.) is the most important staple food and subsistence crop in Ethiopia. Its grain is used for the preparation of different foodstuffs, such as injera, kolo, and local drinks, such as tela, borde and beer Very recently it is being adopted for preparation of bread all alone or mixed with wheat (17).

However, production of barley in Ethiopia fall under low fertility soils (26). Similarly, (23) investigated that low barley productivity was obtained in the highland of Ethiopia due to low soil fertility. Low soil fertility is one of the bottlenecks to sustainable agricultural production and productivity in Ethiopia (23). Among where the most important factors that reduce yield of barley in Ethiopia is poor soil fertility.

In most regions of Ethiopia, soils are deficient in nitrogen (N) and phosphorus (P), this aggravated by the long history of cultivation without any NP replenishment, which led to low soil fertility and low crop yields (12). Studies show that Ethiopia as having a high nutrient depletion rate of more than 60 kg N, P, and K $ha^{-1}yr^{-1}$. These nutrients are the major constraints for barley production in Ethiopia (22). In Ethiopia, fertilizer use trend has been focused mainly on the use and application of nitrogen and phosphorous fertilizers in the form of Di-ammonium phosphate (DAP) (18-46-0) and Urea (46-0-0) or blanket recommendation for the major food crops. Continuous application of nitrogen (N) and phosphorus (P) fertilizers without due consideration of other nutrients led to the depletion of other important nutrient elements such as potassium (K), magnesium (Mg), calcium (Ca), sulfur (S) and micronutrients in soils (1). Balanced fertilization is the key to sustainable crop production and maintenance of soil health. It has both economic and environmental consideration. Nitrogen is the key nutrient input for achieving higher yield of barley. Barley is very sensitive to insufficient nitrogen and very responsive to nitrogen fertilization (3). Phospholipids, which play critical roles in cellular membranes, are another class of universally important phosphorus-containing compounds. Additionally, Micronutrients are essential elements for plant growth and development, which are utilized in very small amounts by plants.

Among micronutrients, boron plays several important physiological roles in plants such as, in cell elongation, nucleic acid synthesis, hormone responses and membrane function (13). An imbalanced fertilizer use results in low fertilizer use efficiency leading to less economic returns and a greater threat to the environment (1).

Moreover, recently acquired soil inventory data revealed that the deficiencies of most of nutrients such as, nitrogen (86%), phosphorus (99%), sulfur (92%), born (65%) and zinc (53%) are widespread in Ethiopian soils and similarly in study area (11). However, information on the application of rate blended fertilizer (NPS and NPSB) and nitrogen, especially for barley, was not determined for the study area. Therefore, this particular experiment was designed to investigate the effects of different blended and nitrogen fertilizers on yield and yield components of food barley (Hordeum vulgare l.) on Nitisols at Bule Hora district, Southern Ethiopia having the following specific objectives:

- To evaluate the response of malt barley to the application of Urea and NPSB rates.
- To identify the economically feasible rates of Urea and NPSB for malt barley production in the study area.

Materials and Methods

The Experimental Site

The experiment was conducted during the main season of 2019 cropping seasons at Bule hora woreda at fesheka kebele on farmer training center (FTC) west Guji zone of the Oromia regional state under rain fed condition. It is geographically located at 5035' N 38015' E altitude ranging 1500-2400 m.a.s.l. It receives mean annual rain fall of 950 mm, with minimum and maximum temperature of 15 and 23°c, respectively. The soil textural class of the experimental area is clay loam with a pH of 7.21. According to the Agricultural Office of the Bule Hora Woreda, some of the dominant crops that are produced in the woreda include maize, teff, barley, wheat, soybean and beans.

Treatments and Experimental Design

The treatment consists of a 4x4 factorial combination of both four level of urea (0, 23, 46 and 69 kg ha-1) and four level of NPSB (0, 50, 100 and 150kg ha-1). The constituents of fertilizer are; urea (46%N) and NPSB (18.9 N, 37.7 P2O5, 6.95 S and 0.1B). The national fertilizer recommendation for malt barley production (50 kg ha-1 N and 100 kg ha-1 NPSB) was used. There will be sixteen treatment combinations, which was assigned to each plot randomly. The treatments were laid in factorial arrangement, with gross experimental area of 260.7m^2 (6.6m*39.5m).

The land was be ploughed using oxen and plots was level manually NPSB will be apply at sowing time, while nitrogen fertilizer in the form of urea was added to the soil at the rates of 1/3 at planting time and the other 2/3 was apply after at tillering stage to avoid leaching. Malt barely varieties (Holker) was sown at the recommended rate of 125 kg ha-1 and planted in rows by using a manual row marker. Proper hoeing, weeding, and irrigation of the experimental fields were carried out uniformly as per research recommendations.

Data Collection and Analysis

Data collection was successively done on soil sampling and analysis, plant growth and yield parameters. Soil samples were collected from the experimental site at a depth of 0-20 cm before and after harvesting. The samples were prepared following the standard procedures and analyzed for selected soil physico-chemical properties. Soil samples were analyzed for pH using a ratio of 2.5 ml water to 1 g soil (6); for available P using Bray-II method (7); for organic C content using (24) method; for total N content using Kjeldahl method (8); for exchangeable cations and cation exchange capacity (CEC) using ammonium acetate method (6) at the soil and plant analysis laboratory.

Data were collected by sampling middle eight harvestable rows excluding the two border rows and one plant from the end of harvestable rows in both sides. Selected phonological, plant growth, yield, and yield component parameters were collected and analyzed. The data were subjected to analysis of variance using the general linear model procedure (PROC GLM) of SAS statistical package version 9.3 (SAS Institute, 2004).Means for the treatments were compared using the MEANS statement with the least significant difference (LSD) test at the 5% probability level.

Results and Discussion

Selected Soil Physical Characteristics of the Experimental Site

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

Table1. *Selected physico-chemical properties of the experimental site*

Soil physical properties	Tested results
Sand (%)	38
Silt (%)	40
Clay (%)	22
Particle size	Clay loam
Soil chemical properties	**Tested results**
pH	7.21
Organic matter content (%)	0.47
Available nitrogen (%)	0.024
Available phosphorus (ppm)	6.00
Electrical conductivity (ds/m)	2.00
Available potassium (ppm)	0.40
Available Boron (Mg/Kg)	0.40
Iron (Mg/l)	2.48
Cupper (Mg/l)	6.00
Zink (Mg/l)	1.00
CEC Cmol/Kg	65.00
Available sulfer (Mg/Kg) 14	14.00

Soil physical (pH) and physico-chemical properties (TN, OM) of the experimental site was rated and classified according to Tekalign (1991). On the other hand, available P was rated as per Olsen *et al.* (1954). As indicated in table 3, the analysis result before sowing was 7.21 for pH, 0.024% for total nitrogen (TN), 0.47% for organic matter (OM) content, 6.00 ppm for available phosphorous (P). The pH was classified as neutral. Values of OM content of the soil was rated as very low (<0.86%). Never the less, available P content and TN were low in the soil. Limited availability of soil nutrients affects crop production and productivity. Thus, addition of single and/or combined fertilizers at the right time and rate might be required whenever there is nutrient deficiency in the study area. The value of EC (2.5 ds/m) was lower considering the standard rates in the literature (16). Soil salinity was not a problem at the time. Generally, according to USDA soil classification, a soil with electrical conductivity of less than 2.0 dS/m at 25°C and pH less than 8.5 are classified as normal soil. Therefore, the soil of the study area was normal soil. So that the pH level of the study is conducive for barley production as normal soil pH for barley is recorded to be from pH of, 6.25 - 7.5 arrange appropriate condition for most barley verities.

The CEC of the site was 65.00-cmol kg-1 (Table 3). Landon, et al. reported that soils having CEC of >40, 25-40, 15-25, 5-15,< 5 cmol kg-1 categorized as very high, high, medium, low and very low, respectively. According to the result obtained from soil laboratory, the value of CEC was in very high range. Available Boron in the study area was 0.40 mg kg-1 (Table 3). EthioSIS, critical B value for most Ethiopian soils is 0.8 mg kg-1. This shows that soils of the study area are deficit in B suggesting application of fertilizer, which contains B. Intensive cultivation in the area, was responsible for low B content of the soil. Available sulfur value of the study area was 14.00 mg kg-1 (Table 3). Based on EthioSIS soil classification for S values lies on low range. The classification is < 9 very low, 10-20 low, 20-80 optimum, and > 80 mg kg-1 high. So, addition of fertilizer which contains S is relevant. This low in sulfur content of the soil may be due to loss of OM and lacking of using S source mineral fertilizer. It was also related to continuous cultivation, which result intensive mining of S from the soil. More over iron, cupper and Zink values of the study area before sowing was 2.48,6 and 1 Mg/l, respectively.

Effect of Blended Fertilizer and Ureaon Phonological Parameters of Barley

Days to Heading

The analysis of variance revealed that the main effect of blended fertilizer and urea application had significant (P<0.001) effect on days to heading having longer days to heading (81.25) of barely was recorded in 23 kg ha^{-1} urea fertilizer rate compared to the control. Where us, longer days of heading (81.91) of barley was recorded in100 kg ha^{-1}blended fertilizer rate compared to the control. The shortest days of heading was observed both for blended and urea fertilizer (80.58) and (79.75) at control, respectively. This difference could be attributed to the application different rates of blended fertilizer rates and urea for malt barley varieties. The difference in nitrogen fertilizer application time might be related to extended vegetative growth stage that delay days to heading. (18) Also reported that nitrogen application significantly affected days to heading in barley. The result indicates that as the amount of nitrogen fertilizer applied at tillering increases, days to heading also simultaneously increased. This is in line with(18) who reported that plants that received 8 g N m–2 at active tillering headed slightly later than those did that received 0 g N m–2. These results also in line with Bekalu & Mamo who reported that, N fertilizer rate and blended fertilizer rate significantly affected days to maturity on.

Days to Physiological Maturity

Days to physiological maturity was (P< 0.001) affected by the main effects of blended fertilizer and urea on malt barley (Table 4). Days to maturity followed the same trend as Days to heading. The longest physiological maturity (138.08) and (137.50) was observed at 100 kg ha-1 of NPSB application with 23 kg ha^{-1} supplementary urea, respectively. The shortest physiological maturity were observed for blended fertilizer and urea on barley production (134.41) and (135.83) at control, respectively. This difference could be attributed to the application different rates of blended fertilizer rates for malt barley varieties. These results were in line with Bekalu &Mamo who reported that, N fertilizer rate significantly affected days to maturity on barley and wheat. The results are similar to Marschener. Who observed when N is applied in excess; the maturity of the crop is delayed by affecting the supply of photosynthesis during critical period of the reproductive phase? Moreover, when N is applied in excess to barley and wheat, the sugar concentration in leaves is reduced during early ripening stage and hence, inhibition occurs in the translocation of assimilated products to spikelet.

Table2. *Effect of blended fertilizer and urea on phonological parameters of barley*

Treatments		DH	DPM
	0	79.75^{b}	135.83^{b}
UREA (kg ha^{-1})	23	81.25^{a}	137.50^{a}
	46	80.66^{a}	136.41^{ab}
	69	80.58^{ab}	136.66^{ab}
	LSD $_{0.05}$	0.87	1.55
	0	80.58^{b}	136.83^{a}
NPSB (kg ha^{-1})	50	78.66^{c}	134.41^{b}
	100	81.91^{a}	138.08^{a}

	150	81.08[ab]	137.08[a]
	LSD $_{0.05}$	0.87	1.55
	CV (%)	1.29	1.36

*Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at p<0.05 level of significance. DH= day to heading and DPM = day to physiological maturity

Effect of Blended Fertilizer and Urea on Growth Parameters of Barley

Plant Height

The analysis of variance revealed that Plant height was significantly ($p<0.05$) influenced due to different rates of blended fertilizer and different rates of urea (Table 5). Maximum plant height (91.15 cm) was observed for 150 kg ha^{-1} blended fertilizer rate, whereas the minimum plant height (83.39 cm) was observed at control. The maximum plant height recorded at 150 kg ha^{-1} blended fertilizer rate was statistically superior to the control and this was statistically not significant with the rest blended fertilizer rates. On the other hand, the shorter plant height was observed at control and this was statistically not significant with that of blended fertilizer rates except 150 kg ha^{-1} blended fertilizer rate.

The study also revealed that maximum plant height of 90.77 cm was obtained at 46 kg ha^{-1} urea. The maximum plant height obtained at 46 kg ha^{-1} urea was not statistically different from the rest rates of urea. On the other hand, the minimum plant height of 83.48 cm was observed at control and it was statistically inferior to the rest urea rates except 23 kg ha^{-1} urea.

Similar studies also reveal that plant height is affected due to different rates of NPSB and different rates of urea in different crops. Most of the growth parameters results were increased along the application rates of NPSB when supplemented with urea fertilizer. The result showed that plant height increases at an increasing rate of nitrogen levels. (2)Also reported similar results of plant height increment with N rate increase and Sofonyas reported significant increments in plant height due to application of high nitrogen rate. The increase in plant height with increasing NPSB could have resulted due to sufficient supply of nutrient, which encourages plant growth: nitrogen plays critical role in the structure of chlorophyll, while P is main element involved in energy transfer for cellular metabolism in addition to its structural role Wiedenhoeft AC. The result was in agreement with the findings of (23).

Spike length

Spike length was not significantly ($p < 0.05$) influenced by the main effects of blended fertilizer rate while significantly ($p < 0.05$) influenced by the main effects of urea. The highest spike length (7.57 cm) was recorded from the plot treated with 46 kg ha^{-1} of urea application which improved by 7% as compared the shortest spike length (7.04 cm) obtained from the control plot (Table 5). According to the experiment the application of mixed blended fertilizer rates along supplementary nitrogen were significantly influenced as compared to the control plot. Bekalu &Mamo reported that optimum amount of fertilizer application has significant effect on spike length growth.

Number of Tillers per plant

The analysis of variance revealed that highly significant ($p<0.01$) difference was observed on barley number of tillers per plant due to different rates of urea while blended fertilizer rates didn't show significant($p>0.05$)variation among treatments during the study season (Table 5).The highest (2.76) number of tillers per plant was obtained at 69 kg ha^{-1} urea and it was statistically superior to the control and similar with that of the rest rates of urea. On the other hand, the minimum (1.73) number of tillers per plant was obtained at control, which was statistically similar to that of 23 and 46 kg ha^{-1} urea rates. The lowest numbers of tillers per plant (1.73) were recorded for barley at control plot; which might be due to the role of N in accelerating vegetative growth of plants. The highest number of tillers per plant was obtained at 69 kg ha^{-1} urea were improved by 36% as compared to the lowest number of tillers per plant at control. The results were in agreement with that of Abdullatif, et al. who reported that increasing in the number of effective tillers with nitrogen fertilization. Bereket, et al. and Abdollahi, et al. also reported that nitrogen fertilization has significant effect on effective number of tillers of barley. Giday et al. also reported positive and significant increase in number of productive tillers with increasing rates of N fertilizer on teff.

Table3. *Effect of blended fertilizer and urea on growth parameters of barley*

Treatments		PH (cm)	SL (cm)	NTPP
	0	83.48[b]	7.04[b]	1.73[b]
UREA(kg ha^{-1})	23	86.75[ab]	7.37[ab]	2.21[ab]
	46	90.77[a]	7.57[a]	2.23[ab]
	69	88.57[a]	7.48[a]	2.76[a]
	$LSD_{0.05}$	7.01	0.36	1.00
	0	83.39[b]	7.33	1.88[a]
NPSB(kg ha^{-1})	50	84.51[ab]	7.25	2.15[a]
	100	87.53[ab]	7.39	2.41[a]
	150	91.15[a]	7.50	2.50[a]
	$LSD_{0.05}$	7.01	NS	NS
	CV (%)	9.70	5.91	53.64

**Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at p<0.05 level of significance. PH= plant height, SL = Spike length and NTPP = Number of Tillers per plant*

Effect of Blended Fertilizer and Urea on Yield and Yield Components of Barley

Thousand Kernel Weight

The analysis of variance indicated that different urea rates had a highly significant ($p<0.001$) effect on thousand kernel weight of barley (Table 6), while the different blended fertilizer rates on malt barley has shown no significant ($p>0.05$) influence on thousand kernel weight. The highest (15.90 g) thousand-kernel weight was obtained at control and it was statistically superior to the rest urea rates. On the other hand, the minimum (14.16 g) thousand-kernel weight was obtained at 69 kg ha-^{1} urea that was statistically similar to that of 23 and 46 kg ha^{-1} urea. In contrast with the result of this study,(15) who reported that average thousand-kernel weight was ranged from 41.43 g to 43.34 g as the rate of nitrogen increase from zero to 69 kg N ha-1. The lower thousand kernel weight was recorded when recommended N is applied basal at planting. This could be related to loss of applied N due to leaching or volatilization or other means. In general, thousand-kernel weight is an important yield determining component and reported to be a genetic character that is influenced least by environmental factors (4).

The increase in thousand kernel weight with increasing rate of NPSB from 0/0 to 32/23 N/P 2O5 could be related to plant growth, the higher the plant growth the higher the photosynthetic area and so photosynthesis, the higher assimilate translocation to the sink. In another way, the reduction in thousand kernel weight with increasing applied rates of both NP beyond 32/23 N/P2O5 might probably be the result of insufficient supply of carbohydrates to individual spikelet's due to competition effect resulted by vigorous plant growth and the increased number of its spikelet's. Tis result agreed to the findings of Heluf and Mulugeta who stated as only application of 13.2 kg ha-1 of P fertilization significantly increased thousand-kernel weight of rice but N had no effect on this parameter (5). Similarly, Hasegawa et al. reported that increased number of spikelets and vigorous growth of rice due to high rates of N fertilizer application induced competition for carbohydrate available for grain filling and spikelet formation (15).

Number of Kernels Per Spike

The effect of blended fertilizer and urea on number kernels per spike of barley was analyzed and the results obtained are presented in Table 6. The statistical analysis carried out indicated that no significant effect among treatments at ($p < 0.05$).Even if, no significant effect observed among treatments, the highest number kernels per spike (23.25cm) and (22.80cm) was recorded from 46 kg ha^{-1} urea under 150 kg ha^{-1} NPSB followed by (22.73 cm) and (22.76cm) obtained 23 kg ha^{-1} urea with 100 kg ha^{-1} NPSB while the shortest number kernels per spike(169.96 cm) was observed at 100 kg ha^{-1} NPSB with no urea condition, respectively (Table 6).Increasing trends of number kernels per spike was observed when both rates of fertilizers increased. This might be due to the addition of blended fertilizer application rates in the experimental site there was increased the appearance of seeds in their spikes. The results were in conformity with that of (23) who stated that increasing N rates up to optimum level significantly increased number of seed spike^{-1}.

Number Spikelet Per Spike

The analysis of variance indicated that different rates urea of application had a highly significant ($p<0.01$) effect on number spikelet per spike of barley (Table 6), while the different blended fertilizer rates on barley has shown no significant ($p>0.05$) influence on number spikelet per spike. The highest (13.58) number spikelet per spike was obtained at 46 kg ha^{-1} urea and it was statistically superior to control and similar with that of the rest urea rates. On the other hand, the minimum (11.78) number spikelet per spike was obtained at no urea condition that was statistically inferior to that of urea rates. Application of fertilizer from control to higher rates of fertilizer increased number spikelet per spike of barley. This result implies that, g number spikelet per spike of barley formation was highly affected by fertilizer (Table 6). This result is in line with of (21)and (23) who reported that the variation of number spikelet per spike of barley with application of fertilizer rates.

Number of Effective Tillers

The analysis of variance indicated that the effect of urea and blended fertilizer application over total number of effective tillers were not significant over factors evaluated (Appendix Table -). However, the maximum and minimum mean values were observed from 100 kg ha^{-1} NPSB with 69 kg ha^{-1}urea (1.63), (1.71) and control (0.81), (0.91), respectively.

Table4. *Effect of blended fertilizer and urea on yield and yield components of barley*

Treatments		**TKW (g)**	**NKS(cm)**	**NSPS**	**NET**
	0	15.90^{a}	21.65	11.78^{b}	0.91^{a}
UREA (kg ha^{-1})	23	14.53^{b}	22.73	12.96^{a}	1.21^{a}
	46	14.39^{b}	23.25	13.58^{a}	1.25^{a}
	69	14.16^{b}	22.30	12.73^{a}	1.71^{a}
	LSD $_{0.05}$	0.74	NS	0.87	0.81
	0	15.35	22.60	12.85	0.81^{b}
NPSB (kg ha^{-1})	50	14.65	21.77	12.32	1.10^{ab}
	100	14.40	22.76	13.17	1.63^{a}
	150	14.58	22.80	12.70	1.55^{ab}
	LSD $_{0.05}$	NS	NS	NS	0.81
	CV (%)	6.04	9.97	8.23	76.80

**Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at p<0.05 level of significance. TKW= Thousand kernel weight, NKS = Number of Kernels per Spike, NSPS = Number spikelet per spike and NET = Number of Effective Tillers*

Grain Yield Production

Different rates of blended fertilizer have significantly influenced the grain yield of barley per hectare production ($P < 0.05$) from the result obtained highest yield was scored (72.01quintal/ ha) from 150 kg ha^{-1} NPSB and it has a significant difference with control and statistically the same with that of rest blended fertilizer rates (table 7). Contrary to this, minimum grain yield (49.90quintal/ha) was obtained at control. The minimum grain yield obtained at control was statistically inferior with that of blended fertilizer rates.

The highest grain yield of barley obtained at 150 kg ha-1 NPSB lead to an improvement of 30% than the control. Of the fertilizer application in NPSB treatments, showed the least effect on yield, while that of treatments in the control showed the greatest reduction of yield. The reduction of fertilizer from 150 kg ha-1 NPSB to zero blended fertilizer rate leads to reduction of grain yield by 30%. The data reveal that higher amount of fertilizer application associated with larger amount of grain yield production and less amount of fertilizer application leads to less amount of grain yield production per hectare.

The highest grain yield at the highest NPSB rates might have resulted from improved root growth and increased uptake of nutrients and better growth favored due to the synergistic effect of the four nutrients, which enhanced yield components and yield. Nitrogen affects the vegetative as well as yields whereas phosphorus plays a fundamental role in metabolism and energy producing reaction and can withstand the adverse environmental effects, thus resulting in enhanced grain yield.

The analysis also revealed that different rates of urea on barley had a highly significant ($p<0.001$) influence on grain yield. Maximum grain yield (83.69quintal/ha) was observed at 69kg ha^{-1} rates of urea. The maximum grain yield obtained at 46 kg ha-1 rates of urea was statistically different with that of the rest treatments (Table 7). Moreover, the minimum (49.05 quintal/ha) grain yield obtained at urea condition it was significantly inferior to both 46 and 69kg ha-1 rates of urea and similar with 26 kg ha^{-1} rates of urea. The highest grain yield of barley obtained at 69 kg ha^{-1} rates of urea lead to an improvement of 41% over no urea condition.

The increased shoot dry matter yield in response to the increased rate of nitrogen application may probably be attributed to increased concentration of nitrogen fertilizer in the soil that may have enhanced root uptake of the nutrient possibly resulting in increased concentration of chlorophyll in the leaves, heightened rate of photosynthesis, high rate of leaf expansion, increased leaf number and dry matter accumulation in the above ground biomass. This result is consistent with the result of (12) that, nitrogen fertilizer plays an important role in canopy development, which in turn increases shoot dry matter.

Nitrogen is an integral component of many compounds essential for plant growth processes including chlorophyll, which is responsible for the dark green color of stems and leaves, which enhances vigorous vegetative growth, plant height, branching and/or tillering, leaf production and size enlargement and many enzymes (12). Nitrogen also mediates the utilization of potassium, phosphorus and other elements in plants. The result affirmed that addition of supplementary N at growing stage attributed to partition of N to grain yield for subsequent growth and development.

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

Aboveground Biomass

The different rates of blended fertilizer on barley have shown a significant ($p<0.05$) influence on aboveground biomass production (Table 8). According to the data, there is no association between urea and aboveground biomass production significantly. Furthermore, their interaction did not show significant effect on aboveground. The highest aboveground biomass (44422.90 kg ha^{-1}) was observed at 150 kg ha^{-1} NPSB. The maximum aboveground biomass obtained at 150 kg ha-1 NPSB was statistically superior to control and similar with that of the rest blended fertilizer rates. Contrary to this, minimum aboveground biomass (3194.40kg ha^{-1}) was obtained at control. The minimum aboveground biomass obtained at control was statistically similar with that of 50 and 100ha^{-1}NPSB.The highest aboveground biomass of maize obtained at 150 kg ha-1 NPSB lead to an improvement of 27.27 % than the control. In general, aboveground dry biomass was increased with increase in NPSB rate, which might be due to improved root growth and increased uptake of nutrients favoring better growth, and delayed senescence of leaves of the crop due to synergetic effect of the nutrients (NPSB). In addition, this might be due to highest blended fertilizer rates in the root zone due to high nutrient amount in 150 kg ha^{-1} NPSB leads to make a favorable condition for maize physiological and photosynthesis processes. Different studies revealed that adequate nutrients in the root zone leads to improve aboveground biomass and grain yield of barley.

The current finding is in line with Melkamu et al. (2019) who reported blended fertilizer supply had a marked effect on the aboveground biomass, grain yield, and straw yield. The maximum aboveground biomass (12.63 t ha-1) was obtained from 200NPSB kg ha^{-1} of blended fertilizer application. However, the lowest (4.29 t ha^{-1}) above ground biomass was recorded from control or unfertilized plot. This result also agrees with the finding of (25) who found that application of 150 kg ha-1 NPSB blended fertilizer with compost increased the biomass by 11.5 t ha^{-1}. This due to Sulfur enhanced the formation of chlorophyll and encouraged vegetative growth and B helps in N Absorption.

Harvest Index

Analysis of variance revealed that, harvest index was not significantly affected by main effect of blended NPSB fertilizer rates and urea fertilizer rates. Moreover, the interaction effect of blended NPSB and varieties was not significant on the harvest index.

Table5. *Effect of blended fertilizer and urea on yield and yield components of barley*

Treatments		**ABM(kg/ha)**	**GY (quintal/ha)**	**HI (%)**
	0	3423.0	49.05^c	15.35^a
UREA (kg ha^{-1})	23	3569.4	50.79^c	16.39^a
	46	4084.8	68.08^b	18.49^a
	69	4126.8	83.69^a	21.49^a
	LSD$_{0.05}$	NS	15.14	8.01
	0	3194.4^b	49.90^b	17.45^a
NPSB (kg ha^{-1})	50	3524.3^{ab}	69.68^a	22.26^a
	100	4062.5^{ab}	60.03^a	15.82^a
	150	4422.9^a	72.01^a	16.15^a
	LSD $_{0.05}$	927.49	15.14	8.01
	CV (%)	29.26	28.87	53.63

**Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at p<0.05 level of significance. ABM = above ground biomass per hectare, GYPHA = grain yield per hectare and HI = harvesting index*

Grain Quality Parameters

Hectoliter Weight

Results showed significant differences (P< 0.001) among NPSB blended fertilizer rate treatments and N from urea for hectoliter weight. Moreover, the interaction effect of the two factors was also significant. The highest (66.45 kg ha^{-1}) hectoliter weight was recorded from the highest applied N fertilizer (69 kg ha^{-1}), whereas the lowest (55.54 kg ha^{-1}) hectoliter weight was obtained from control treatment (Table 8). Hectoliter weight was found to increase with increasing nitrogen application rates from zero to (69 kg ha^{-1}) this might be N is an essential component of the proteins used to build cell materials and plant tissues. Moreover, (5) who found that under more favorable growing conditions slight increase specific weight in response to N fertilizer application. Rick et al. (2014) reported that the acceptable test weights (hectoliter weight) for barley were in the range 66.1- 72.8kg ha^{-1}. The current results exhibited an acceptable hectoliter weight in all N fertilizer rates except the control. While, the highest hectoliter weight (63.28 kg ha^{-1}) recorded from blended NPSB at 150 kg ha^{-1} and it was statistically same with the previous rates of NPSB while the lowest hectoliter weight (62.63 kg ha^{-1}) was recorded from the control treatment. Significantly higher hectoliter weight with the application of blended NPSB rate might be due to the role of balanced nutrients on quality of barley such as flour yield and protein content as N increases the plumpness and protein content of the cereal grains. Similarly, the highest hectoliter weight (80.2 kg ha^{-1}) recorded from blended NPSB at 183 kg ha^{-1} (80.2 kg ha^{-1}) and it was statistically at par with the two preceding rates of NPSB while the lowest hectoliter weight (77.3 kg ha^{-1}) was recorded from the control treatment was reported by (Dinkine). Rick et al. (2014) reported that the acceptable test weights (hectoliter weight) for barley were in the range 66.1- 72.8kg ha^{-1}. The current results exhibited an acceptable hectoliter weight in all blended fertilizer rates except 50 kg ha^{-1} NPSB fertilized treatment.

Grain protein content

The main effect of N highly significantly (P < 0.001) influenced the grain protein content. However, the main effect of blended NPSB and the two-factor interaction did not significantly influence the grain protein content of durum wheat. Grain protein content increased almost linearly in response to the increased rate of nitrogen fertilizer application. The highest grain protein content (12.73 %) was obtained at the highest rate of N (69 kg N ha^{-1}) which was statistically superior with the rest N rates; whereas the lowest grain protein content (10.83%) was obtained from unfertilized plot

(Table 8). Increasing the application of N fertilizers from nil to 69 kg N ha^{-1} remained at par to each other, consistently increased grain protein contest. Generally, grain protein contents obtained at the application of 69 kg N ha^{-1} exceeded that of the nil N by about 14.92%.

The increase in grain protein with increasing nitrogen rate might be due to greater synthesis and accumulation of storage proteins. Nitrogen is the building block of protein in which nitrogen increases the plumpness of the cereal grains and protein content of both seeds and foliage (Foth and Ellis, 1997).

Adane (2015) found that with low available nitrogen in the soil, malt barley responds well to applied fertilizer, showing increases in both grain yield and protein content. Increasing in protein may increase steep times, create undesirable qualities in the malt, excessive enzymatic activity and low extract yield (14). It also slows down water uptake during steeping, potentially affecting final malt quality.

According to the Ethiopian standard authority and Asella malt factory (AMF), the protein level of the raw barley quality standard for malt should be between 9-12% (10).

Both main effect of N fertilizer rate and blended fertilizer rates had grain protein content within the acceptable range (Table 8).

Table6. *Effect of blended fertilizer and urea on grain quality parameters of barley*

Treatments		**HLW**	**PC**
	0	55.54^{d}	10.83^{d}
UREA (kg ha^{-1})	23	61.64^{c}	11.55^{c}
	46	64.20^{b}	12.11^{b}
	69	66.45^{a}	12.73^{a}
	LSD $_{0.05}$	0.70	0.35
	0	62.63^{b}	11.81
NPSB (kg ha^{-1})	50	59.95^{c}	11.75
	100	62.63^{ab}	11.83
	150	63.28^{a}	11.82
	LSD $_{0.05}$	0.70	NS
	CV (%)	1.35	3.64

**Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at p<0.05 level of significance. HLW = Hectoliter weight and PC = Grain protein content*

Partial Budget Analysis of Barely Yield Production

The market price of barley grain was 20.00 Eth-birr kg^{-1} and prices for blended fertilizers NPSB and Urea were 14.62 and 13.93 Eth-birr kg^{-1}, respectively. While the cost of other production practices like cost of labor, seed and weeding were assumed to remain the same or insignificant among the treatments. Partial budget analysis of the combination of nitrogen levels with different rates of blended fertilizers was presented in Table 9. Partial budget analysis was done using procedure described by CIMMYT Economics Program (1988) recommendations, which stated that application of fertilizer with the marginal rate of return above the minimum level (100%) is economical.

Information on costs and benefits of treatments is a prerequisite for adoption of technical innovation for farmers. The results in this study indicated that the application of blended NPSB and N fertilizer rate resulted in higher net benefits than the unfertilized/control treatments (Table 9). As a result, the partial budget analysis revealed maximum net benefit of Birr Birr 127426.80 ha-1 with an acceptable marginal rate of returns (MRR) of 2850.18 % with the treatment 150 kg blended NPSB ha-1 (Table 9). However, the lowest net benefit of (Birr 89836.20 ha-1) was recorded from control treatment. While, maximum net benefit of Birr 149686.38 ha^{-1} with an acceptable marginal rate of returns (MRR) of 8637.45 % with the treatment 69 kg N from urea ha^{-1} (Table 9). However, the lowest net benefit of (Birr 88304.40 ha^{-1}) was recorded from control treatment.

Therefore, fertilizer application of 150 kg NPSB ha^{-1} and 69 kg N ha^{-1} were economical, and uncertainly recommended for production of malt barley in the study area and other areas with similar agro-ecological condition

Table7. *Partial budget analysis of barely yield production under blended NPSB and N fertilizers rate in Bulehora District.*

Treatments		Yield (kg/ha)	Adjusted Yield(kg/ha)	TotalReturn (Birr/ha)	Totalcost (Birr/ha)	Net Income (Birr/ha)	MRR (%)
	0	4990.90	4491.81	89836.20	0.00	89836.20	0.00
NPSB (kg ha-^{1})	50	6968.50	6271.65	125433.00	731.00	124702.00	4769.60
	100	6003.00	5402.70	108054.00	1462.00	106592.00	0.00
	150	7201.10	6480.99	129619.80	2193.00	127426.80	2850.18
	0	4905.80	4415.22	88304.40	0.00	88304.40	0.00
UREA (kg ha^{-1})	23	5079.50	4571.55	91431.00	321.54	91109.46	872.38
	46	6808.70	6127.83	122556.60	643.08	121913.52	9580.16
	69	8369.50	7532.55	150651.00	964.62	149686.38	8637.45

N.B: Prices of Urea: 13.4 birr/kg, NPSB: 14.62, Price of barley: 20 birr/kg in local market. Family labor cost was not assigned cost because similar labor time was used on each treatment.

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