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**Effect of Nitrogen Levels on Grain Yield and Protein Content of Malt Barley (Hordeum Vulgare L.) Varieties in Digalu-Tijo District, Southeastern Ethiopia**

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**ABSTRACT**

Nitrogen is the most important plant nutrient for crop production and grain quality of malt barley improvement; but the yield and quality of malt barely produced in Ethiopia is very low due to nutrients diminished from the soil. A field experiment was conducted at Digelu–Tijo District, Southeastern Ethiopia to evaluate the effect of different rates of nitrogen on yield and protein content of two malt barley varieties in 2015/16 cropping season. Factorial arrangements of the two malt barley varieties (Grace and Traveler) and six nitrogen rates (0, 19.0, 30.5, 42.0, 53.5 and 65.0 kg N ha$^{-1}$) were laid out in a randomized complete block design with three replications. Nitrogen rate had significant ($P<0.05$) effect on days to physiological maturity, plant height, tiller number, grain per spike, spike length, grain yield, biological yield, straw yield, harvest index and grain protein content. Variety had significant ($P<0.05$) influence on days to physiological maturity, plant height, spike length, grain per spike and thousand kernel weights. Their interaction showed significant ($P<0.05$) influences only on grain per spike and harvest index. When nitrogen fertilizer rate increased from 0 to 65 kg ha$^{-1}$, the growth, yield and quality components were significantly increased with corresponding increase of grain yield from 17.8 to 58.8 quintals. The responses of malt barley varieties to applied nitrogen fertilizer rate increased with respect to growth, grain yield and yield components. Thus, irrespective of varieties, the highest net benefit of 38481.55 Birr ha$^{-1}$ with acceptable protein content (11.3%) was recorded at nitrogen fertilizer rate of 65 kg ha$^{-1}$ in the study area. Generally, from the study result, it can be concluded that the farmer in the study area can produce optimum grain yield and quality of malt barley varieties at the application rate of 65 kg ha$^{-1}$ of nitrogen fertilizer in the study area.

However, further studies should be done using more levels of nitrogen at different seasons and locations through integrating with other fertilizer types to reach at dependable conclusion.

**Keywords**: malt barley, grain yield, protein content, nitrogen fertilizer, economic yield, traveler and grace varieties.

## 1. INTRODUCTION

Barley (*Hordeumvulgare* L.) is one of the cereal crops which are an important crop in the world, mainly used for animal feed and malt. It is the fourth cereal crop in the world, and the most adaptable crop. It is also one of the most important staple food crops produced in the highland areas of Ethiopia. Its grain is used for the preparation of different foodstuffs, such as injera, Kolo, and local drinks, such as tela, borde and beer. The straw is used as animal feed, especially during the dry season. Besides its use as food, feed and beverage barely has many important features. It is adapted to wide environmental condition, matures soon and has high yield potential. According to Hailu and Van LeurJoop (1996) report, barley has wide environmental adaption with matures soon and has high yield potential.

Soil fertility is the greatest factor influencing growth and yield of barley crop; from soil nutrient, nitrogen is the most important plant nutrient for crop production in most of crop producing areas and the most deficient plant nutrient in the most of the soils. According to Kho (2000) report, nitrogen and phosphorus are among the most limiting nutrients for barley productivity. Yields of barley under N and P stresses were reported to be less than 50-46% as compared to those of non-stressed environments (Atlin and Frey, 1989; Cantero-Martínez *et al*., 2003). Also Sinebo *et al*. (2003) reported that about 65% of grain yield difference in barley was attributed to nitrogen stress. Also, Bertholdsson (1999) and Fox (2008) reported that an increase in grain protein content with N fertilizer addition. Similarly, Meharie and Kindie (2010) reported that application of 46 kg N $ha^{-1}$ on average could gave optimum yields of acceptable grain protein content of Holker and Miscal-21 barley varieties demanded by the malting industry.

However, increasing N fertility beyond a certain limit induced lodging and ultimately decreased grain yield and its components. According to Pettersson (2007) report, too much protein lowers the extract yield giving unclear beer, slowing down the start of germination, too little protein which results in lower enzyme activity and slowing growth of the yeast in the brewery. Also

Palmer (2000) research result indicated that uneven protein and maturity levels. One reason for difficulties in establishing acceptable crude protein content of grain is that it depends on the nitrogen supply from fertilizer and soil, as well on the carbon supply from the atmosphere (Wang *et al.,* 2001; McKenzie *et al.,* 2005; Mengel *et al.,* 2006).

The production of malt barley used by factory in Ethiopia was only about 2% of total barley produced and supplied into malt barley factory in the country (Tefera, 2012). According to ATA 2012 report, the demand of factory was fulfilled only by one-third by local supplier where as two-third were imported from foreign country. Malt barley quantity needed by brewery factories in Ethiopia [BGI-Castel, Diageo (Meta, Zemen)], Dashen, Bedele, Heineken [(Harar and Waliya) and Raya beer] reached 110,000 to 130,000 MT in the year 2016. According to Grant (2000) report the most important limiting factors which highly affect the yield and quality of malt barley are variety, fertilization, seed rate, sowing time, and soil moisture. The greatest constraints in malt barley production are limited research related nitrogen, varieties and agronomic practices to improve yield and malt quality traits of the barley varieties. Now a day some improved cultivars (like variety Grace and Traveler) were released to solve these problems which were adapted to our country's environment which exhaustively utilize nutrients from the soil. For sustainable production of crops for a particular area and variety specific fertilizer recommendation is very crucial; even if farmers are not using new technologies including new varieties and appropriate package of fertilizers. But nitrogen requirement differ from cultivar to cultivar and also with site of production as a result of its characterization by depletion by different processes. To produce the expected amount of yield and quality of the crop it should be important to know the standard amount of N fertilizer required by the crop. Thus, this study was initiated with the objective of evaluating the effect of different rates of nitrogen on the yield and protein content of malt barley varieties.

## 2. Materials and Methods

### 2.1. Description of the Study Area

The experiment was conducted at Digalu-Tijo district, Arsi zone of Oromia Regional State, Ethiopia during the 2015/16 main cropping season, from mid-July to mid-December. The area is located at longitude of 38°59 ' 40" to 39 ° 24'31" E and Latitude of 7 °35'57" to 7 ° 59'40" with an altitude range of 2000 to 3600 m.a.s.l. The experimental soil contained 22% sand, 44% silt and 34% clay. Rain fall received and temperature recorded during the growth period of the crop indicated in Table 1.

Table 1: Mean monthly rainfall, minimum and maximum temperatures at study area during 2015/16 main cropping season

| | Months | | | | | | |
|---|---|---|---|---|---|---|---|
| Climatic Variables | June | July | August | September | October | November | December |
| Rain Fall | 103 | 54.4 | 55.5 | 115.2 | 12.7 | 28.4 | 0.3 |
| Tmin | 13.4 | 12.8 | 12.7 | 12.3 | 13.8 | 12.2 | 11.7 |
| Tmax | 24.6 | 23.8 | 23.4 | 22.8 | 24.9 | 23.7 | 23.0 |
| AVGT | 19.0 | 18.3 | 18.0 | 17.5 | 19.4 | 18.0 | 17.3 |

## 2.2. Experimental Materials

The two malt barley varieties (*Grace* and *Traveler*) were introduced to Ethiopia by Heineken Breweries Share Company following the adaptation test made at Holota Agricultural Research Centre (HARC). The varieties were selected based on good agronomic performances, low lodging, plant height, yield potential and disease resistances (Table 2).

Table 2: Description of malt barley cultivars used in the experiment during 2015/16 main cropping season

| NO. | Name of Varieties | Area of adaptation | | | Maturity days | Maintainer center |
|---|---|---|---|---|---|---|
| | | Year of release | Altitude (m) | Rainfall (mm) | | |
| 1 | Grace | 2013 | 2000-2400 | 500-1000 | 95-155 | HARC/EIAR |
| 2 | Traveler | 2013 | 2200-2600 | 500-1000 | 130-160 | HARC/EIAR |

**Source**: Ministry of Agriculture (MoA) June (2013). Plant Variety Release, Protection and Seed Quality Control Directorate Crop Variety Registrar Issue NO 16, Where: HARC= Holeta Agricultural Research Center, EIAR=Ethiopian Institute of Agricultural Research.

### 2.3. Experimental Design

The treatments were consisted of a combination of two malt barley varieties (Traveler and Grace) and six nitrogen levels (0, 19, 30.5, 42, 53.5 and 65 kg N $ha^{-1}$), which were applied from both NPS and Urea. The same level of NPS fertilizer (100 kg NPS $ha^{-1}$) were applied per plot to each treatment, except the treatment without any of external fertilizer (control). The two varieties and fertilizer rates combinations were replicated three times in factorial randomized complete block design (RCBD).

### 2.4. Experimental Procedures and Plot Size

Fertilizer materials applied were phosphorus, nitrogen and sulfur nutrients in the form of NPS. Urea was applied in split form; one third during sowing and two third after 30 days of germination. Urea fertilizer was used to adjust the nitrogen levels available in compound fertilizer NPS in each treatment level. For this experiment, constant rate of NPS and different levels urea were used excluding control adjust the rates of nitrogen required for the treatment. NPS fertilizer containing 19%N: 38%P: 7% S nutrients.

The total experimental land size was 36 x 5.6 $m^2$ = 201.6 $m^2$ and the total experimental area was 2x3x6=36 plots, each measuring 1.4m x 4m (5. 6 $m^2$). Spacing of 1 m between blocks and 0.5 m between plots were used. Total spacing between plot were 0.5mx 1.4 mx36 =25.2 $m^2$; path way between block was 1mx4mx3 =12 $m^2$. Thus, the total experimental area was 352.8 $m^2$ (25.2m × 14m). Seeds were planted at a rate of 56g/plot or 100kg/ha; and NPS fertilizer rate was 56g/plot or 100kg/ha.

### 2.5. Trial Management

Land preparation for experiment was ploughed four times by oxen including land clearing or removing unwanted things from the field. After the land prepared for sowing, NPS and one –

third of calculated rate of urea fertilizer were applied during sowing. Phosphorus and sulfur nutrients were applied uniformly to all plots in the form of NPS. The remaining two–third of urea rate calculated for the experiment was applied by top dressing after 30 days of seeds germination. The seeds were sown in row of 3-4 cm depth by drilling manually in the rows at the spacing of 20cm apart between rows on mid July 2015/16. Then, the crop management was continued by weeding of broad leaves of weeds at 20 days interval after sowing. The harvesting of the matured crop was started at 149 days and continued until 160 days after sowing of the crop when they attained a physiological maturity from three internal rows by leaving two border rows of each plot. The crop exposed to sun for six days and threshed manually by a labourer separately for each plot.

**2.6. Data Collection**

Data on growth, yields and quality attributes were collected from each treatment of the study experiment. Physiological maturity were recorded when about 75% of plants in a plot lose their green color from both vegetative and reproductive tissues; Plant heights were determined at maturity from five representative plants in a plot by measuring from the ground surface to the tip of the spike excluding the awns; and spike length was determined at maturity from five representative plants in a plot by measuring from the start of spike to the tip of the spike.

Number of tiller was recorded at the time of spikes fully extruded out; Number of spike per plant was counted from five representative plants in a plot of each plot; Thousand Kernel weight was measured by weighing 1000 kernel in gram per plot; Biological yield was determined by weighing the three middle rows of the total dried above ground biological yield of the plants in kilogram; Grain yield per hectare was determined as grain yield in kilogram of the three central rows adjusted to 12% moister level and converted to a hectare bases; Harvest index was calculated as ratio of grain yield to above ground total biomass multiplied by 100%; and straw yield were measured in kilogram calculation after threshed the **s**traw yield of the three central rows and converted to a hectare bases. Then, at the end of harvesting the yield samples were taken from each plot planted with two varieties which was fertilized with different rates of nitrogen for grain protein analysis. The samples were taken to Kulumsa Agricultural Research Centre laboratory and the grain protein content of the crop from each treatment was analyzed.

Soil analysis was done by taking randomly six soil samples before planting from the experimental site at a depth of 20 cm using manual by digging in zigzag pattern and the samples were mixed thoroughly to produce one representative composite sample of 1kg. The soil result used for identification of soil physical and chemical characteristics. Soil pH: was determined in 1:2.5 soil to water ratio using a glass electrode attached to a digital pH meter (Page, 1982). Organic matter: was recorded based on the oxidation of organic carbon with acid potassium di-Chromate ($K_2C_2O_7^{-2}$) medium using the Walkley and Black method as described by Dewis and Freitas (1970). Total nitrogen: was determined using Kjeldal method (Dewis and Freitas, 1970) Mineral nitrogen: $NH_4^+$-N and $NO_3^-$-N were determined according to the methods of Pawels *et al*. (1992) as described by Bernard et al. (1992). Exchangeable potassium, calcium and magnesium: were extracted using 1N neutral ammonium acetate at pH 7 (Pratt, 1965), and determined by atomic absorption spectrophotometer. Available phosphorus was determined according to the methods of Olsen and Dean (1965).

### 2.7. Economic Analysis

The partial budget analysis was done as described by CIMMYT (1988) where the variable cost that vary in each treatment including the cost of fertilizer as well as the cost involved in its application and other variable activities of each treatment. Seed cost of grace and traveler variety was 15.67 birr for 1 kg seed. Nitrogen was applied as urea and NPS having a price of 12.89 and 13.08 Birr $kg^{-1}$ respectively during the study period. The gross benefit was calculated as 10% adjustment to compromise with that of the farmers' grain yield (kg $ha^{-1}$) and multiplied by market price that farmers received for the sale of the crop. The total variable cost included was the cost of urea, seed cost, cost of labour (sowing, fertilizer application, weeding, harvesting and threshing) as the sum of all cost that was varied. The net return was calculated by subtracting total variable cost from the gross benefit.

### 2.8. Data Analysis

Analysis of variances (ANOVA) for the data recorded was conducted using the SAS software. Least significant differences (LSD) test at 5% probability was used for mean separation when the analysis of variance indicated the presence of significant differences between means. Correlation analysis was also performed to determine simple relationship between yield and quality attributes of two malt barley varieties as affected by rates of nitrogen application.

## 3. Results and Discussion

### 3.1. Soil Physico-Chemical Properties of Experimental Site

Soil samples were collected from the experimental field before planting the crop at depth of 0-20 cm and one composite soil sample was made for physico-chemical properties analysis (Table 4). Thus, on the basis of particle size distribution the soil textural class of the experimental site was found to be clay along the composition of very high (>6) organic matter (Westerman, 1990), moderate acid (Landon, 1991), low (<10 ppm) phosphorus (Tekalign, 1991), very high cation exchange capacity (>40 cmol/kg) (Landon, 1991) and low (0.2–0.5%) nitrogen level (Tekalign, 1991). Thus, depending on the soil nutrient status identification of the required amount and application of external fertilizer was an important issue.

Table 4: Soil physical and chemical properties of the experimental field before planting the crop at a soil depth range of 0 -20cm

| **No.** | | **Character** | **Value** | **Rating** | | | |
|---|---|---|---|---|---|---|---|
| 1 | | pH $H_2O$ | 5.13 | Moderately acid | | | |
| 2 | | Available Phosphorus (ppm) | 4.68 | Medium | | | |
| 3 | | Total N (%) | 0.37 | Low | | | |
| 4 | | Organic carbon (%) | 8.10 | Medium | | | |
| 5 | | CEC [Cmol (+)/kg)] | 44.97 | Very high | | | |
| **Particle Distribution** | | | | | | | |
| Sandy (%) | 22 | Clay (%) | 34 | Silt (%) | 44 | Textural class | Clay |

### 3.2. Effects of Nitrogen Rates and Varieties on Growth Parameters

The effect of nitrogen fertilization on different growth and yield parameters and protein content of Grace and Traveler varieties of malt barley were indicated in Table 5. Generally, number of tiller, plant height, grain per spike, days to physiological maturity, protein content, biological yield, harvest index and grain yield showed significant ($P<0.05$) variations in response to the rates of nitrogen fertilizer applied but thousand kernel weight was not significantly influenced. Also, malt barely variety showed significant difference on days to physiological maturity, grain protein content, plant height, thousand kernel weight and grain per spike. However, interaction effects of nitrogen rates and varieties were showed significant differences only on grain per spike and harvest index (Table 5).

Table 5: Mean square values for growth, yield and quality components as influenced by the main and interaction effects of inorganic nitrogen rates and malt barley varieties

| **Parameters** | **Nitrogen** | **Variety** | **Nitrogen x Variety** |
|---|---|---|---|
| Plant height/PH/ | 149.36*** | 36.60* | $5.30^{ns}$ |
| Spike length /SL/ | $0.59^{ns}$ | 2.67* | $0.44^{ns}$ |
| Days to physiological maturity/DPM/ | 100.00*** | 144.00*** | $1.80^{ns}$ |
| Number of Tiller /TL/ | 132.89*** | $8.03^{ns}$ | $1.03^{ns}$ |
| Grain per spike/GPS/ | 20.38*** | 18.49** | 3.36* |
| Thousand kernel weight/TKW/ | $47.59^{ns}$ | 168.74* | $44.82^{ns}$ |
| Biological Yield/BY/ | 41251970.7*** | $1041964.6^{ns}$ | $4046630.0^{ns}$ |
| Grain Yield /AY/ | 1347.64*** | $0.45^{ns}$ | $10.25^{ns}$ |
| Straw Yield/SY/ | 8684644.03* | $909162.25^{ns}$ | $3976577.72^{ns}$ |
| Harvest index/HI/ | 150.89** | $2.48^{ns}$ | 104.92* |
| Grain protein content /GP/ | 3.51*** | 1.07* | $0.077^{ns}$ |

Where, ns =non-significant, and *, **, ***, significant at $P < 0.05$, 0.01 and 0.001 LSD tests, respectively

The analysis of variance of data were illustrated that rate of nitrogen fertilizer had significant ($P<0.05$) effect on plant growth parameters like height and days to physiological maturity; but not on spike length (Tables 5 and 6). The result indicated that all plots received external N application resulted higher plant height and early maturity; while the lowest plant height and late maturity was recorded from the control plot (56.27cm and 158.5 days) (Table 6). The main effect of N fertilizer is to increase the rate of leaf expansion, leading to increased interception of daily solar radiation by the canopy (Salwa *et al*., 2005). Dry matter accumulation increased significantly with N fertilizer application along the growth stages of the crop which increases vegetative growth of crop; this might be the reason of barley height increment with the increased nitrogen rate application. These result agreed with the finding of Maqsood *et al.* (2001), Kenbaev and Sade (2002), Salwa *et al*. (2005), Arif *et al*. (2006) and Pervez *et al*. (2009) who reported significant increases in plant height of wheat with application of nitrogen. Also according to Rashid *et al*. (2007) study result, plant height was linearly increased with increasing levels of N fertilization. Plant height and spike length are an important yield related parameters which is reported to be a genetic character that influenced least by environmental factors such as nutrients and others (Hailu, 2010).

The analysis of variance showed that the varieties had significant ($P < 0.05$) differences on plant height, spike length and days to maturity (Table 6). The study result indicated that differences among the varieties; Grace variety resulted in highest plant height (67.35cm), spike length (9.10cm) and early maturity (149.8 days) as compared to Traveler variety (Table 6). The results reported by different scholars (Ahmed *et al*., 2008; Elbana *et al*., 2011; Molasadegi and Shahryari, 2011) indicated that variations in growth attributes in different barley and wheat genotypes. Generally, plant height and spike length were affected by genotype and this result was agreed with the finding of El-banna *et al*. (2011) who had found significant variation in growth parameters among different genotypes of barley.

Table 6: Effect of different rates of nitrogen fertilizer and barley varieties on growth of barley crop in the cropping season of 2015/16

| | **Parameters** | | |
|---|---|---|---|
| **Nitrogen (kg ha$^{-1}$)** | **Plant height(cm)** | **Spike length (cm)** | **Days to physiological maturity** |
| 0.0 | 56.27$^{b}$ | 8.37 | 158.5$^{a}$ |
| 19.0 | 67.37$^{a}$ | 8.80 | 153.5$^{b}$ |
| 30.5 | 67.75$^{a}$ | 8.68 | 153.5$^{b}$ |
| 42.0 | 68.33$^{a}$ | 9.01 | 148.5$^{c}$ |
| 53.5 | 69.17$^{a}$ | 8.80 | 148.5$^{c}$ |
| 65.0 | 69.17$^{a}$ | 9.30 | 148.5$^{c}$ |
| SE | 0.897 | | |
| LSD(0.05) | 2.78** | NS | 0 *** |
| **Variety** | | | |
| Grace | 67.35$^{a}$ | 9.10$^{a}$ | 149.8$^{b}$ |
| Traveler | 65.33$^{b}$ | 8.56$^{b}$ | 153.8$^{a}$ |
| SE | 0.518 | | |
| LSD(0.05) | 1.60* | 0.47* | 0.0 *** |
| CV(%) | 3.27 | 7.18 | 0.0 |

SE-Standard Error; LSD-Least Significant Differences; CV-Coefficient of Variation; NS- Non Significant

### 3.3. Effects of Nitrogen and Variety on Yield Components of Malt Barley

#### 3.3.1. Grain per Spike

The highly significant differences (P≤0.01) in number of grain per spike were observed at different rates of N-fertilizer, varieties and their interaction (Table 7). The variety Grace gave the highest grain per spike (33.0) at 65 kg ha$^{-1}$ of N-fertilizer applied and also the lowest (26.2) grain per spike was obtained from same variety on the control plot. This highest grain was improved by about 20.61% as compared to the lowest grain produced with fertilizer application on the control. Number of grain per spike is determined by environmental factors and inherent characteristics of a variety. The research result is agreed with that of Brown *et al.* (1987) and Ryan *et al.* (2009) who reported that variation in number of grain per spike as a function of barley genotype at various fertilizer rates applied.

Table 7: Interaction effect of nitrogen rates and barley variety on grain per spike of barley crop in the cropping season of 2015/16

| | **Nitrogen rate (kg ha$^{-1}$)** | | | | | |
|---|---|---|---|---|---|---|
| **Variety** | 0 | 19 | 30.5 | 42 | 53.5 | 65 |
| Grace | 26.20$^{g}$ | 31.30$^{abcd}$ | 32.26$^{ab}$ | 31.40$^{abcd}$ | 32.10$^{abc}$ | 33.00$^{a}$ |
| Traveler | 27.20$^{fg}$ | 29.70$^{de}$ | 29.13$^{ef}$ | 30.20$^{cde}$ | 31.20$^{abcd}$ | 30.20$^{bcde}$ |
| **LSD/0.05** | **1.28** | | **CV %** | | **3.27** | |

#### 3.3.2. Number of Tiller

The analysis of variance illustrated that N fertilizer rates application significantly (P<0.01) affected the tiller number of the two malt barley varieties (Table 8). Application of N-fertilizer at 65 kg ha$^{-1}$ showed statistically higher result as compared to those produced on the control plot; which implied that the number of fertile tiller has being significantly increased along the nitrogen application rates. However, there was no significant difference between plots fertilized with 53.5, 42, 30.5 and 19 kg ha$^{-1}$ nitrogen rates (Table 8). The fertile tiller of barley was the growth component which set up the crop for a high yield potential which might be due to N responses during the early development stages. This finding agrees with the result obtained by Maqsood *et al.* (1999) who reported that the increased in number of fertile tillers with increasing nitrogen levels could be attributed to the well-accepted role of nitrogen in accelerating vegetative growth of plants. This is due to the more availability of nitrogen that played a vital role in cell division of the crop.

### 3.3.3. Thousand Kernel weight

Thousand kernel weights did not show significant variation due to applied nitrogen fertilizer rates and interaction of nitrogen rates and varieties. However, it was significantly ($P < 0.05$) influenced by effect of variety (Table 8). Traveler variety gave highest (53.56 g) thousand kernel weight as compared to Grace variety (49.2g); which indicated that genotype variations within the crop. This finding is also in agreement with Ahmad *et al.* (2008) report that indicated highest level of genetic variation in barley for thousand grain weight.

### 3.3.4. Biological Yield

Biological yield is one of the yield components of barley crop. The highly significant differences ($P<0.01$) were observed in biological yield with the rates of nitrogen fertilizer (Table 8). The highest biological yield (12,138.9 kg $ha^{-1}$) was recorded at nitrogen rate of 65 kg N $ha^{-1}$ which were significantly increased over the result recorded from the control plot (4,916.7 kg $ha^{-1}$); which indicated that improvement (60%) of biological yield along the increased rates of N-fertilizer application from 0 to 65 kg N $ha^{-1}$. This result indicated that the effects of nitrogen on the biological yield due to biomass related trait of the crop along increased application of N fertilizer. These indicated that nitrogen increases vegetative growth of plants at higher rate of application of fertilizer per hectare. Generally, this result was agreed with Alam and Haider (2006) who showed that the linearly increased nitrogen levels were resulted in increased total dry matter. This is due to availability of adequate N at the vegetative growth stage ensures maximum biological yield.

Table 8: Effect of different rates of nitrogen fertilizer and barley variety on yield attributes of barley crop in the cropping season of 2015/16

| | **Parameters** | | | | |
|---|---|---|---|---|---|
| **Nitrogen ($kg\ ha^{-1}$)** | **Tiller Number** | **1000 kernel weight(g)** | **Biological yield ($kg\ ha^{-1}$)** | **Straw yield ($kg\ ha^{-1}$)** | **Grain yield ($Qt\ ha^{-1}$)** |
| 0.0 | 6.50[c] | 54.40 | 4916.67[c] | 3134.67[b] | 17.82[d] |
| 19.0 | 15.00[b] | 55.22 | 10138.88[b] | 5341.67[a] | 47.97[c] |
| 30.5 | 15.83[b] | 51.43 | 10916.67[ab] | 5741.67[a] | 51.75[bc] |
| 42.0 | 17.17[b] | 49.53 | 11145.83[ab] | 5268.83[a] | 54.18[abc] |
| 53.5 | 17.33[b] | 48.63 | 11361.12[ab] | 5888.33[a] | 54.73[ab] |
| 65.0 | 20.33[a] | 49.18 | 12138.90[a] | 6721.00[a] | 58.77[a] |
| SE | 0.854 | 1.79 | 627.38 | 566.36 | 1.85 |
| LSD(0.05) | 2.58*** | NS | 1712*** | 1649* | 6.49*** |
| **Variety** | | | | | |
| Grace | 15.83 | 49.23[b] | 10273.10 | 5508.28 | 47.65 |
| Traveler | 14.89 | 53.56[a] | 9932.88 | 5190.44 | 47.43 |
| SE | 0.49 | 1.03 | 362.22 | 326.99 | 1.07 |
| LSD(0.05) | NS | 3.78 ** | NS | NS | NS |
| CV (%) | 13.60 | 8.50 | 15.20 | 25.90 | 9.50 |

SE-Standard Error; LSD-Least Significant Differences; CV-Coefficient of Variation; NS- Non Significant

### 3.3.5. Straw Yield

Straw yield of barley significantly increased by nitrogen fertilizer rates applied from both varieties of the crop (Table 8). The highest straw yield was obtained at the highest nitrogen rate of 65 kg N $ha^{-1}$ (6,721 kg $ha^{-1}$) even though the results obtained from the plots received 65, 53.5, 42, 30.5 and 19 kg N $ha^{-1}$ was not statistically differed from each other; except those produced on the control plot produced the lowest straw yield (3134.7 kg $ha^{-1}$) (Table 8). Generally, this experiment revealed that as the rate of N-fertilizer increased the straw yield became increased significantly. This indicated that straw yield of malt barley responded to rate of nitrogen applied positively. This is due to the fact that application of N fertilizer in plants increases uptake of other nutrients. This result is agreed with the findings of Amsal *et al*. (2000) and Teklu *et al*. (2000), who reported that N rates significantly enhanced the straw yield of wheat, since N usually, promotes the vegetative growth of a plant.

### 3.3.6. Grain Yield

The significant differences ($P \leq 0.01$) in grain yield per hectare of barley varieties were recorded between different rates of N- fertilizer applied (Table 8). Application of nitrogen at the rate of 65 kg N $ha^{-1}$ produced highest grain yield (58.8 Qt $ha^{-1}$) without significant differences in grain yield harvested from N-fertilizer applied at the rates of 53.5 kg $ha^{-1}$ ( 54.7 Qt $ha^{-1}$) and 42 kg (54.2 Qt $ha^{-1}$). However, the highest grain yield obtained was statistically differed from those fertilized with nitrogen at 30.5 kg $ha^{-1}$ (51.8 Qt $ha^{-1}$); at 19 kg N ha $^{-1}$ (47.97 Qt $ha^{-1}$) and control (Table 8). The lowest grain yield (17.8 Qt ha $^{-1}$) was obtained from the control plot which was reduced by 70% as compared to those fertilized with highest nitrogen rate (65 kg N $ha^{-1}$). Generally, grain yield of barley was increased by N-fertilizer applied along its rates. This is similar with the findings of Amanullah *et al*. (2008b) who reported that nitrogen is one of the most important factors affecting crop growth and grain yield. Generally, the yield and yield components of barley genotypes significantly increased by the application of fertilizer. Thus, the increase in growth and yield owing to the application of N-fertilizers may be attributed to the fact that these nutrients being important constituents of nucleotides, proteins, chlorophyll and enzymes, involve in various metabolic processes which have direct impact on vegetative and reproductive phases of plants. These findings are also in agreement with that of Bangarwa (1997) who reported grain yield increased with increasing nitrogen rates.

### 3.3.7. Harvest Index (%)

The data analyzed indicated that nitrogen, variety and their interaction had significant effects on harvest index (Tables 5 and 9). The analysis of variance illustrated that interaction of N-fertilizer rates and variety had significant differences ($P<0.05$) on harvest index of barley (Table 9). Traveler variety gave the highest harvest index (54.76) at 30.5 kg ha$^{-1}$ of N-fertilize applied and lowest (33.86) was recorded from the same variety on the control plot which was reduced by about 38.17% as compared the highest result obtained from same variety at 30.5 kg N ha$^{-1}$ (Table 9). This result is agreed with findings of Taye *et al.* (2002), who reported a mean of HI of about 50% with a positive trend due to increasing N rate. This finding also supported by Papakosta and Gagianas (1991) who reported that harvest index was increased with increasing application of nitrogen for wheat.

Table 9: Interaction effect of nitrogen rates and varieties on harvest index of barley crop in the cropping season of 2015/16

| | **Nitrogen rate (kg ha$^{-1}$)** | | | | | |
|---|---|---|---|---|---|---|
| **Variety** | 0 | 19 | 30.5 | 42 | 53.5 | 65 |
| Grace | 39.46$^{c}$ | 53.21$^{ab}$ | 41.90$^{bcd}$ | 49.84$^{abc}$ | 48.53$^{abc}$ | 46.40$^{abc}$ |
| Traveler | 33.86$^{d}$ | 42.86$^{bcd}$ | 54.76$^{a}$ | 48.70$^{abc}$ | 49.14$^{abc}$ | 53.16$^{ab}$ |
| LSD(0.05) | 5.73 | | CV (%) | 9.51 | | |

### 3.4. Effect of Nitrogen and Variety on Malt Barley Quality

The analysis of variance illustrated that the effect of N fertilizer rates had significant ($P> 0.05$) differences on grain protein content of malt barley varieties (Table 10). The result is indicated that the highest grain protein was obtained at N fertilizer rate of 65 kg N ha$^{-1}$ (11.33%); while lowest (9.3%) was recorded from the control plot. However, those plants fertilized with different rates of N did not show statistically significant variations except the control plot (Table 10). Generally, this experiment revealed that as the rate of N-fertilizer became increased the grain protein content significantly increased; yield achieved even if highest rate of N-fertilizer from this experiment were acceptable protein content of grain because it is below 12.5%. This result agreed with the finding of Baethgen *et al*. (1995) who reported that the highest grain protein content of barley crop with the highest N rate applied.

The analysis of variance also illustrated that variety had significant ($P<0.05$) differences on grain protein content of malt barley (Table 10). This result indicated that Grace variety produced higher grain protein (11.01%) as compared to Traveler variety (10.67%) even though both results were in acceptable protein range for malt barley. The results of the study showed that the highest level of N fertilizer rate (65 kg $ha^{-1}$) applied produced good protein content on both malt barley varieties (Traveler and Grace) which can be categorized within the acceptable range of protein. Sadowska *et al*. (2001) also reported that the grain quality of the different wheat cultivars was strongly influenced by the cultivars.

Table 10: Effect of different rates of nitrogen fertilizer rates and varieties on quality of barley crop in the cropping season of 2015/16

| **Nitrogen (kg $ha^{-1}$)** | **Grain protein content (%)** |
|---|---|
| 0.0 | $9.30^{b}$ |
| 19.0 | $10.95^{a}$ |
| 30.5 | $11.22^{a}$ |
| 42.0 | $11.12^{a}$ |
| 53.5 | $11.12^{a}$ |
| 65.0 | $11.33^{a}$ |
| SE | 0.18 |
| LSD(0.05) | 0.49*** |
| **Variety** | |
| Grace | $11.01^{a}$ |

| | |
|---|---|
| Traveler | 10.67[b] |
| SE | 0.1 |
| LSD(0.05) | 0.28* |
| CV (%) | 4.00 |

SE-Standard Error; LSD-Least Significant Differences; CV-Coefficient of Variation; NS- Non Significant

### 3.5. Partial Budget Analysis

The partial budget analysis showed that the highest and the lowest net benefit (7105.8 and 40106.60 Birr ha$^{-1}$, respectively) was obtained from N-fertilizer rate of 65 kg N ha$^{-1}$ and the control (Table 11). However, the corresponding marginal rate of return (MRR) showed an increasing trend until 30.5 kg N ha$^{-1}$ and then decrease until 53.5 kg N ha$^{-1}$. The optimum net benefit (34427.67 Birr /ha) was attained at 30.5 kg N ha$^{-1}$ with affordable total variable costs to the farmer. This result is in contrary to the findings of Tanner *et al.* (1999) who reported that higher net economic advantages was achieved from the application of the highest N rate of 139 kg ha$^{-1}$ in the South-Eastern Ethiopian highlands.

Table 11: Partial budget analysis result for nitrogen rate study on two malt barley varieties at Digelu-Tijo in 2015/16 main cropping season

| **Treatment** | **AGY (kg/ha)** | **AdY (kg/ha)** | **GB (ETB/ha)** | **TVC (ETB/ha)** | **NB (ETB/ha)** | **MRR (%)** |
|---|---|---|---|---|---|---|
| 0.0 | 1782 | 1604 | 16019.77 | 8914 | 7105.77 | |
| 19.0 | 4797 | 4317 | 42349.77 | 11120 | 31229.77 | 1094 |
| 30.5 | 5175 | 4658 | 45681.67 | 11354 | 34327.67 | 1324 |
| 42.0 | 5418 | 4876 | 47641.11 | 11510 | 36131.11 | 1156 |
| 53.5 | 5473 | 4926 | 48266.23 | 11588 | 36678.23 | 701 |
| 65.0 | 5877 | 5289 | 51928.60 | 11822 | 40106.6 | 1465 |

AGY=Average Grain Yield, AdY=Adjusted grain Yield by 10%, GB=Gross Benefit, TVC=Total Variable Cost, NB=Net Benefit, MRR=Marginal Rate of Return and ETB=Ethiopian Birr

## 4. Conclusion

Based on the results discussed in this study, among the six N-fertilizer rates and two malt barley varieties evaluated, 65 kg $ha^{-1}$ of nitrogen fertilizer across the two varieties gave more growth, higher grain yield and good protein content along better economic advantages. However, it is better to undertake further studies to confirm the nitrogen fertilizer effects on different varieties at various locations and seasons. Also, integrative test with different inorganic and organic fertilizer types for yield and quality improvement is required to identify the types and rates of fertilizers that can increase the productivity of the malt barley crop varieties.

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