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Nutrient Use Efficiency and Grain Quality of Malt Barley (*Hordeum vulgare* L.) Varieties in Response to Nitrogen Fertilizer in Southeastern Ethiopia

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Abstract:
The expansion of brewing industries in Ethiopia has been inducing a growing demand for the supply of malt with optimum kernel protein content. However, the supply has been constrained by the unavailability of sufficient volumes of acceptable quality of malting barley grain to meet the ever-increasing demand. In this regard, field experiments were conducted in the southeastern Ethiopian highlands to evaluate the combined effects of six fertilizer levels (0, 11.5, 23, 34.5, 46, and 57.5) N kg ha-1 and three malt barley varieties (Fanaka, Ibon and Holker) on the yield, quality and nutrient use efficiency of malting barley. The experiment was laid out in a randomized complete block design with three replications. Application of 11.5, 23, 34.5, 46 and 57.5 N kg ha-1 increased the grain yields by 1010.3, 1065.9, 1288.1, 1421.3, and 1777.6 kg ha-1 and economic benefits by 31 %, 30.4 %, 32.9%, 33.16% and 33.38% respectively, for each increment of on N fertilizer, when compared to the control treatment. The production of malting barley with improved yield, optimum kernel protein concentrations and enhanced economic benefit was attained through 57.5 and 46 N kg ha-1 as first and second option respectively in the study area. Thus, to improve the likelihood of acceptance of malting barley by malting industries, growers are recommended to select low-protein containing varieties and decide application of N fertilization based on soil test results.

Keywords: Nutrient use efficiency, Malting barley, nitrogen fertilizer level, malt quality

INTRODUCTION

Barley (Hordeum vulgare L.) is an annual cereal crop, which grows in diverse environments ranging from the desert of the Middle East to the high elevation of Himalayas (Hayes et al. 2003). The soil and agroecological conditions of Ethiopia, where this study was conducted are very suitable for producing malting barley. The specific study areas West Arsi, is among the potential districts in the southeastern Ethiopian highlands identified for malting barley production (Atlas of Arsi Zone 2002). Apart from the benefits for food and feed, malting barley is a specialty crop for which a premium price is being paid by domestic malters and exporters (BMBRI 2010). Ethiopia is the second largest barley producer in Africa after Morocco, accounting for about 25% of the total food and malting barley production (FAO 2014). In the 2021 cropping season, 0.93 million ha of land was allocated for food and malting barley production in Ethiopia; this was the fifth largest area under production after tef (Eragrostis tef), maize (Zea mays), wheat (Triticum aestivum) and sorghum (Sorghum bicolor) (CSA 2021).

In Ethiopia, Barley production started long years ago and is largely grown as a food crop. It is growing in the central and northern parts of Ethiopia, including; Oromia, Amhara, Tigray, and Southern Nations, Nationalities, and People's Region, (ATA, 2012). The use of malt barley as a row material in brewery factories has increased its value and the demand of farmers to produce (ATA, 2012). Some of the principal characteristics used to define malting quality are protein (low, moderate, or high), malt extract (high), enzyme activity (moderate to high), and beta glucan (low). Despite the immense potential for producing malt barley in Ethiopia, only about 2% of total barley produced goes into malt factory for the six local breweries (Tefera, 2012). Only one-third can be supplied from locally produced barley. The remaining two-thirds are imported primarily from Belgium and France (ORDA (2008b), ATA, 2012). To satisfy the ever-increasing demand for raw materials by the beverage industry, and to ensure dependable and higher cash returns to the farmers, expansion of the malt barley production is very important since immense potential areas are available for malt barley production to meet the national demand. However, its production has not expanded, and productivity at farm level has remained low. One reason for the low productivity of the crop is the poor soil fertility of farmlands, mainly aggravated by continuous cropping, overgrazing, high soil erosion and removal of crop residues, without any soil amelioration. Soils in the highlands of Ethiopia usually have low levels of essential plant nutrients, low availability of nitrogen and it is the major constraint to cereal crop production (Taye et al., 2002, Assefa et al. 2017). Quality requirements for malt barley are fairly strict, and directly related to processing efficiency and product quality in the malting and brewing industries. Excessively higher protein content is undesirable, because of the strong inverse correlation between protein and carbohydrate content; thus, high protein content leads to a low malt extract level (Fox et al., 2003). Grain N content is thus a determining factor of malt quality; high grain N content not only means lower carbohydrate content and lower malt extract level. Although, varieties play an important role in quality and yield of malt barley, grain quality and yield of malt barley is significantly influenced by rate of N fertilizer. Consequently, assessing grain yield and malt quality response of varieties to different rate of N fertilizer is important since malt quality and grain yield fluctuation leads to significant loss for beverage industries and farmers. However, no studies have been carried out sofar on the interaction between Nitrogen fertilizer rates and different released malt barley varieties under the study area. The present investigation was conducted with the main objective of identifying appropriate malting barley varieties, with their respective optimum level of N fertilizer, for malt barley-growing areas of Western Arsi Zone, Ethiopia. Thus, the specific objectives of the study were: To assess the effects of different nitrogen fertilizer rate on the grain yield and malting quality of malt barely varieties. To identify the optimum rate of Nitrogen fertilizer and barley variety that would enhance grain yield without affecting the malt quality.

MATERIAL AND METHODS

Field Experiment

The field experiment was conducted at Bekoji experimental site (07° 30‟ 37″ N - 39° 11‟ 31‟E, 2450-2780 m.a.s.l) located in the Arsi Zone, Southern Ethiopia during 2019 and 2020 main cropping season (June-November). The long- term average annual at the experimental site is 951.5 mm and the mean maximum and minimum temperatures are 19.88 and 4.05 oc respectively.

Treatment and Experimental Design

The treatment studied were six N level (N1= 0, N2 = 11.5, N3 = 23, N4 = 34.5, N5 = 46 and N6 = 57.5) kg N ha^{-1} and three malt barley varieties (V1= Fanaka, V2 = Ibon and V3 = Holker). The treatment was arranged in randomized complete block design with three replications. A gross and net plot size of 10.4 m^{-2} and 7.8 m^{-2} was used. Varieties used for this study are the most popular malt barley varieties in Ethiopia and are widely grown in the study area. The land was ploughed using oxen and plots was level manually TSP was applied at sowing time, while nitrogen fertilizer in the form of urea was added to the soil at the rates of 1/2 at planting time and the rest 2/3 was apply at mid tillering stage to avoid leaching. Malt barely varieties was sown at the recommended rate of 125 kg ha^{-1} and planted in rows by using a manual row marker. Proper hoeing and weeding of the experimental fields were carried out uniformly as per research recommendations.

Measurements

The following parameters were determined: Grain yield. Biomass yield, productive tillers per plant, grain per spike, malt extract content, sieve test, germination capacity, N use efficiency, nutrient recovery efficiency. Grain yield was adjusted to 12.5% moisture after determining the moisture content using a grain moisture test. The following formula was used for adjusting grain yield using moisture content.

$$Yadj= ((12.5- mc/100) *Y) + Y)$$

Where, Yadj is moisture adjustment grain yield, Y is unadjusted grain yield and mc is measured seed moisture content (%).: Sieve test was carried out using 2.2, 2.5, 2.8 mm size sieves and proportion of the seed trapped by each sieve was weighed and converted to percentage. Finally, the sums of all the three sieve sizes were used for sieve test. Extract content was carried out at Holeta Agricultural Research Center food science and nutrition research laboratory taking grain sample of 300g from each treatment using near infrared (NIR) spectroscopy as described in AACC (2000). Germination capacity two hundred seeds was soaked in a flask with 0.3M H_2O_2 (hydrogen peroxide) and counted after 48 hours and converted to percentage to determine germination capacity.

Partial Budget Analysis

It was done comparing the difference the difference N level used for the study. The mean grain yield data were reduced by 10% to adjust the yield to the farmers' management condition s and subjected to partial budgets analysis (CIMMYT 1988). The average farm gate price of barley seed for malting and food during the three months of experimental years 2019 and 2020 was used for the partial budget analysis (Table 7). The cost of urea fertilizer and labor that varied among treatments was considered as variable cost. Treatments were arranged in ascending order to variable cost and their corresponding net benefits. Dominance analysis was done to eliminate those treatments which cost more but produced a lower net benefit. The marginal rate of return (MRR) was calculated for each non- dominated treatment and minimum acceptable MRR was assumed (CIMMYT 1988).

Data Analysis

Data were analyzed using PROC MIXED of SAS (SAS Institute Inc. 2007). Malt barley variety and N rate were considered as fixed effects. Year and replicates were considered as random effects. Separate analysis of variance was done for each experiment followed by testing experimental errors for homogeneity. After proving homogeneity of error variances, combined analysis over years was performed. Significant differences between and/or among treatment means were compared using least significant differences (LSD) test. All differences were deemed significant at $P \leq 0.05$. Regression analyses were conducted and regression equations describing the relationship between the dependent variables and N rate were fitted. Orthogonal contrasts were used to test for linear and quadratic responses to N rate.

RESULT AND DISCUSSION

Effects of N Fertilizer Rate for Selected Parameters of Malt Barley

Nitrogen fertilizer rate had a significant effect on grain yield (*P<0.001*), biomass yield (*P<0.001*), grains per spike (*P<0.01)* and number of productive tillers per plant *(P<0.01*). Table 2 showed that grain and biomass yield of malt barley increased as the level of N fertilizer rate increased up to the highest 57.5 N kg ha^{-1}. Malt barley grown at a rate of 57.5 N kg ha^{-1} gave the highest grain 3377.8 kg ha^{-1} and biomass 651.2 kg ha^{-1} yields. N fertilizer at rates of 46 and 34.5 N kg ha^{-1} gave 3022.2 and 2888.9 kg ha^{-1} grain yield and 597.1 and 611.3 kg ha^{-1} biomass yield respectively, which were statically not difference each other. Compared to the 11.5 N kg ha^{-1} malt barley grains grown at a rate of 46 and 57.5 N kg ha^{-1} provide grain yield advantage of 411 kg and 776.7 kg respectively. The corresponding increment for biomass yield was 78.8 kg and 118.7 kg respectively. The lowest grain (1923.6 kg ha^{-1}) and biomass (436.8 kg ha^{-1}) yield of malt barley were recorded form the control treatment (0 N kg ha^{-1}). The cutoff point for the optimum rate of N fertilizer was not attained in this study since yield of malting barley increased as the rate of N increased from control to 57.5 N kg ha^{-1} indicating the need for further study. In order to balance maximum yields with optimum levels of protein concentration, application of N fertilizer for malting barley production needs to consider the available residual soil N. The current result is in agreement with Agegnehu et al. (2014), Derebe et al. (2018), O'Donovan et al. (2011), and Upendra et al. (2013), who all reported increased malting barley yield with increased N fertilization rates.

Grains per spike of malt barley was significantly (*P< 0.01)* affected by N rates. Grains per spike of malt barley increased as the level of N fertilizer increased from control treatment to 57.5 N kg ha^{-1}. The higher (30.5) and (31.1) grains per spike was gained from fertilization of higher, 46 N and 57.5 N kg ha^{-1} respectively. Likewise, application of 34.5 N kg ha also gave (30.22) grain per spike, which has statically equivalent value with the higher two fertilizer rate. Malt barley grown with 11.5 N and 23 N kg ha-1 gave (28.77) and (29.22) grain per spike, which are statically similar with each other. But far apart from the highest nitrogen fertilizer rate. The lowest (23.6) grain per spike was obtained from the lowest, control treatment. In this finding grains per spike showed a linear and positive response to nitrogen fertilizer rate. This could be related to the ability of plants to uptake, translocation, assimilate and use nitrogen for the synthesis and development of spikelet. The result was in line with the finding Shafi *et al.,* (2011). Schulthess *et al.,* (1997), Tilahun *et al.,* (1996a), reported that nitrogen applied at the rate of 60 kg ha^{-1} resulted in maximum number of grains per spike. Moreover, Assefa *et al.* (2017) reported that nitrogen increased the number of grains per spike and this parameter is the best indicator of barley response to nitrogen.

The plant height of malt barley was significantly *(P<0.01)* affected by the rate of N fertilizers. As the levels of N fertilizer increased from control treatment to 57.5 N kg ha^{-1} the plant height of malt barley increased from (78.3 cm) to (108.8 cm). Malt barley grow at a rate of 57.5 N kg ha^{-1} gave higher (108.8 cm) plant height. Grown malt barley at a rate of 46 N kg ha^{-1} produced a plant height of (97.4), which was statically equivalent with plant height recorded from 57.7 N kg ha^{-1}. Statically equivalent value with each other was also recorded by malt barley varieties grown with 11.5 and 23 kg ha^{-1} nitrogen fertilizer rate with a value of (92 cm) and (93.4 cm) respectively. The increment of plant height along with increasing of nitrogen fertilizer rate might be directly related to the effect of nitrogen which promotes vegetative growth as other growth factors are in conjunction with it. These findings are similar to Wakene *et al.,* (2014) and Minale *et al.,* (2011) who reported that plant height of barley increased with increasing nitrogen fertilizer rates. Moreover Melesse (2007) reported that as the nitrogen fertilizer rate increased from 0 to 69 kg ha^{-1}, the plant height of bread wheat was increased from 82.63 cm to 94.18 cm.

Main Effects of Malt Barley Varieties on Selected Parameters

Varieties also highly significantly affect most the variables such as grains per spike ($P<0.01$), productive tillers per plant ($P<0.001$), grain yield ($P<0.01$), biomass yield ($P<0.001$), plant height ($P<0.001$) and harvest index ($P<0.001$). Spike length spike per 50 cm was not significantly affected by malt barley varieties in this research finding.

The average grain and biomass yield show that the main effects of malt barley varieties were highly significant difference. The highest grain (3246.7 kg ha^{-1}) and biomass (625.94 kg ha^{-1}) yield was gained from ibon and fanaka variety respectively. The mean value of biomass yield that obtained from holker variety was not different from Fanaka variety. The lowest and statically equivalent grain (2746.7 kg ha^{-1}) yield was obtained from fanaka and holker varieties. Likewise, the lowest biomass (520.5 kg ha^{-1}) yield was recorded from ibon variety.

The analysis of variance showed that Harvest index had significant ($P<0.001$) difference among malt barley varieties. The highest harvest index (62.4%) was obtained from the variety ibon variety, followed by statically equivalent with each other, but far apart from the harvest index obtained from ibon variety was gained from holker and fanaka with (44.02%) and (45.01%) harvest index value respectively.

Numbers of effective tillers per plant are the largest yield-donating factor since it determines the cereal's final economic yield. The highest (6.7) effective tillers per plant was obtained from ibon variety Followed by the (6.2) effective tillers per plant was gained from the varieties Fanaka while, the lowest (5.8) effective tillers per plant was gained from Holker variety. In variety evaluation, the study by Aynewa Y. *et al.*, (2013) noted the most extensive number of effective tillers in varieties HB52, HB120, and EH1847 and the lowest number of effective tillers for varieties Ibon174 and HB1533. Likewise, Molla K. *et al*; (2017) and Bizuneh & Assefa (2019) reported variations between genotypes for grain yield, time of germination, flowering and maturity, plant height, spike length, and the number of tillers. Similarly, significant differences were recorded for agronomic traits and grain yield Tahir Z. and Azanaw A. (2019). In other studies, there was also a significant difference in malt barley variety for tillering capacity Abebe A. (2018). Any change in tillering number and spike length directly affects grain yield Patel A. and Meena .M, (2018).

Table 1: Mean effects of varieties and N rate on selected yield and growth parameters of malt barley over season.

Treatment	NGPS	NPTPP	Gy kg/ha	By kg/ha	HI %	ph (cm)	sl (cm)
Varieties							
V1	29.4	6.2	2746.7	5201.5	45.01	107.8	7.9
V2	31.2	6.7	3246.7	6193.5	62.42	86.5	7.6
V3	29.26	5.8	2746.7	6255.9	44.02	93.2	7.5
N rates	23.6	5.6	1923.6	4362.8	2270	78.1	6.8
N1	17.9	5.5	1600.8	3324.1	48.1	69.8	6.2
N2	28.7	5.8	2611.1	5328.75	51.03	92.3	7.6
N3	29.2	7	2666.7	5516.2	48.33	93.4	7.6
N4	30.2	6.3	2888.9	5979.1	49.27	95.5	7.8

N5	30.5	6.2	3022.2	6118.3	50.12	97.4	7.6
N6	31.1	5.9	3377.8	6514.2	53.7	108.8	7.6
Anova							
V	**	***	**	***	***	***	NS
N	**	**	***	***	NS	**	NS
N*V	NS	NS	NS	NS	NS	NS	NS
Rep	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.6	11.2	12.7	10.3	16.1	4.03	8.23

The level of significance at p<0.01 is design by * P<0.01 by ** and P< 0.001 by ***

Nutrient Use Efficiency by Malt Barley Varieties

Nitrogen fertilizer also highly significantly affect most of the variables such as Agronomic Nitrogen Efficiency (P<0.01), Nitrogen use efficiency (P<0.001 and Nitrogen utilization efficiency of malt barley (P<0.001).

Agronomic Nitrogen Efficiency:

There was a significant difference between the interaction effect of nitrogen levels and varieties on agronomic nitrogen use efficiency (Table 3). The maximum (92.32) agronomic nitrogen use efficiency was recorded with the combination of 11.5 kg N ha^{-1} and Fanaka variety, whereas the lowest (17.93) agronomic nitrogen use efficiency was obtained with the combination of 57.5 kg N ha^{-1} and Ibon variety (Table 3). The agronomic nitrogen use efficiency was decreased with increasing rates of nitrogen fertilizer, which indicated efficient use of nitrogen at lower rate of nitrogen fertilizer application. It might be due to the capability of yield increase per kilogram N declined remarkably with increasing nitrogen. In line with the present finding (Bereket *et al*; 2014 and Abebe, 2012) elaborated that high agronomic efficiency could be obtained if the yield increment per unit N applied is high because of reduced losses and increased N uptake. Different varieties show different agronomic use efficiency of nitrogen under the same environmental condition. The highest mean agronomic nitrogen efficiency (61.51) was recorded from HB1963 variety while the lowest mean (14.99) obtained from Explorer variety (Table 7). This might be due to genetic variation of malt barley varieties plus levels of nitrogen fertilizers. This result was in agreement with Getachew *et al.* (2016) who reported that agronomic nitrogen use efficiency of different genotypes was different. According to Dobermann (2005), agronomic nitrogen efficiency has common value with in the range of 10 to 30. If the obtained results are above these common values, it could be concluded that the farm was under well managed system; and the reverse is true.

Table 3: Interaction effects of nitrogen levels and varieties on Agronomic N efficiency of malt barley

			N- fertilizer rate (kg ha^{-1})				
Varieties	**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**Mean**
V1	0	92.32^{a}	65.13^{c}	47.68^{d}	38.59^{de}	29.39^{de}	46.68
V2	0	80.11^{b}	52.58^{d}	34.31^{e}	27.13^{e}	17.93^{f}	35.34
V3	0	78.64^{b}	52.77^{d}	44.87^{d}	35.6^{de}	26.4^{e}	39.71
Mean	0	86.02	56.82	42.28	33.77	24.57	40.58
Lsd (5 %)				8.70			
CV (%)		6.58					

Means followed by the same letters are not significantly different at (p ≤ 0.01)

Nitrogen Use Efficiency of Malt Barley:

The interaction effect of nitrogen levels and varieties were highly significant ($p \leq 0.001$) influenced nitrogen use efficiency of malt barley (Table 4). The highest nitrogen use efficiency (323.05%) was recorded with the combination of Ibon variety with fertilization of 11.5 $kgha^{-1}$ n fertilizer, while, the lowest nitrogen use efficiency (89.51%) was obtained with the combination of 57.5 kg N ha^{-1} fertilizer and Holker variety. Nitrogen use efficiency was decreased with the increase in rate of N fertilizer dose in malt barley. The reason for the decline in nitrogen use efficiency as the level of nitrogen increased was a decline in nitrogen uptake efficiency and utilization efficiency of malt barley. This is in agreement with Barraclough, *et al.* (2014); Gaju *et al.* (2014) who reported that nitrogen use efficiency of malt barley varieties were decreased significantly in responses to increasing N fertilizer rates. This study indicated that the development and use of malt barley varieties with higher nitrogen use efficiency can contribute to a reducing in the amount of N to be applied without decreasing grain yield and quality.

Table 4: Interaction effects of nitrogen levels and varieties on N use efficiency of malt barley

			N- fertilizer rate (kg ha^{-1})				
Varieties	**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**Mean**
V1	0	240.15^{b}	163.05^{c}	149.93^{c}	108.43^{cde}	102.93^{de}	127.41
V2	0	323.05^{a}	167.01^{c}	147.53^{c}	106.03^{de}	100.53^{de}	140.69
V3	0	240.35^{b}	126.52^{cd}	131.01^{cd}	89.51^{f}	84.01^{f}	111.9
Mean	0	290.8	152.19	142.82	101.32	131.01	126.66
Lsd (5 %)				27.91			
CV (%)				14.25			

Means followed by the same letters are not significantly different at ($p \leq 0.001$)

Nitrogen Utilization Efficiency of Malt Barley:

Nitrogen utilization efficiency of malt barley was significantly ($p \leq 0.01$) affected by both main effect of N rates and varieties, and their interaction. Malt barley grown with the combination of control (0 N kg ha^{-1}) and Ibon variety gave the highest (57.11) nitrogen utilization efficiency, followed, highest (49.62) value of use efficiency was produced from Fanaka variety with control (0 kg ha^{-1}) fertilizer rate (Table 5). The lowest (21.66) nitrogen utilization efficiency was obtained from Holker variety and from the highest, 57.5 kg N ha^{-1}. The present research finding showed that, the higher dry matter partitioning to the grain per unit of total plant nitrogen for Ibon variety occurs at control treatment. In line with the present finding Nigussie et al. (2012) also reported that the highest nitrogen utilization efficiency of barley was measured from the lowest N fertilizer application. Moreover, Singh and Arora (2001) reported that genetic variation highly influences on nitrogen utilization efficiency.

Table 5: Interaction effects of nitrogen levels and varieties on N utilization efficiency of malt barley

			N- fertilizer rate (kg ha^{-1})				
Varieties	**N1**	**N2**	**N3**	**N4**	**N5**	**N6**	**mean**
V1	49.62^{b}	39.21^{d}	37.24^{d}	31.52^{ef}	26.48^{fg}	22.48^{fgh}	34.42
V2	57.11a	41.83^{cd}	38.61^{d}	31.91^{ef}	25.86^{fg}	22.01^{fgh}	36.16
V3	44.09^{c}	34.22^{de}	35.32^{de}	31.73^{ef}	25.62^{fg}	21.66^{fgh}	32.22
Mean	50.41	38.42	37.04	31.70	25.98	22.05	34.26
Lsd (5 %)				4.67			
CV (%)				11.26			

Means followed by the same letters are not significantly different at ($p \leq 0.01$)

Malt Barley Grain Quality

Grain Proteins (%):

Grain protein content of malt barley grains were significantly ($P<0.05$) affected by nitrogen fertilizer rates, while the effect of variety and interactions were non-significant (Table). Grain protein content increased as N fertilizer increased from 0 to 57.5 kg N ha^{-1}. Malt barley grown with the highest 46 N and 57.5 N kg ha^{-1} gave highest (11.91% and 12.21 %) mean value of grain protein content, followed by statically similar value with each was obtained form (11.5 23 and 34.5) N kg ha-1 with protein contain value of 10.21%, 10.32% and 10.21% respectively. The lowest (9.93 %) grain protein content was obtained from the control treatment (0 kg N ha^{-1}. The increase in grain protein content of malt barley with increasing N fertilizer rate was supported by Adane (2015) who reported that application of N fertilizer increased both grain yield and protein contain. Similarly, McKenzie and Jackson (2005) found that an increase in N fertilizer application resulted in an increase in grain yield and protein content. Johnston et al., (2017) also reported that, increasing in grain protein content of malt barley not only increased steep times but also created undesirable quality in the malt, due to excessive enzymatic activity and low extract yield. According to the Ethiopian standard authority and Asella malt factory (AMF), the protein level of raw barley for malt should be 9-12.5% (EQSA, 2006). Analysis result of this study revealed that grain protein in all treatments was within the acceptable standard range for malt purpose despite significant variation among applied N- levels.

Sieve Test:

Sieve test is done to test the plumpness of barley grains. Plump barley is a sum of barley that remains on the top of a 2.2, 2.5, 2.8 mm size sieves. Plump is determined only up on request unless any barley may qualify plumpness. The analysis of variance shows that the mean value of seed size test of malt barley was significant ($P< 0.01$) affected by only the main effects of n fertilizer level, while the man effects of variety and interaction of variety and N level was not significantly affected malt barely sieve test (Table 6). The highest mean sieve test value (4.8) and (4.17) was obtained from the lowest fertilizer rate (0 and 11.5) kg N ha $^{-1}$ respectively. Followed malt barley grown with fertilizer rate of 23 N kg ha^{-1} produced (3.44) mean sieve test value. The lowest sieve test value (1.77) and (1.33) was obtained from highest (46and 57.5) N kg ha^{-1} fertilizer rate respectively. In addition to fertilizer rate genotype variation among malt barley variety play an important role for varied sieve test vale. Statically equivalent value of sieve test was gained among the tested varieties in this research study. This study is in line with the findings of the Getachew (2014) who reported that interaction of preceding crop and N fertilizer rate revealed that grading percentages for 2.8 mm sieve size increased as the N rate increased, but decreased for 2.5 mm sieve size at Holetta. O'Donovan *et al.,* (2012) also reported that, plumpness increased with increasing seeding rate, however; the largest decreases in kernel plumpness tended to occur at seeding rates above 300 seeds m2 with a relatively minor decline as seeding rate increased from 100 to 300 seeds $m^{-2.}$

Germination Capacity:

Germination capacity was significantly ($P \le 0.01$) different among varieties and nitrogen fertilizer rates while the interaction effect was not significant (Table 6). Malt barley grown at rat of 46 N kg ha^{-1} gave the higher (98.33) germination capacity, likewise malt barley grown with fertilization of 23, 34.5 and 57.5 N kg ha^{-1} were giving equivalent germination capacity with each other and the highest one. While, the lowest (97.11) and (97.33) germination capacity was obtained from unfertilized plot and the lowest (11.5 kg N ha^{-1}) fertilizer rate respectively. This implies that the applied treatments do not have any effect on germination capacity. In this study germination capacity of malt barley increased linearly no much difference as the rates of applied N increased from zero to highest 57.5 N kg ha^{-1}. In line with the present finding Biadge *et al.*, (2016) who reported that germination energy was significantly different among varieties and different rates of nitrogen fertilizer application. The overall mean germination was above Ethiopian national seed germination standard (Berhan, 2017). Nonetheless, as per the suggestions of Kinaci and Donmez (1998) and ESA (2001), all varieties demonstrated required standard set for malt barley quality for both germination energy and germination capacity which ranged from 90 to 95% and 96 to 98% respectively (Wondimu *et al.*, 2013).

Table 6: Mean value of selected malt barley grain quality parameters

		Grain parameters	
Treatments	**GC (%)**	**ST (%)**	**GP (%)**
N-rate kg ha^{-1}			
N1	97.11b	4.8a	9.93c
N2	97.33b	4.17a	10.21b
N3	98.11a	3.44b	10.32b
N4	98.21a	2.62c	10.8b
N5	98.33a	1.77d	11.91a
N6	98.22a	1.32d	12.21a
LSD (0.05 %)	0.56	0.77	0.5
Varieties			
V1	96.1b	3.21	10.71
V2	98.8a	3.48	10.92
V3	96.9b	3.31	10.69
LSD (0.05%)	2.7	NS	NS
CV (%)	3.6	11.54	7.71

Where: GC (%) = germination capacity, ST (%) Sieve test and GP (%) = grain protein of malt barley

Economic Analysis

To organize the experimental data and information about the costs and benefits of various alternative treatments, a partial budget analysis was done to determine the economic impact of various alternative treatments as compared to the farmers' practice for malt barley production in the study area. The Analysis of variance revealed that malt barley grown from 11.5 N kg ha^{-1} to 57.5 N kg ha^{-1} was found to be economically profitable in the study area, and it gave acceptable rate of return (Table 7). The maximum MRR of 33.38 ETB and 33.16 ETB were attained from the application of 57.5 N kg ha^{-1} and 46 kg ha^{-1} respectively. Applications of 34.5,23 and 11.5 N kg Nha^{-1} also provided profitable returns of 32.9 ETB, 30.4 ETB and 31.0 ETB respectively. The economic profitability is generally in conformity with the agronomic results. In line with the present finding Kassie and Tesfaye (2019), who elaborated that higher MRR of US$9.76 for every unit investment for the application of 48 kg N ha-1 for malting barley (cv Holker) production in Lemu-Bilbilo district in the southeastern highlands of Ethiopia.

Table 7: Evaluation of the economic feasibility of the use of different nitrogen fertilizer rates for malting barley production in southeastern highlands of Ethiopia

N level kg ha^{-1}	AGY kg ha^{-1}	BY kg ha^{-1}	GFB (ETB ha^{-1})	TVC (ETB ha^{-1})	NB (ETB ha^{-10})	MRR %
0	1600.8	3324.1	76024.92	0.000	76024.92	0.00
11.5	2611.1	532.75	123895.2	3623.8	120271.4	31.00
23	2666.7	5516.2	126620.94	3703.5	122917.44	30.40

34.5	2888.9	5979.1	137175.42	4012.32	133163.1	32.90
46	3022.2	6118.3	143340.96	4193.74	139147.22	33.16
57.5	3377.8	6514.2	149818.04	4382.1	145435.94	33.38

Where: AGy = Adjusted grain yield, BY = biomass yield, GFB = Gross field benefit, TVC=Total variable cost, NB = net benefit, MRR=Marginal rate of return

CONCLUSION AND RECOMMENDATION

The results showed that optimizing malt barley varieties and nitrogen fertilizer rates significantly maximized the yield productivity, nutrient use efficiency, quality and economic profitability of malting barley. Grain yields of malting barley increase by grain yields of malting barley increased by 1777 kg ha^{-1}, 1421.0 kg ha^{-1} and 1288.1 kg ha^{-1} and economic benefits enhanced by 33.38 ETB, 33.16 ETB and 32.9 ETB for every unit investment due to applications of 57.5, 46 and 34.5 N kg ha^{-1}, respectively, when compared to the control with having detrimental effects on the grain protein concentration. Therefore, growing malting barley variety with a rate of 57.5 N kg ha^{-1} is recommended as first option and 46 N kg ha^{-1} as the second option for growers in the study area and other similar agro ecologies for optimum grain yield, acceptable kernel protein concentration and economic benefit. Thus, N application should be limited to 57.5 N kg ha^{-1} in order to mitigate the negative effects on grain quality. While this may result in reduced yield compared to applying N at higher rates, economic returns would still be higher if the barley is accepted for malting due to the increased premium for malting compared to food barley. Because of the diversities in agro ecological zones, application of nitrogen fertilizer should be based on soil test results to achieve optimum malting barley yields. Since excessive protein concentration is a major factor in the rejection of barley for malting, breeders in their future studies are recommended to focus on screening of new malting barley cultivars that maintain higher yields and relatively low protein concentration in response to nitrogen application.

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