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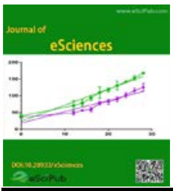

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Productivity and Grain quality of Holker, Ibon and Franka malt barley (hordeum vulgare l.) varieties to the rate of nitrogen fertilizer at central highland of Arsi, Ethiopia

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ABSTRACT

A field experiment were conducted during the 2018 cropping season at central highlands of Ethiopia to determine grain quality and yield response of malt barley (Hordeum vulgare L.) varieties to different rate of nitrogen fertilizer. The experiment was laid in a split plot design; Nitrogen rate as main plot and varieties as subplot with three replications. Phonological traits, Grain quality parameters and yield were taken as experimental variables and analyzed using SAS software. The result showed that grain yield, thousand kernel weight and hectoliter weight were significantly affected by interaction of Nitrogen and varieties. However, days to heading, days to maturity, plant height, number of productive tillers, straw yield and number of grain per spike were significantly affected by both N and varieties. On the other hand days to emergence, spike length and harvest index was not significantly affected by N and varieties. The higher (2.705 t ha-1) grain yield was recorded from the combination of Ibon variety with 57.5 kg N ha-1. Therefore, application of 57.5 kg N ha-1 fertilizer rates and Holker variety and 57.5 kg N ha-1 and Ibon variety were found to be better in terms of agronomic for malt barley production at central highland of Arsi, Ethiopia.

Keywords: Nitrogen, fertilizer rate, Grain quality, Holker, Ibon, Franka, malt barley varieties.

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INTRODUCTION

In Ethiopia, Barley production started long years ago and is largely grown as a food crop in the central and northern parts of Ethiopia, with Oromia, Amhara, Tigray, and Southern Nations, Nationalities, and People's Region (SNPPR) as the main areas of production (ATA, 2012). The use of malt barley as a row material in brewery factory has increased its value and the demand of farmers to produce (ATA, 2012). There are many types of barley malt – from light to dark but all are variations on two principal themes: germination and kilning. 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, but also makes the barley more difficult to modify, causing problems for the maltster, as a result the preferred grain N level is not greater than 1.6–1.8% (Zhao *et al.*, 2006).

Variety has also played an important role in quality and yield response of malt barley. Thus, grain quality and yield of malt barley varieties is significantly influenced by rate of N fertilizer that means when assessing grain yield of cultivars in different rate of N fertilizer in different barely varieties. Thus, malt quality and grain yield fluctuation leads to significant loss for beverage industry, individual farmers at national level. Therefore, identification of appropriate varieties of malting barley and the use of appropriate production practices are critical to the production of quality malting barley. However, limited data were available and these studies have been carried out on the interaction between Nitrogen fertilizer rates and different improved malt barley varieties under center high land of Ethiopia. The present investigation was conducted with the aim of identifying appropriate malting barley varieties, with their respective optimum level of N fertilizer, for malt barley-growing areas of central highland, Arsi, Ethiopia. Thus, the 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 and to determine the optimal rate of Nitrogen fertilizer and barley variety that would enhance grain yield without affecting the malt quality.

MATERIALS AND METHODS

The field experiments were laid out in Split-plot design with N-level as main plot and malt barley varieties as sub-plot, replicated 3 times. The main plot factors contained five rates of N fertilizer (N1 = 11.5, N2 = 23, N3 = 34.5, N4 = 46 and N5 = 57.5 kg ha^{-1}) and the sub-plot factor contained three malt barley verities (V1 = Holker, V2 = Ibon, V3 = Fanaka). Accordingly, treatments and treatment combinations were assigned randomly to the experimental unit within each block.

Experimental Procedure and Management

The experimental field was prepared following the conventional tillage practice before planting the malt barely seeds. In accordance with the specifications of the design, a field layout was prepared and each treatment was assigned randomly to experimental plots within each blocks. The blocks were separated by a 1.5 m wide, whereas the plots within a block were 0.5 m apart from each other. Each plot consisted of 20 rows of 4 m in length and spaced 20 cm apart. The total and the net plot size were10.4 m^2 (2.6 m × 4 m) and 2 x 3 m respectively. Malt barely seeds, were planted at the recommended rate of 137.5 kg ha^{-1}, in rows by using a manual row marker on the beginning of July, 2018 G.C. A blanket application of TSP (Triple supper phosphate) 100kg ha^{-1} was applied across all treatments at the time of sowing and UREA (46% N) fertilizer was applied per treatment level evenly to the surface in two doses: half at planting and half at tillering stage after weeding and during the presence of light rainfall to avoid the potential loss of nitrogen into the atmosphere. All other recommended cultural practices were properly followed to produce a successful crop. The grain was harvested within the range of middle of November to early December 2018, depending on the maturity date of each variety.

Yield and yield components

Number of productive tiller was estimated before harvest from five randomly selected portion with 0.50 m^2 quadrant from five randomly selected sections within the net plot, and finally converted to a m^2 basis. Number of grains per spike was determined from the actual count of the number of spikelet of the mother spike on five randomly selected plants at harvest. Grain yield data was recorded on clean, dried samples harvested from 18 middle rows and plot yields was adjusted to 12.5% moisture level and converted to ton ha^{-1}. Harvest index was calculated as the ratio of grain yield to the aboveground biomass yield, expressed as a percentage.

Quality parameters

Thousand kernels from the plot harvest were counted by using electronic seed counter and weighed and adjusted to 12.5 % moisture. Grain protein and moisture content in the malt barely varieties were determined using near infrared (NIR) spectroscopy (NIR Grain analyzer model 1241) as described in AACC (2000). Hectoliter weight is flour density produced in a hectoliter of the seed and it was determined using moisture and hectoliter analyzer (kg/HL).

Soil analysis

Soil samples were collected from representative points within the experimental field (0-20 cm depth) before planting by auger to make two composite samples. Similarly, surface soil samples of the same depth were collected at the time of full maturity for each treatment by taking samples from 3 points within each plot. Soil analyses were carried out at the soil laboratory of debrezeit Agricultural Research Center. The pre-planting soil samples were used to analyze available nitrogen, available phosphorus, organic carbon, and soil pH, similarly, at the time of full maturity soil samples were taken to analyses total N, available P, and soil pH in a single plot basis.

Available P was measured using Bray II (Bray, 1945). The pH of the soil measured potentiometrically in the supernatant suspension of 1:5 soil: water mixture by using a pH meter, and Organic Carbon was determined by following Walkely and Black wet oxidation method as described by Jackson (1958). Total Nitrogen was determined by using Kjedahl method as described by Jackson.

Table 1: Major soil properties of the experimental site before planting

Soil properties	
PH	6.0^{SA}
OM%	6.0^{H}
OC%	3.5^{M}
Total N (%)	0.25^{M}
P(ppm)	14.9^{H}

Where: OC = Organic carbon, OM = Organic matter, N = Total nitrogen, P = available Phosphorus, SA = slaytly acidic, H = high; VH = very high, M = medium.

According to the fertility classification of Lando (1991),the pre planting soil analysis indicated that the soil of the experimental sites were slightly acidic, high to very high content of organic carbon(OC),high content of available P, medium content of total nitrogen(N) and Luvosoil soil type. Different crops have different nutrient requirement. However, optimum pH range for barley is 6.0 to 7.0 (CLDB, 2001). Therefore the experimental soil pH is suitable for barley. Other soil chemical properties were: organic matter content 6.0 and 7.02%, total N 0.25 and 0.23%, available P 14.9 ppm.

Data Analysis

All data was subjected to analysis of variance (ANOVA) for both sites following the standard procedure for split plot design. Variety and nitrogen fertilizer interaction will be performed using PROC GLM Procedure of SAS software version 9.1(SAS, 2004). Correlation analysis was conducted using Pearson correlation coefficient. Then path analysis was used to investigate cause relationships and direct and indirect effects of traits on grain yield and quality traits. Mean separation was employed following the significance of mean squares using Least significant difference (LSD) at 5% level of significance.

Results

Physico-chemical Analysis of Soil

Table 2: Some physical and chemical property of soil after harvest

Treatments	Result of analysis				
N-rate	PH	OM%	OC%	N%	P
11.5	5.8	5.6	3.4	0.2	12.3
23	5.9	6.0	3.5	0.2.5	13.0
34.5	5.9	6.2	3.6	0.3	13.3
46	5.9	6.1	3.6	0.3	12.5
57.5	5.9	6.3	3.7	0.3	13.5
mean	**5.9**	**6.1**	**3.6**	**0.22**	**12.9**

Where: OC = Organic carbon, OM = Organic matter, N = Total nitrogen, P = available Phosphorus.

Crop Phenology

Table 3: The main effects of Nitrogen rate and Variety on phonological parameters

Treatment	phonological parameters		
N kg ha^{-1}	DE	DH	DM
11.5	8.3^{a}	63.4^{d}	101.8^{c}
23	8.3^{a}	66^{c}	102.5^{c}
34.5	8.2^{a}	69.9^{b}	104.1^{c}
46	8.2^{a}	71.7^{b}	109.5^{b}
57.5	8.1^{a}	75.2^{a}	115.4^{a}
LSD 5%	Ns	2.49	3.4
CV%	2.8	275	2.3
Varities			
Holker	8.2^{a}	71.2^{b}	111.3^{a}
Ibon	8.2^{a}	67.9^{ab}	100.7^{c}
Fanaka	8.2^{a}	69.1^{a}	103.0^{b}
LSD 0.05%	**Ns**	**3.03**	**3.1**
CV%	**2.08**	**2.79**	**2.38**

Mean values within column followed the same letters are not significant different (P < 0.05), LSD = Least significant difference, CV% = Coefficient of variation, ns = non-significant different, DE = Days of emergency, DM = Days to maturity and DH = Days to heading.

Growth parameters

Table 4: Mean crop growth parameters of malt barley varieties with different rates of Nitrogen fertilizer.

Treatment	Growth parameters result		
N kg ha^{-1}	PH	NTR	SL
11.5	88.6^{c}	3.7^{b}	5.5^{a}
23	90.6^{c}	4.1^{ab}	5.6^{a}
34.5	92.4^{bc}	4.6^{ab}	5.8^{a}
46	96.0^{ab}	4.6^{ab}	5.6^{a}
57.5	99.4^{a}	5^{a}	5.6a
LSD 0.05%	**5.2**	**0.9**	**Ns**
CV%	**4.3**	**11.5**	**9.3**
Varities			

Holker	105.1^{a}	4.3^{a}	5.6^{a}
Ibon	90.4^{b}	4.8^{a}	5.3^{a}
Fanaka	84.7^{c}	4.1^{a}	5.2^{a}
LSD 0.05%	**4**	**0.76**	**Ns**
CV%	**2.7**	**10.2**	**12.1**

Means in column followed by the same letter are not significantly different at 5% level of significant; LSD (0.05%) = Least significant difference at 5% level; CV = Coefficient of variation. NS = non-significant different; PH = Plant height; NTR = Number of tillers per plant; and SL = Spike length.

Yield and Yield Components

Table 5: Mean value of yield and yield components of malt barley varieties with different rates of Nitrogen fertilizer.

Treatment	Mean value of yield and yield components			
N kg ha^{-1}	NPT	GPS	SY t ha^{-1}	HI%
11.5	31.3^{ab}	24.0^{b}	7.208^{d}	21.6a
23	33.3^{ab}	24.9^{ab}	10.420^{c}	20.2a
34.5	30.8^{b}	25.1^{ab}	12.643^{a}	18.9a
46	37.5^{ab}	26.2^{a}	11.225^{bc}	22.1a
57.5	40.09^{a}	26.5^{a}	11.744^{ab}	22.5a
LSD 5%	8.3	2.06	404	Ns
CV%	10.25	8.8	9.3	2.08
Varities				
Holker	33.4^{ab}	25.6^{a}	10.462^{b}	21.9a
Ibon	39.7^{a}	23.8^{b}	11.905^{a}	20.1a
Fanaka	31.2^{b}	24.3^{b}	10.520^{b}	18.7a
LSD 0.05%	7.7	1.59	1.385	4.6
CV%	14.2	8.2	6.4	2.4

Means in column followed by the same letter are not significantly different at 5% level of significant; LSD (0.05%) = Least significant difference at 5% level; CV = Coefficient of variation. NS = non- significant different; NPT= Number of productive tillers plant^{-1}; GPS = Grain per spike; SY t ha^{-1} tons per hectare and HI% = Harvest index.

Quality parameters

Table 6: Mean value of Quality parameters of malt barley varieties with different rates of Nitrogen fertilizer.

Treatment	Mean value of quality result	
N kg ha^{-1}	GE%	GP%
11.5	97.5^{a}	9.95^{c}
23	98.3^{a}	10.3^{ab}
34.5	97.4^{a}	10.4^{ab}
46	97.2^{a}	10.8^{b}
57.5	97.7^{a}	12.3^{a}
LSD 5%	**Ns**	**0.5**
CV%	**1.3**	**4.1**
Varieties		
Holker	96.9^{b}	10.6^{a}
Ibon	98.9^{a}	10.9^{a}
Fanaka	96.0^{b}	10.7^{a}
LSD 0.05%	**2.7**	**Ns**
CV%	**1.7**	**5.7**

Mean values within column followed the same letters are not significantly different at 5% level of significant; LSD (0.05%) = Least significant difference at 5% level; CV = Coefficient of variation. NS = non- significant different; GP=Grain protein and GE= Germination energy.

Table 7: Mean value of interaction effect of nitrogen and malt barley varieties on thousand kernel weigh; grain yield and hecto liter weigh.

Treatment		Mean value of N interaction result		
N kg ha^{-1}	Varieties	GY t ha^{-1}	TKW	HLW kg/hl
	Holker	1.8197^{h}	47^{d-f}	64.3^{g}
	Ibon	2.020^{fg}	46.9^{ef}	66.3^{de}
N1	Fanaka	1.4697^{j}	45.6^{f}	65.0^{fg}
	Holker	2.015^{g}	45.9^{f}	66.6^{ef}
	Ibon	2.4983^{c}	45.9^{f}	69.3^{cd}
N2	Fanaka	1.6897^{i}	47.2^{d-f}	66.3^{e-g}

	Holker	2.125^{e}	45.5^{f}	67.3^{de}
	Ibon	2.002^{b}	52.2^{bc}	70.0^{bc}
N3	Fanaka	2.014^{g}	45.9^{f}	65.0^{fg}
	Holker	2.314^{d}	46.9^{ef}	68.3^{c-e}
	Ibon	2.639^{ab}	54.9^{ab}	71.6^{ab}
N4	Fanaka	2.119^{ef}	52.9^{bd}	66.6^{ef}
	Holker	2.314^{d}	50^{c-e}	70.0^{bc}
	Ibon	2.705^{a}	56.6^{a}	72.6^{a}
N5	Fanaka	2.157^{e}	50.6^{cd}	67.6^{de}
LSD 0.05%		**99.3**	**3.1**	**2.04**
CV%		**2.83**	**2.04**	**3.21**

Mean values within column followed the same letters are not significantly different at 5% level of significant; LSD (0.05%) = Least significant difference at 5% level; CV = Coefficient of variation. NS = non- significant different; GY t ha^{-1} = Grain yield tons per hectare; TKW= Thousand kernel weigh and HLW = Hectoliter weight.

Table 1: Correlation analysis of yield and yield components of malt barley.

	SL	GP	NPT	TKW	M	PH	NGPS	TLR	GE	DH	AGY	HI
SL		0.14^{ns}	0.16^{ns}	0.02^{ns}	-0.11^{ns}	0.19^{ns}	0.16^{ns}	-0.67^{ns}	-0.16^{ns}	-0.13	0.07^{ns}	-0.13^{ns}
GP			0.47**	0.27^{ns}	-0.06^{ns}	0.22^{ns}	0.28^{ns}	0.29^{ns}	-0.01^{ns}	0.57***	0.46**	-0.21^{ns}
NPT				0.41**	-0.05^{ns}	-0.06^{ns}	0.17^{ns}	0.37*	0.02^{ns}	0.25^{ns}	0.61***	0.29*
TKW					-0.19^{ns}	0.30*	0.35*	0.22^{ns}	0.13^{ns}	0.29^{ns}	0.58***	0.17^{ns}
M						-0.23^{ns}	0.02^{ns}	-0.11^{ns}	-0.25^{ns}	0.03^{ns}	-0.05^{ns}	-0.11^{ns}

PH	0.37*	-0.1^{ns}	0.21^{ns}	0.21^{ns}	0.02^{ns}	-0.19^{ns}
NGPS		-0.06^{ns}	-0.02^{ns}	0.04^{ns}	0.32*	0.05^{ns}
TLR			0.20^{ns}	0.31*	0.39*	0.14^{ns}
GE				0.08^{ns}	0.05^{ns}	0.16^{ns}
DH					0.37*	-0.28^{ns}
AGY					0.77***	0.09^{ns}
HI						0.05^{ns}

Pearson Correlation Coefficient (r) Among Grain yield and Yield related traits of Malt barley varieties.

Discussion

Table 9: Mean square value for crop phenology of malt barley varieties planted with different rate of N fertilizer.

SV	DF	Days to emergence	Days to heading	Days to maturity
		Pr>F	Pr>F	Pr>F
REP	2	0.512	0.169	
Nt	4	0.066	0.0001	0.0001
Var	2	0.310	0.0004	0.0001
Nt*Var	8	0.09	0.481	0.927
CV%		**7.35**	**2.79**	**3.8**

Where: SV = source of variation, DF = degree of freedom, Rep = Replication, Nt = Nitrogen rate, Var = varieties, CV% = cofieciance of variation.

Table 10: Mean square value for crop growth parameters of malt barley varieties planted with different rate of N fertilizer.

SV	DF	TLR	PH	SL
		Pr>F	Pr>F	Pr>F
REP	2	0.283	0.098	0.128
Nt	4	0.003	0.0001	0.888
Var	2	0.199	0.0001	0.26
Nt*Var	8	0.705	0.111	0.873
CV%		**13**	**2.75**	**12.1**

Where: SV = source of variation, DF = degree of freedom, Rep = Replication, Nt = Nitrogen rate, Var = varieties, CV% = cofieciance of variation, SC = Stand count, TLR = Number of tillers, PH = Plant height and SL = spike length.

Table 11: Mean square value for yield and yield components of malt barley varieties planted with different rate of N fertilizer.

SV	DF	PT	GPS	GY t ha^{-1}	SY t ha^{-1}	HI%
		Pr>F	Pr>F	Pr>F	Pr>F	Pr>F
REP	2	0.103	0.126	0.078	0.069	0.875
Nt	4	0.001	0.001	0.0001	0.002	0.101
Var	2	0.0004	0.004	0.0001	0.001	0.503
Nt*Var	8	0.469	0.994	0.0006	0.032	0.043
CV%		**9.4**	**8.25**	**2.67**	**5.13**	**8.6**

Where: SV = source of variation, DF = degree of freedom, Rep = Replication, Nt = Nitrogen rate, Var = varieties, CV% = cofieciance of variation, PT = Number of productive tillers, GPS = Number of grains per spike, GY t ha^{-1} = Grain yield ton ha^{-1}, SY t ha^{-1} = Straw yield ton ha^{-1}, HI% = Harvest index.

Table 12: Mean square value for quality parameters of malt barley varieties planted with different rate of N fertilizer.

SV	DF	TKW	HLW	GP%	GE%
		Pr>F	Pr>F	Pr>F	Pr>F
REP	2	0.913		0.202	0.047
Nt	4	0.0002	0.0001	0.0001	0.233
Var	2	0.0001	0.001	0.355	0.0001
Nt*Var	8	0.0003	0.008	0.358	0.18
CV%		**4.2**	**5**	**5.7**	**1.7**

Where: SV = source of variation, DF = degree of freedom, Rep = Replication, Nt = Nitrogen rate, Var = varieties, CV% = cofieciance of variation, TKW= Thousand kernel weight, HLW= Hector litter weight, GP% = Grain protein and GE% = Germination energy

Physico-chemical Analysis of Soil

Analytical data of soil pH, organic matter, organic carbon and total N determined from the composite surface (0-20 cm) soil samples collected from each plots of the experimental field before planting and after harvesting of malt barley were presented in (Table 1).

The results revealed that the average soil pH of the experimental field were 6.0 and 5.9. Ranging from 5.30 to 5.59 qualifies for the strongly acidic soil reaction class (pH 5.1-5.5) set by (Murphy, 1968) while working with Ethiopian soils.

The average organic matter (OM %) content of the soil at was 6% and 6.1% before and after sowing, (Table 1). (Murphy 1968) classified soils with less than 1, 1-2, 2-3, 3-5 and greater than 5% organic matter (OM) as very low, low, medium, high and very high in their OM contents, respectively, while (Tekalign *et al.,* 1991) suggested soils with less than 0.85, 0.85-2.60, 2.60-5.20 and greater than 5.20% OM to be classified as very low, low, moderate and high, respectively, in their OM status. Thus, the soil of the study area falls under medium OM level as per the classification of (Murphy, 1968) and under the moderate level of OM as per the classification suggested by (Tekalign *et al.,* 1991).

The average total nitrogen was 0.25% and 0.22% before and after owing respectively, (Table 1). According to N availability soils classified as very low, poor, moderate and high when the total N contents are less than 0.05%, 0.05-0.12%, 0.12-0.25% and > 0.25%, respectively (Tekalegn et al., 1991). There for the soil of the study area falls under moderate N level.

Crop Phenology

I. Days of emergency:

The main effects of varieties and N rates as well as their interactions did not affect the duration of crop emergence significantly (Appendix Table 9). Seedlings from all plots were fully emerged between 8 to 9 days after planting at both locations. During germination the seedling mostly depends on stored food than on external nutrient. Because of this, significant variation might not be observed on days to emergence by N fertilizer application within three varieties. In agreement with this, Quinones (1997) who reported that once the germination process is set, seedling emergence might take less than a week, depending on soil temperature, moisture availability and seeding depth. Similarly, Shrivastava et al. (1992) who reported that plants depend mostly on stored food than on external nutrients for germination.

II. Days to heading:

The result showed that the main effect of fertilizer and varieties highly significant ($P<0.01$) on days to heading, although the interaction was not significant (Table 9). The longest (75.2) days to heading were recorded from (57.5 kg N ha^{-1}) fertilizer rate, while the shortest (63.4) days to heading were recorded from application of 11.5 kg N ha^{-} (Table 5). Increased levels of N fertilizer from control (11.5 kg N ha^{-1}) to highest (57.7 kg N ha^{-1}), days to heading increased consistently. This might be attributed to the behavior of increased N fertilizer increases vegetative growth of crops thereby it delaying heading time.

In agreement with the result, Mekonen (2005) reported that a day to heading was significantly delayed when N fertilizer was applied at the highest rate for wheat and barley production compared to the lowest rate. (Rashid *et al.,* 2007) also reported that nitrogen fertilizer application significantly affected days to heading of barley.

Statistically significant variation was observed in days to heading of the tested varieties. The longest duration for days to heading was recorded from Holker (71.2 days) whereas the other tested varieties took statically similar shortest days to heading (Table 3). This might be due to variation in genotypes. In agreement with the result, Daniel *et al.* (2013) reported that barley genotypes differ in days to heading.

III. Days to 90% physiological maturity

Days to maturity were significantly affected by varieties and N treatments, but their interaction was not significant in both locations (Table 9). The two top N rates 46 and 57.5 kg ha^{-1} were at pare between each other and they were significantly different the remains three treatments. The longest days to maturity (115.4 were recorded from the highest (55.7 kg ha^{-1}) N fertilizer rate, while the shortest (101.8) days to maturity were obtained from control treatments (Table 3). Increased levels of N fertilizer from control (11.5 kg N ha^{-1}) to highest (57.5 kg N ha^{-1}), days to maturity increased consistently. This might be attributed to the behavior of the fertilizer N which increases vegetative growth of crops whereby it delays maturity time. This result was in line with Damene Darota (2003) who reported that from similar experiment conducted on wheat, indicating that significant differences due to N treatments were observed in the field with respect to plant maturity .Similar result was reported by Woinshet Tariku, (2007) reported as high rates of nitrogen prolong days to physiological maturity.

Statistically significant variation was observed in days to 90% physiological maturity of the tested varieties in both locations. The longest duration for maturity was recorded for Holker (111.3) whereas the other tested varieties took statically similar shortest days to heading (Table 3). Similar result was reported by Melle et al. (2015) who showed that varieties showed significant difference in days to maturity. Similarly, Wosene et al. (2015) reported that genotypes could differ in days to physiological maturity.

Growth parameters

I. Plant height

Analysis of variance revealed that the main effect of variety and N fertilizer rate showed significant (p<0.001) difference on plant height at both location ,But the interaction was not significant(table 10).Generally, as the rate of N fertilizer increase from 11.5 to 57.7 kg ha^{-1} a significant increase in plant height was observed in both location. The tallest plant height (99.4 cm) while the shortest plant height (88.6) was recorded with application of 11.5 kg N ha^{-1} (Table 4). Such increment of plant height along with increasing of N 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 rate of Nitrogen fertilizer. Similarly, 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.

The tallest plant height (105 cm) was recorded from Holker variety, while the shortest plant height (84.7 cm) was recorded from Fanaka variety. Holker variety exceeded the two other varieties; they may be due to combined effect of genotypic and environmental effect, which were suited for the local cultivar than the two others.

II. Number of tillers per plant

Analysis of variance showed that the main effect of N fertilizer rate had significant effect (P<0.05) on number of tillers per plant. On the other hand, the main effect of variety and the interaction effect of variety and fertilizers were not significant (Table 10). Height (5) number of productive tiller were produced from application of 57.7 kg N ha^{-1}, while the lowest (3.7) number of tillers per plants were recorded from 11.5 kg N ha^{-1} (Table 4). The number of tillers per plants was significantly increased in response to increasing application rate of nitrogen. These may be due to nitrogen promotes activities essential for carbohydrate utilization and its most important function in plant promotion of rapid growth through increasing number of tillers per plant. The current result is in agreement with Melesse (2007), who reported that as the N fertilizer rate increased from 0 to 69 kg ha^{-1}, the total number of tillers of bread wheat was increased from 4 to 7 per plant, respectively. Similarly, Okubay *et al.* (2014) reported that the number of total tillers increased significantly with increasing levels of N from 0 to 69 kg ha^{-1} in tef. In addition to this Kumar (2005), who reported that the number of total tillers plant^{-1} was significantly increased with increasing nitrogen rate.

III. Spike length

The result showed that the interaction of fertilizer and variety did not show significant effect on spike length (Table 10).Longer spike length 5.8 cm was recorded from Holker variety with application of 34.5 kg N ha^{-1}, Whereas the shortest spike 5.2cm were recorded from Fanaka variety with 11.5 kg N ha^{-1} (Table 4).

Yield and Yield Components

I. Number of productive tillers

Analysis of variance revealed that the main effect of variety and N fertilizer rate showed significant ($p \leq 0.05$) difference on number of productive tillers at both location, But the interaction was not significant (Table 10).

Comparison of treatment means from both locations indicated that number of productive tillers generally increased with increasing rate of N-fertilizer. Hence, maximum numbers of productive tillers (40.09) were produced from 57.5 kg N ha^{-1}, whereas the lowest numbers of productive tillers (31.3) were obtained from plants grown with control/initial N- fertilizer application (Table 5). The results were in agreement with Abdullatif *et al.* (2010), who reported that, the number of productive tillers increased with nitrogen fertilization. Similarly, Evans *et al.* (1975) found that tillering is enhanced by increased light and N availability during the vegetative crop phase. Prystupa *et al.* (2004) reported that the number of productive tillers of barley was affected significantly by N fertilizer application.

Statistically significant variation was observed on number of productive tillers of the tested varieties in both locations. The highest (39.7) number of productive tillers was recorded from Ibon variety whereas smallest (31.3) number of productive tillers was recorded from Fanaka variety.

II. Number of grains per spike

Number of grains per spike was significantly ($P \leq 0.01$) different to the main effect of varieties and N levels, while the interaction effect was not significantly affected at both locations (Appendix Table 5). The highest number of seeds per spike (26.5) at (25.7) at was recorded from the application of 57.7 kg N ha^{-1} , while the lowest number of grains per spike (24.0) were recorded with application of 11.5 kg N ha^{-1} (Table 5). Number of seeds per spike had a linear and positive response to N fertilizer rate. These might be the ability of the plants that absorb high amount of N fertilizer, to translocation and assimilate N for the synthesis and development of spikelet during anthesis phase. Similarly Shafi *et al.* (2011) also reported Nitrogen applied at the rate of 60 kg ha^{-1} resulted in maximum grain spike^{-1}. Schulthess *et al.* (1997) reported a high response of number of grains per spike to N application rate. Similarly, Tilahun *et al.* (1996a) reported great variation of grains per spike between the highest N level and the lowest application.

There was variation among varieties on number of grains per spike. In both location highest (26.5) number of grains per spike was produced from Holker variety, while the lowest (23.8) (Table 5).Thus variation of number of grains was come resulted from varieties difference. In line with this result Adane (2015) reported genotypic differences of barley in spikelet per spike that in turn resulted in higher numbers of grain per spike.

III. Grain yield t ha^{-1}

The analysis of variance showed that grain yield was significantly ($P < 0.001$) different as result of the interaction effect of the two factors at both location (Table 11).

The highest grain yield (2.705 ton ha^{-1}) were obtained with combination of 57.5 kg N ha^{-1} and Ibon variety, whereas the lowest grain yield (1.4697 ton ha^{-1}) were recorded from combination of 11.5 kg N ha^{-1} and Fanaka variety (Table 6). In this study grain yield ranged between 1.4697 ton ha^{-1} (Fanaka) and 2.705 ton ha^{-1} (Ibon) and 1.395 ton ha^{-1} (Ibon) and 2.629 ton ha^{-1} (Fanaka) (Table 7). This large grain yield variation among barley varieties under different nitrogen rate treatments could help in the selection of better varieties for different N supply environments. This result were in line with Amare (2015) reports who mentioned that significant increases in grain yields of malt barley crop with increasing levels of N fertilizer. Similarly, the result was support by many authors: Alam *et al.,* 2005 and Moreno *et al.,* 2003, who reported that accumulation of dry matter of barley increased with higher doses of N-fertilizer rate. Similarly Amare (2015) who was elaborated that those significant increases in grain yields of malt barley crop with increasing levels of N fertilizer. In addition to this Shafi *et al.* (2011) also reported Nitrogen applied at the rate of 60 kg ha^{-1} resulted in maximum thousand grain weight, biological yield and grain yield.

IV. Straw yield t ha^{-1}

Straw yield was significantly (P< 0.05) different to the main effect of varieties and N levels, while the interaction effect was not significantly affected at both locations (Table 11). The highest straw yield (12.643 ton ha^{-1}) was recorded from the highest fertilizer rate (57.5 kg N ha^{-1}), While the lowest straw yield (7.208 ton ha^{-1}) was obtained from the lowest fertilizer rate (11.5 kg N ha^{-1}). The application of N fertilizer rates from 11.5 to 57.5 kg N ha^{-1} increased straw yield from 7.208 ton ha^{-1} to 12.643 ton ha^{-1}, which is 54.35% higher than the initial fertilizer rate (Table 5). Increase in straw yield in response to application of N fertilizer rates might be due to its enhanced availability, uptake and induction of vigorous vegetative growth with more leaf area resulting in higher photosynthesis and assimilates that resulted in more dry matter accumulation. The result of this study was in line with; Amsal *et al.* (2000) who found that N rate significantly enhanced the straw yield of wheat, since N usually promotes the vegetative growth of a plant.

There were also significant differences (P < 0.05) among the three varieties of malt barley on straw yield. The highest (11.905 ton ha^{-1}) mean straw yield were recorded from Ibon variety, whereas the lowest (10.462 ton ha^{-1}) straw yield were obtained from Fanaka variety (Table 5).

V. Harvesting index

Generally, harvesting index indicates the balanced between the productive parts of the plant and the reserves, which from the economic yield. High harvesting index indicates the presence of good partitioning of biological yield to economical yield. The analysis of variance revealed that no significant difference among any of treatments in harvest index of malt barley (table 11).

Quality parameters

I. Thousand kernel weight

Analysis of variance revealed that the main effect of Nitrogen rate, variety as well as the interaction effect of two factors had showed highly significantly ($p<0.001$) difference on thousand kernel weight at both location(Table 12).

The highest mean thousand kernel weight (56.6) and (55.2) were obtained with combination of 57.5 kg N ha^{-1} and Ibon variety, while the lowest mean thousand kernel weight (45.6) were recorded from combination of 11.5 kg N ha^{-1} with Holker and Ibon varieties respectively. Generally thousand kernel weights increased almost linearly in all varieties with increasing rates of N up to 57.5 kg N ha^{-1} (Table 7). In greement with this report, Rashid and Khan (2008), Bagheri and Sadeghipour. (2009) and Yetsedaw *et al*. (2013) reported that variation of thousand kernel weight as a function of barley genotype and N fertilizers. Thousand kernel of malt barley weight should be >45 g for 2-rowed barley and >42 g for 6-rowed barley (Anonymous, 2012).There for the result of the present experiment exhibited an acceptable thousand kernel weight (Table 7).

II. Hector litter weight

The analysis of variance revealed that Hectoliter weight (HLW) was significantly (P< 0.05) different as result of the interaction effect of the two factors (Table 12).

The highest (72.6 kg hl^{-1}) hectoliter weight was recorded with combination of (57.5 kg Nha^{-1}) and Ibon variety followed by (71.6,70 and 70 kg hl^{-1}) from combination of 46 kg N ha^{-1} with Ibon variety,57.5 kg N ha^{-1} with Holker variety and 34.5 kg N ha^{-1} with Ibon variety respectively. Whereas the lowest (64.3 kg hl^{-1}) hectoliter weight was obtained from combination of 11.5 kg N ha^{-1} with Holker variety followed by 11.5 kg N ha^{-1} with Fanaka variety. Rick *et al.* (2014) reported that the acceptable test weights (hectoliter weight) for barley were in the range 66.1- 72.8 kg hl. The current results exhibited an acceptable hectoliter weight in all varieties for all N fertilizer rates (Table 7).

III. Germination energy

The analysis of variance for germination energy of malt barley was significantly (p ≤ 0.05) different among varieties (Table 4). The highest (98.9%) germination energy was obtained from Ibon variety. In this study, the number of grains germinating within 48 hr was significant different among varieties (Table 8) .In conformity with this result, Biadge et al. (2017) reported that the differences in the genetic factors determining germination energy of malt barley varieties after three days and a minimum of 95% germination on 3 days germination test is an absolute requirement. In addition to that Thomas (cited by Swanston et al., 2002) also noted differences in the genetic factors determining germination after three days and also suggested that there were environmental effects on their expiration. EBC (1998) also reported that germination energy of malt barley should >95%. The current result indicated that the germination energy was in the acceptable range in all variety at both locations. The germination energy did not show significant differences among nitrogen levels, but the germination energy varied between 97.2-98.3%. Germination energy was slightly decreased as N rates increase (Table 8).

IV. Grain protein

Grain protein content of malt barley was highly significant (p <0.05) difference to the main effect of N fertilizer levels, while the main effect of variety and interaction effect was non-significantly (p ≤ 0.05) affected on grain protein content at both locations(table 12). As N fertilizer increase from (11.5 to 57.5 kg Nha^{-1}) grain protein content also increases at both locations. The highest (12.3%) grain protein content was recorded from the highest N fertilizer application (57.5 kg N ha^{-1}.The variation in grain protein of malt barley with the application of N fertilizer rate was supported by many authors. Adane (2015) who reported that with low available nitrogen in the soil, malt barley responds well to applied fertilizer, which showing increase in 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. Increasing in protein may increase steep times, consequently create undesirable qualities in the malt. Johnston et al. (2017) who reported that increasing in protein content of malt barley may increase steep times, create undesirable quality in the malt, excessive enzymatic activity and low extract yield. In addition to these it also slow down water uptake during steeping and affect 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 9-12.5% (EQSA, 2006). However, grain protein in all main effect of treatments was within the acceptable standard range for malt purpose in both locations (Table 8).

Pearson Correlation Coefficient (r) Among Grain yield and Yield related traits of Malt barley varieties.

I. Correlations of grain yield and yield related traits

Correlations of grain yield and related traits are presented in (Table 8). The characters studied were spike length, grain protein, number of productive tillers, thousand kernel weight, plant height, number of grains per spike, number of tillers per plant, germination energy, days to heading, grain yield and harvest index. Most of yield related traits were positively correlated with grain yield in both locations, except the negatively correlation of moisture.

Plant height was positively correlated with spike length, grain protein, thousand kernel weights, and number of seed per spike, germination energy, days to heading and grain yield, but negatively correlated with number of productive tillers, grain moisture, number of tillers per plant and harvest index Days to maturity was positively related with spike length, grain protein, number of productive tillers, thousand kernel weight, plant height, number of grains per spike, number of tillers per plant, germination energy, days to heading, grain yield, while it was negatively related with spike length and harvest index.

II. Correlation between malt qualities related traits

Correlation between malt quality related traits were presented in (Table 8).At both location thousand kernel weights was positively correlated with germination energy and grain protein content, but negatively correlated with grain moisture content.

Germination energy was positively correlated with thousand kernel weights, but negatively correlated with grain protein and grain moisture. Protein content was negatively correlated with grain moisture and germination energy, but positively correlated with thousand kernel weight.

High protein is undesirable because of the strong correlation with low carbohydrate (starch) levels and thus low extract values (Bishop 1930). However, if the protein content of malt is too low, brewing performance may be impaired through poor yeast amino acid nutrition. According to the Ethiopian Standards Agency, the acceptable test weight (HLW) of raw malt barley ranges from 48 to 62 kg/HL (EQSA, 2006). Generally, positive and significant association of pairs of characters justified the possibility of correlated response to selection. The negative and significant correlation prohibits the simultaneous improvement of those traits. The non-significant coefficient of correlation indicates that selection for these different traits could be done separately and independently and also simultaneously.

Conclusion

A filed experiment was conducted during the main cropping season of 2018 with major objective of determining appropriate malting barley varieties, with their respective optimum level of N fertilizer and their interaction effects on malt barley qualities. The analysis of soil sample before planting and after harvest indicates that the soil of the experimental sites were slightly acidic, high to very high content of organic carbon (OC), high content of available P, medium content of total nitrogen (N) .

Number of tillers, plant height, number of grains per spike, straw yield, hectoliter weight, and thousand kernel weight of malt barley were increased with N fertilizer rates increased. Grain yield and protein content of malt barley were increase with increasing N fertilizers rates. However, high nitrogen rate leads to high grain protein content while low nitrogen rates leads to optimum grain yield with acceptable quality. Among three malt barley varieties Ibon variety had good performance comparatively the rest two verities. The application of 46 kg ha^{-1} N fertilizer rates and Ibon variety which generated optimum grain yield with required quality, and economically reasonable.

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