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Yield and Quality Response of Malt Barley (Hordium Dischiton L.) to Applied Levels of N Fertilizer and Seed Sources on Luvisol of Farta District South Gonder Zone, Ethiopia

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Abstract
Field and laboratory experiments were conducted to investigate the effect of seed sources and rate of nitrogen fertilizer on yield and quality of malt barley (Hordium dischiton L.) and to determine agronomically optimum level of nitrogen (N) and seed sources at Farta District. Factorial combination of four levels of N (0, 70, 110, and 150 kg N ha^{-1}), and three seed sources seed from local farmer (LFM seed), seed from local seed business farmer (LSB) and seed from Amhara seed enterprise (ASE) were laid out in a Randomized Complete Block Design with three replications. Phenological traits, quality parameters and yield were taken as experimental variables and analyzed using SAS software. The result showed that 100-seed weight, straw yield, biomass yield and grain yield were significantly affected by different rates of N application ($p \leq 0.005$). As laboratory experiment indicates, there were significant effects in seed moisture content from the main and interaction effect of seed sources and nitrogen fertilizer rates ($p \leq 0.001$). The main effects of seed sources (LFM, LSB and ASE) had 11.6%, 11.59% and 12.5% of protein content respectively. Protein contents were significantly higher in higher nitrogen fertilizer rates than the control ($p \leq 0.05$). Nitrogen fertilizer rates resulted in linear responses with mean protein contents of 9.15%, 11.6% and 12.14%, from 0, 70, 110 and 150 rates, respectively. Germination percentage was significantly affected by seed sources; rates of N fertilizer application and their interactions. I n this study (2763.96, 6625 kg/ha) of grain and total above gowned yield respectively and quality of malting barley were significantly improved when using 150 kg of N rates. Overall, the use of ASE seed and 150 kg of N fertilizer rate may maintain satisfactory crop yield and protein content, reduce the costs of production, and therefore increase profitability and improve soil fertility.
Keywords: seed, quality, protein content, sources, malt barley.

INTRODUCTION

Barley (*Hordium vulgar* L.) is one of the most important cereal crops in the world, ranking fourth after wheat, maize, and rice in terms of production (Lapitan *et al*. 2009). In 2005, barley was grown in more than 100 countries worldwide, with total barley grain production of 138 million tons from 57 million hectare, with proximate productivity of 2.4 t/ha (Getachew Agegnehu, Berhane Lakew & Paul N. Nelson 2003). The highest commercial yields tend to come from central and northern Europe.

In Ethiopia, Barley production started long years ago, but up to this time there is shortage of malt barley both in quality and quantity to meet the demand of the local breweries (Mohammed and Getachew Agegnehu, 2003) Malt barley is one of the principal ingredients in the manufacture of beer. Brewers can either purchase malt barley to manufacture malt themselves or purchase malt from malting companies. In either case, malting quality barley must meet the special quality specifications (Getachew Agegnehu, Berhane Lakew & Paul N. Nelson 2003). The malting characteristics of barley also depend on growing conditions, harvesting conditions, and storage of grain as well as seeds (HBQL) (Fekadu *et al*., 1996).

Seed supply system of malt barley in the developing countries indicates that all of the seed materials come from the general crop production rather than from crop grown especially for seed purpose, except for the small quantity produced by seed growing farmers and those supplied by seed brokers and cooperatives. Even this quality does not measure up to the required seed standards. Use of seed that is produced on farm or obtained from relatives, friends or other informal channels is still by far the most important seed source for agriculture in developing countries, and is still important in more industrialized agricultural countries as well. Eighty percent of all seed in developing countries is estimated to be on farm produced seed and as seed source vary malt quality also vary. Of course, the percentage varies widely between crops (ICRISAT, 2005).

One important factor influencing malting barley production is the supply of N because of its effects on yield, on the one hand, and grain protein content and malting quality, on the other (Spaner *et al*. 2001). Excess soil N may raise the protein content of the kernel, which is undesirable for malting. Barley grains with high protein content are more difficult to malt, yield low amounts of extracts and can cause difficulties in brewing (Mather *et al*. 1997; Schelling *et al*. 2003).

In Farta District malt barley production started many years ago, now the country is proved to have reasonable potential to grow different barley verities for rain feed ecosystems (Amhara region agriculture bureau

2014). Tiret Corporation (Dashin Brewers) & Debretabor University have various cropping system & collections including new malt barley and wild verities species, but still there is a problem of seed quality.

The farmers in the district primarily rely on only two fertilizers to supplement the nutrient content in their soil, phosphorus in the form die ammonium phosphate (DAP) and nitrogen in the form of Urea based on their standard application rate. But the effect of the application of these rates of N fertilizer on quality of malt barley was not studied. Furthermore nothing had been studied about effect of different sources of malt barley seed and different rate of nitrogen fertilizer on yield and yield related factors and quality of Malt barley in the study area. Hence, this research was initiated to achieve the effect of different sources of malt barley seed and their response on the application of different rates of nitrogen fertilizer on quality and yield of malt barley, specifically;

- To evaluate the productivity & quality of different sources of seeds of malt barley.
- To determine appropriate level of nitrogen fertilizer to maximize malt barley quality
- To assess the interaction effect of different seed sources of malt barley and rates of nitrogen fertilizer on quality and yield of malt barley in Farta District.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at Farta District during 2014 cropping season. The district is one of the 149 districts of the Amhara Regional State in South Gonder Zone, located in a temperate ecology about 645 km from Addis Abeba and 123 km south east of Bahir Dar town(Fig 1), in north west Ethiopia. The site Mayent *Keble* was found an altitude of 3500 m.a.s.l and its geographical position is within latitude of 11^0 43’50.7”N and longitude of $34^0$48’59.62”E.

The mean annual temperature is about 15.94^0C, ranging from a mean minimum of 8.425 ^{0}C to mean maximum of 23.458^0C. The mean annual rainfall is 161.4 mm /year, with high variation from year to year. The growing season rainfall was taken as a total rain fall. And it is bimodal, the short rainy season is between March to April and the long rainy season is between June-September (NZS, 2014).

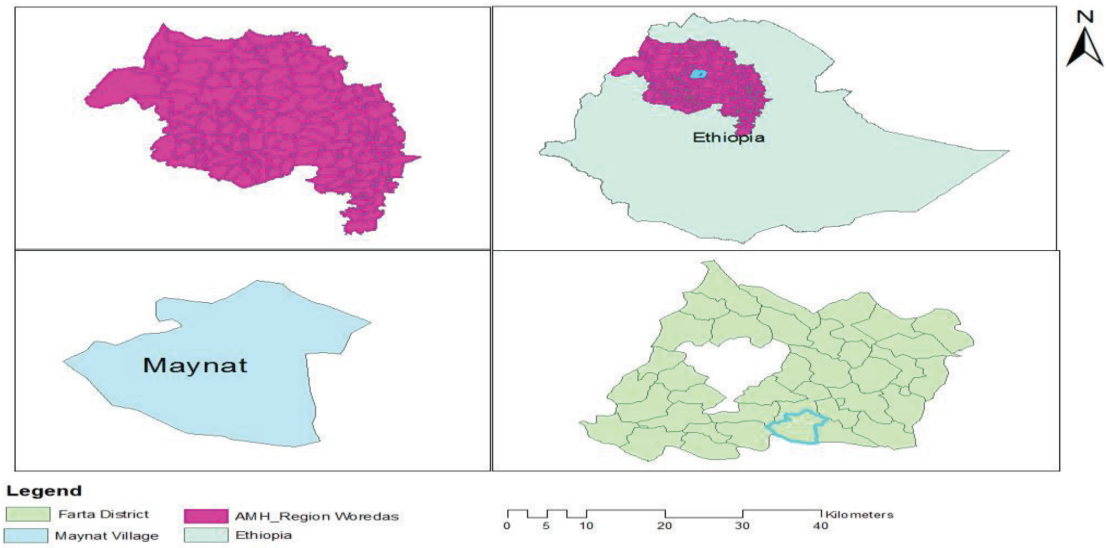

Fig 1 Map of the Study area

Experimental Design, Treatments and Procedures

The experiment was done in RCBD design with three different sources of seeds and four rates (levels) of N fertilizer in three replications. The crop varieties were appropriate cultivars of Holker (Amhara seed enterprise), Holker (LSB), and Holker (Local farmer).The levels of N fertilizer (0, 70, 110, and 150 kg N ha^{-1}) were applied as urea. The Amhara region agricultural package standard application rate for malting barley production is 110 kg N ha^{-1}. The recommended phosphorus fertilizer amount (100 kg P ha^{-1}) was uniformly applied as DAP to all plots at planting. Therefore nil N rates were considered as control treatment for comparison with other levels of N treatments. Nitrogen fertilizer was applied 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 N into the atmosphere.

The gross plot size was 1.2 x 2.0 m (2.4 m^2) with 0.2 m row spacing and a total of 6 rows leaving two outer rows and edge of 0.1 m length at both ends of each plot. Each plot within replication and each block or replication was separated by 0.5 m and 1 m distance, respectively. Accordingly, the treatments and treatment combinations including the control treatment were assigned randomly to the experimental unit within a block (Table.3.1).

Table.3.1. Treatment combinations

Source of seeds	Rate of N fertilizer			
	N0	N1	N2	N3
S1	S1N0	S1N1	S1N2	S1N
S2	S2N0	S2N1	S2N2	S2N3
S3	S3N0	S3N1	S3N2	S3N3

Where, No = Nile nitrogen fertilizer, N1 = 70 kg of nitrogen fertilizer, N2 = 110 kg of nitrogen fertilizer, N3 = 150 kg of nitrogen fertilizer, S1 = Holker from local farmer, S2 = holker from local seed business, S3 = holker from Amhara seed enterprise.

The experimental plot was plowed by oxen. Accordingly, the field was plowed three times, the plowing, was done in the mid of February, at the end march and the third plow at the end of April. The final plow was conducted with oxen plow using a local implement called Maresha on May 20 and planting was conducted on the same date.

Sowing took place at the onset of rainfall in the location, this being the third week of May at Farta District. The variety, holker widely grown by farmers in the area was used for the field experiment. A malt barley seed was drilled in rows in each plot uniformly and other agronomic practices were applied based on local research recommendations. Conducive environmental conditions during the growing seasons such as adequate amount and distribution of rainfall and high dose of nitrogen fertilizer application contributed to high weed infestation. The most dominant types of weeds encountered in the experimental filed were most grass weeds like *Digitaria abyssinica,* and *Guizotia scabra, Plantago lanceolata, Phalaris paradox and Setoria pumila.* Because of vigorous growth and high infestation of weeds, the malt barley plots were hand weeded three times at the 21^{st}, 48^{th} and 63^{rd} days after sowing. The crop was finally harvested on november13, 2014 on the basis of physiological maturity of each net plot size.

Data Collection and Analysis

Data collection

Soil data: - Soil samples (0–30 cm depth) were taken from the experimental sites before planting. A total of 9 samples were taken and combined into one composite per site for analysis.

For the post-harvest soil samplings, five samples were taken from each plot and combined into one composite sample per plot for analysis. It was analyzed for soil color using monsoon chart color identification method, for pH using a ratio of 2.5 ml water to 1 g soil (Peech 1965); for organic C content using Walkley and Black (1954) method; for total N content using Kjeldahl method (Bremner & Mulvaney 1982); at the soil laboratory of Adet research center. Not all soil samples were analyzed for all parameters after and Pre-planting values for pH, organic C, total N, organic matter C: N ratio and texture was discussed.

The weight of thousand kernels was determined by measuring the weight of 1000 kernels randomly taken from the total grains harvested from each experimental plot and it was adjusted at 12.5% moisture content by using Dicky John hand moisture tester instrument. The moisture correction factor was obtained by the following formula.

$$\text{Moisture correction factors} = \frac{100-y}{100-x}$$

Where Y is the actual moisture content measured by using Dicky John hand moisture tester instrument, X is standard moisture content for cereal crops i.e. 12.5% therefore, 12.5 % moisture adjusted grain yield = moisture correction factors X grain yield obtained from each plot (Birru, 1979)

Grain yield (kg/ha) (GY) was determined by harvesting the crop of the entire net plot area (inclusive of plant sample for yield components) and was adjusted to 12.5% moisture content. The total above ground biomass (TBY) was determined by weighing the straw yield (SY) and yield for each plot. Harvest index (HI) was calculated as a ratio of grain yield to the total above ground biomass at 12.5% moisture content. Malt barley plants lodging percentage was determined by field visual assessment.

Laboratory data: - after threshing, the seeds were cleaned and weighed, and the moisture content was measured by using Dicky John hand moisture tester instrument purity percentage also checked by separating and measured the pure seed, inert mater and other crop seed from the sample taken. Total germination also done by realizing normal, abnormal and dead seed in amhara region quarantine bearo, Protein content, the major quality parameter of malting barley, was determined using a micro kjeldah in polley campus food laboratory adjusting and using by the following formula.

$$N\% = \frac{\text{VHcl} - \text{blanck})*\text{NHcl}*1.4007}{\text{sample wetigh (gm)(w)}}$$

Where: - N% = nitrogen %

VHcl = volume of Hcl (end point)
Blank = 0.8 (constant)
NHcl = normality of Hcl= 0.1
1.4007= molecular weight of nitrogen
W = Sample weight
% protein = %N*6.25
Where: - 6.25 is conversion factor

Data Analysis

The data were subjected to analysis of variance using the general linear model procedure of SAS statistical package version 9.1 (SAS Institute, Cary, NC, USA). All other effects were tested against the residual. Means for the main effects of preceding crops were compared using the means statement with the least significant difference (LSD) test at the 5% level of probability. The interaction effects were compared using the PDIFF STDERR option in the LSMEANS statement of the GLM procedure, in particular specifying the R (P) as an appropriate error term for separating LSMEANS for the interaction effect of the crop and N fertilizer rate (Agegnehu; *etal.2003*).

RESULTS AND DISCUSSION

Soil Analysis

Analytical data of soil particle size distribution (texture), pH, organic matter, organic carbon, total N and CEC determined from the composite surface (0-30 cm) soil samples collected from each block of the experimental field before sowing malt barley are presented in Table(4.1).

The results revealed that the surface soil of the experimental field was brown (dry) and dark brown (moist) in color and clay loam in texture. As indicated in (Table 4.2), the clay content is 31% while the sand content 36% and silt content 33%.The average pH (H_2O) of the experimental field soil which was 5.81and 7.9 after and before sowing (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 content of the soil was 2.792 %, 2.7% before and after sowing respectively (Table 4.1, 4.2). (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).

Table.4.1. Chemical properties of the soil at the study area before sowing

	pH	OC (%)	OM (%)	N (%)	CEC Cmol (+) kg^{-1}	Texture (in %)			
						Particle composition (%)			
						clay	silt	sand	class
value	7.9	1.619	2.79	0.55	33.9	31	33	36	clay loam

Where: - OC = Organic carbon; OM = Organic matter; N = total nitrogen, CEC = cat ion exchange capacity

Similarly, the average total N of the experimental field was 0.155 % before sowing and 0.144% after harvest (Table4.1, 4.2) respectively. With regards to the classification of N fertility of soils, Landon (1991) classified soil having total N of greater than 1.0% as very high, 0.5-1.0% high, 0.2-0.5% medium, 0.1-0.2% low and less than 0.1% as very low. Moreover, (Tekalegn *e t al.*1991) classified soils according to N availability 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. Thus, the soil of the study area falls under the low N fertility class of (Landon 1991) and the moderate class of (Tekalign *e t al.* 1991).

Table.4.2. some physical and chemical properties of soil after harvest

Treatment	pH	OC (%)	OM (%)	N (%)	CEC Cmol (+) kg^{-1}	Texture (in %)			
						Particle Composition (%)			Class
						clay	silt	sand	remark
T1	6.54	1.379	2.378	0.124	30.1	31	33	36	clay loam
T2	6.23	1.391	2.397	0.122	32.3	31	33	36	clay loam
T3	6.48	1.514	2.610	0.135	30.7	31	33	36	clay loam
T4	4.44	1.430	2.465	0.133	32.7	31	33	36	clay loam
T5	6.69	1.706	2.942	0.157	31.7	31	33	36	clay loam
T6	6.89	1.545	2.663	0.142	34.1	31	33	36	clay loam
T7	6.21	1.435	2.474	0.131	32.1	31	33	36	clay loam
T8	4.29	1.690	2.913	0.156	34.3	31	33	36	clay loam
T9	4.52	1.490	2.569	0.126	34.1	31	33	36	clay loam
T10	6.68	1.657	2.856	0.168	33.8	31	33	36	clay loam
T11	4.42	1.997	3.443	0.188	36.1	31	33	36	clay loam
T12	6.43	1.593	2.747	0.145	33.6	31	33	36	clay loam
Average	5.82	1.57	2.70	0.144	32.97				

Where: - OC = Organic carbon; OM = Organic matter; N = total nitrogen, CEC = cat ion exchange capacity

The carbon to nitrogen (C:N) ratio of 1.619 to 0.144 observed in the soil of the study site is within the optimum range for arable lands which ranges from 8:1 to 15:1 and usually between 10:1 and 12:1 as indicated by Rowell (1994).

Laboratory Analysis

Physical purity and seed moisture content

The physical quality of malt barley seeds and determination of seed moisture content for individual seed samples collected from different results are presented in Table (4.3). In this study, the physical purity analysis showed that most of the seed samples collected from the result were satisfied the physical purity standards of Ethiopia. The purity levels of all samples were not lower than 95% which is the minimum national seed standard for certified malt barely seed in Ethiopia. The average physical purity of malt barely seed was 98.33%, 98.16%, and 98.33% (local farmer seed, LSB seed and ASE seed) respectively. There were no significant differences in physical purity in different seed sources and among fertilizer rates ($p \leq 0.005$). The highest mean analytical purity (98.33%) was obtained from both local seed and ASE seed (Table 4.3). The lowest but not the least seed purity (98.16%) was observed at local farmer seed. The mean for inert matter was 1.79%.

There were highly significant differences in seed moisture content between seed sources and nitrogen fertilizer rates ($p \leq 0.001$). The highest seed moisture content (10.8%) was obtained from local farmer seed and 11.06% was obtained from 70 kg of N level where as the lowest but not least seed moisture content (10.14%) was also obtained from LSB seed and 9.68% was obtained from 0 kg of N level. All of seed samples results showed in between the minimum and maximum seed moisture content standard of malt barley. The moisture content over 13.5% is unacceptable for malting purpose (Getachew, Agegnehu and Jenberu, 2014).

Table 4.3 Laboratory result of malt barley seed

Applied N rate	Effect of N fertilizer			
Level of N (kg/ha)	PU	MO	NG	TPC
0	97.88%	9.68%	93.13%	9.15%
70	98.33%	11.06%	95.6%	11.6%
110	98.88%	10.8%	94.8%	12.14%
150	97.99%	10.89%	94.2%	13.27%
SE (+)	0.547	0.138	5.866	1.0108
CV (%) 2. 048				
Seed sources	Effect of seed source			
L FM seed	98.33%	10.8%	94.15%	11.6%
		10		
LSB	98.16 %	10.14%	94.27%	11.59%
ASE	98.33 %	10.77%	95%	12.5%
CV (%)	2.04841	2.048	2.048	2.048
SE (+)	0.547	0.138	5.866	1.0108

Where**: -** LSB, local seed business, ASE, Amhara seed enter prize, Pu, purity, MO moisture content, NG normal germination, TPC Total protein content

Normal germination percentage of malt barley samples

Germination capacity indicates the percentage of pure seed fraction that produces normal seedlings under optimal conditions in the laboratory test and by inference the field planting value under favorable environment in the soil (ISTA, 1999). A germination test was conducted according to internationally standardized rule which indicates the percentage of seeds, which have produced normal seedlings, abnormal seedlings and which failed to produce seedlings (dead seed).

In the present study, statistically significant variation in normal germination for the main effect of seed sources, N fertilizer rates and the interaction effect between N fertilizer rates and seed sources (Tables 4.3). Considering the main effect of N fertilizer, the lowest (93.13%) and the highest (95.6 %) normal germination were obtained with no application of N and with the application at 70 kg N/ha, respectively (Table 4.3). Generally, the normal germination of malt barley increased linearly no mach difference as the rates of applied N increased from the nil N to highest N rate. The overall mean germination was above Ethiopian national seed germination standard.

The results indicated that there was significant difference ($P \leq 0.05$) among seed sources seeds regarding first count germination percentage, normal seedlings, abnormal seedlings and dead seeds. The highest germination percentage (95%) was obtained from ASE .whereas the lowest but not least germination percentage (94.15%) was also obtained from local seed. The first count measures at which the seeds were germinating and those seedlings with highest germination on first count were expected to show rapid germination and seedling emergence and to escape adverse field conditions.

Protein content analysis

Seed sources and N fertilizer application significantly influenced grain protein content of malting barley (Table 4.3). The average malting barley grain protein content of local farmer, LSB and Amhara seed enterprise seeds were 11.6%, 11.59% and 12.5% respectively all of which are within the acceptable range. Protein contents were significantly higher in higher nitrogen fertilizer rates than nil nitrogen rates ($p \leq 0.05$). Nitrogen fertilizer rates resulted in linear and quadratic responses with mean protein contents of 9.15%, 11.6% 12.14% and 13.27%, from the nil, 70, 110 and 150 rates respectively (Tables 4.3). Seed sources and application of N fertilizer increased grain yield more than they did grain protein content.

High kernel plumpness and uniformity are desirable quality characteristics since potential malt extract is directly associated with barley kernel size. As result indicates the fertilizer rate increase the protein content of the seed was increase but the malt quality decrease for brew.

Laboratory result before planting

A seed qualities test was conducted according to internationally standardized rule and they are in between the lower and higher recommended standards. The result shows Amhara seed enterprise seed purity, moisture content and normal germination were higher than local farmer seed and LSB seed whereas the protein content local farmer seed >LSB> ASE.

Table 4.4 Seed qualities test of malt barely before planting.

Seed sources	PU (%)	Mo (%)	NG (%)	TPC (%)
L FM seed	98	10	94	9.5
LSB seed	98.5	11	93	10.21
ASE seed	99.11	10.1	91	12

Where; - Pu = percent of purity, Mo, moisture content, NG= normal germination TPC= total protein content, LFM, local farmer seed LSB= local seed business, ASE = Amhara seed enterprise

CONCLUSION AND RECOMMENDATION

Conclusion

A filed experiment was conducted during the rainy season (May– November) of 2014 at the Farta district Maynat *Keble* with major objective of determining the optimum nitrogen fertilizer rate and seed sources and their interaction effects on malt barley. The experimental site, Maynat *Keble*, is found in the Farta District, South Gonder Administrative Zone, Amhara National Regional State.

Analysis of composite soil samples indicated that the soil of the experimental field was clayey loam in texture and brown (dry) and dark browns (moist). The pH (H_2O) of the experimental field soil was 5.8 qualifying for the acidic soil reaction class. The average organic matter content of the soil was 2.792% and falls under medium to moderate OM level, which the total N of the soil was 0.155% which means low to medium level and C: N ratio was within the optimum range for arable land soils.

An important finding in this study (2763.96, 6625 kg/ha) of grain and total biomass yield were found at using ASE seed and 150 kg N fertilizer rate respectively. Qualities of malting barley were significantly improved when using 150 kg/ha N fertilizer rate and Amhara seed enterprise seed. Overall, the use of Amhara seed enterprise seed and 150 kg/ha N fertilizer rate may maintain satisfactory crop yield and protein content, reduce the costs of production, and therefore increase profitability and improve soil fertility to enhance long-term sustainability of the crop production.

Recommendation

Based on the present finding, the maximum yield (3376.66 kg/ha) was obtained by the highest level of 150 kg N/ha and Amhara seed enterprise seed for clayey loam in texture and brown (dry) and dark browns (moist), acidic soil class in Farta District. It is obvious that fertilizer recommendations for crops in most cases are based on a soil test for plant available nutrients. However, a major limitation is that, for the same sites, plant species and management systems, the absolute crop yields may differ from year to year due to different seasonal conditions. So, it is too early to reach at a conclusive recommendation.

Attention shall be given to the following issues in the future research programs:

Studying interactions of N and seed sources with different production practices such as broadcasting planting methods vs. row planting, planting time, crop sequence, weeding practices with different methods and frequencies are also important.

Response of malt barley to P nutrients needs to be taken up in the future. The interaction between rotation and fertilizer management should be tested over longer periods involving representative locations across major malting barley producing areas of the country.

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