# Response of Varieties, Nitrogen and Seeding Rate on Grain Yield and Malt Quality Parameters of Malt Barley (Hordeum vulgare L.) in the Central Highlands of Ethiopia

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**Abstract**
Identifying optimum seeding and Nitrogen rate for crop varieties is an important agronomic practice to improve the productivity and the quality of the produces. Therefore, this study was conducted to evaluate the effect of variety, Nitrogen and seeding rate on protein content and yield performance of malt barley under rain-fed conditions at wolmera district, west shoa, Ethiopia for three years (2016-2018). The experiment was arranged in a split-split plot design with two malt barely varieties (Beka and traveller) as main plots, factorial combination of four N fertilizer levels (0, 23, 46, and 69 kg ha$^{-1}$) and five seeding rates (75, 100, 125, 150. 175 kg ha$^{-1}$) as subplots, with three replications. The three year combined results indicated that malt barley varieties tasted were significantly different in grain yield, biomass yield, kernel weight and malt extract. But there is no significant difference on protein content of varieties. Nitrogen rate significantly affect grain yield. biomass yield, protein content and malt extract of malt barley. But kernel weight is not significantly altered by nitrogen rate. Effect of seed rate was not significant to alter grain yield , biomass yield, protein content and malt extract. Only kernel weight was significantly affected by malt barley seed rate. Interaction effect of varietie , nitrogen rate and seed rate was not significant to affect any of parameters tasted in the study. According to this study, Application of 100 kg ha$^{-1}$ seeding rate with 46 kg N ha$^{-1}$ can be preferable for farmers for maximum benefit in terms of grain and quality parameters of malt barley production on Nitisols of West Shoa under rain fed conditions for both varieties.
**Keywords:** Nitrogen rate, Seed Rate, Protein Content,, Varieties and Malt extract
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## Introduction

Barley (*Hordeum vulgare* L.) is the fourth important cereal crop in the world and fifth important cereal in Ethiopia (Bayeh and Birhane, 2006). Barley is one of the major cereal crops that are largely produced in the central and southeast mid- and high- altitudes of Ethiopia. It is the fifth important cereal crop next to tef, maize, sorghum and wheat in the country's domestic production with total area coverage of 959,273.36 hectares and total annual production of about 2.03 million tons in main season, whereas the mean barley productivity was 2.1 tons ha-1 (CSA, 2017).

Historically in Ethiopia, there has been a concern regarding the use of high plant density that has a risk of a decrease in yield and quality that would reduce returns. Growers will focus on maximizing returns when growing malt barley and these returns are a function of yield by quality. However, maximum yield and maximum receival quality is unlikely to occur under the same management. The target density for malt barley differs by variety, and that target density for sowing barley decreases as N supply increases, and that the optimum management strategy will depend on the variety sown.

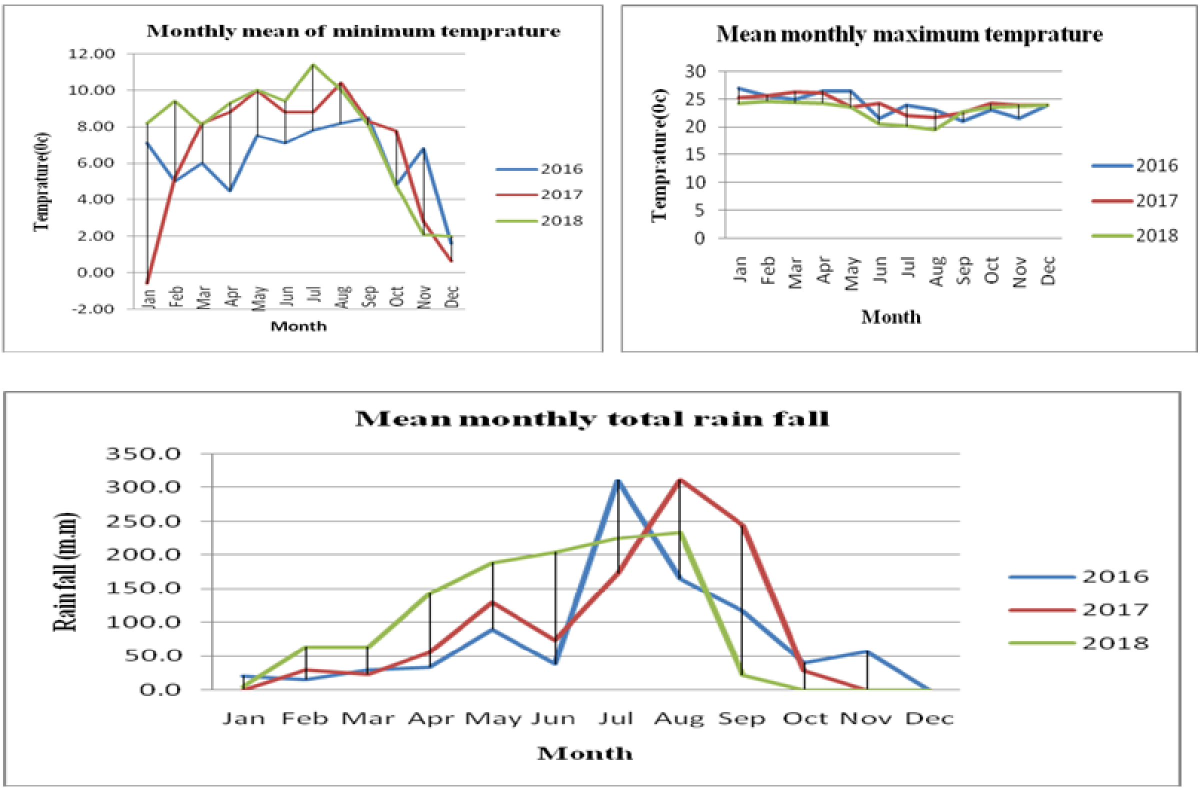
Nitrogen (N) fertility is another factor that can impact malting barley production, especially in regard to its acceptability for malting status in relation to grain protein content (Spaner *et al*., 2001; McKenzie *et al.,* 2005). Nitrogen fertilization can increase malt barley grain yield compared with no N fertilization (O'Donovan *et al.,* 2011), but high protein concentration and low plump kernels of malt barley grains due to increased N fertilization rate for malting grade (Wade and Froment, 2003; O'Donovan *et al.,* 2011) present unique challenges to maintain barley quality and farm income for producers (AMBA, 2005). Malt barley grain with high protein concentration can enhance enzymatic activity, fine-coarse extract difference, and low malt extract (Broderick, 1988). Because of the strict requirement of grain quality, only about 25% of malt barley is accepted for malting purpose while the rest is being used for livestock feed, thereby resulting in lower revenue for producers (O'Donovan *et al.,* 2011). Management practices, such as seeding rates, cultivars, and N fertilization rates can affect malt barley yield and quality (Therrien *et al.,* 1994; Wade and Froment, 2003). Therefore this study was initiated to determine the effects of seeding rates and N fertilizer rates on the yield and quality of two recently released an introduced malting barley varieties under rain-fed conditions in the Ethiopian highlands.

## Materials and methods

This experiment was conducted at wolmera , West Shoa, central highlands of Ethiopia. The soil type of the experimental site is Eutric Nitisol. The experiment was arranged in a split-split plot design with two malt barely varieties (Beka and traveller) as main plots, factorial combination of four N fertilizer levels (0, 23, 46, and 69 kg ha$^{-1}$) and five seeding rates (75, 100, 125, 150. 175 kg ha$^{-1}$) as subplots, with three replications. In all plots, P as triple superphosphate was band applied at planting at the rate of 20 kg P ha$^{-1}$. Urea was used as the source of N, which was applied in a band half at planting and the remainder side dressed at mid tillering stage of the crop. The cultivars were hand drilled in 20 cm rows. Other agronomic practices were applied based on local research recommendations.

**Statistical analysis**
The data were subjected to analysis of variance using the procedure of the of SAS statistical package version 9.3 (SAS Institute, 2004). Means for the main effects were compared using the means statement with least significant difference (LSD) test at the 5% level.

**Results and discussion**
In the study area, grain filling for barley crop often takes place during the months of September and October. Total rain fall and maximum air temperature of the three cropping years of the experiment did not show a big difference especially during grain filling periods during the months of September and October as indicated (Fig 1) below.
Fig.1 : The total rain fall and minimum and maximum air temperature of the study area during the main cropping seasons (2016-2018).




Analysis of variance (ANOVA) result showed that both malt barley varieties tasted were significantly ($p<0.01$) different in grain yield, biomass yield, Kernel weight, and malt extract this is because yield and grain quality of barley depends greatly on the varietal characteristics. But the protein content of the two varieties tasted were not significantly different (Table 1). On the other hand, protein content was not significantly ($p>0.05$) affected by varieties. Beka variety gave significantly higher grain yield , biomass yield and kernel weight when compared with Traveller variety (Table 1). However, significantly ($p<0.01$) higher malt extract was obtained by Traveller variety.

ANOVA result also showed that seeding rate did not significantly affected ($P>0.05$) grain yield, biomass yield, protein content and malt extract (Table 1). However, the main effect of seeding rate significantly ($P<0.05$) affected kernel weight of malt barely in which other parameters were not significantly affected by seeding rate. Significantly higher kernel weight was obtained by 75 kg ha$^{-1}$ though it was not significantly different from 100 kg ha$^{-1}$. Lowest kernel weight was obtained by the highest seeding rate (175 kg ha$^{-1}$). High seeding rates were more likely to reduce malt quality than increase it, although effects are mixed and relatively weak. Similar to this study other investigators (Kirby 1969; Lafond 1994),indicated that increased seeding rates reduced kernel size.

ANOVA result also indicated that that N rate significantly affected (P>0.05) grain and biomass yield, protein content and malt extract (Table 1) of malt barley. Significantly higher grain and biomass yield was obtained by 46 kg N ha$^{-1}$ even though it was not significantly different from 69 kg N ha$^{-1}$. Significantly higher protein content was obtained by 69 kg N ha$^{-1}$ even though it was not significantly different from 69 kg N ha$^{-1}$). Similarly, Increased malting barley grain yield with increased N fertilization rates have been documented by several researchers (Agegnehu *et al.* 2014; O'Donovan *et al.* 2011, 2015; Sainju *et al.* 2013, 2015). The grain protein content of malt barley always increases with the amount of applied N fertilizer whether or not a yield increase resulted (Castro *et al.* 2008; Jankovic *et al.* 2011; Kilic *et al*. 2010; Sainju *et al*. 2013; Wade and Froment 2003). Proteins are among barley components that are essential for the quality of malt and beer. Malt extract measures the amount of fermentable sugars. It determines the amount of alcohol that can be made from a tonne of grain. The higher the extract level the more alcohol that can be made. The export standard for malt is a minimum malt extract level of 80%. Significantly higher malt extract (82%) was recorded by 46 kg N ha$^{-1}$ even though it was not significantly different from 69 kg N ha$^{-1}$) in this study.

Table 1: Main effects of Variety, Seeding rate and Nitrogen rate on malt barley yield and quality parameters

| **Treatments (kg ha$^{-1}$)** | **Mean Grain yield (kg ha$^{-1}$)** | **Mean Biomass yield (kg ha$^{-1}$)** | **Mean Kernel weight (gm)** | **Mean Protein content (%)** | **Mean Malt extract (%)** |
|---|---|---|---|---|---|
| **Variety** | | | | | |
| **Beka** | 3513a | 12968a | 43.4a | 11.1 | 80.6b |
| **Traveller** | 2907b | 11004b | 42.0b | 11.1 | 81.4a |
| **Sig.** | *** | *** | *** | ns | ** |
| **Seeding rate** | | | | | |
| **75** | 3086 | 11923 | 44.0a | 11.3 | 80.8 |
| **100** | 3256 | 12119 | 43.0ab | 11.2 | 81.0 |
| **125** | 3274 | 11949 | 42.5b | 11.0 | 80.9 |
| **150** | 3243 | 12060 | 42.7b | 11.1 | 80.4 |
| **175** | 3191 | 11877 | 41.1c | 11.0 | 81.0 |
| **Sig.** | ns | ns | *** | ns | ns |
| **Nitrogen rate** | | | | | |
| **0** | 1474c | 9328c | 43.1 | 9.3d | 78.5c |
| **23** | 3304b | 11662b | 42.1 | 10.4c | 79.5b |
| **46** | 4088a | 13583a | 43.2 | 11.5b | 82.9a |
| **69** | 3975a | 13370a | 42.4 | 13.2a | 82.4a |
| **Sig.** | *** | *** | ns | *** | *** |
| **CV (%)** | 19.3 | 14.6 | 4.6 | 7.9 | 1.9 |

Notes. Significant at *P ≤ 0.05, **P ≤ 0.01, *** P ≤ 0.001; ns, not significant; CV, coefficient of variation

In malt barley production, there is often a conflict between the aim of growing the crop to meet the quality requirements of maltsters and of achieving the highest grain yield. Pettersson and Eckersten (2007) indicated that malting barley is required to have 9.5 to 11.5 % crude protein on a dry matter basis in order to be accepted in the market. In this study suitable protein content for making beer out of malt barley was obtained by applying 46 kg N ha$^{-1}$.

**Conclusion and recommendation**

The results of this research work showed that the two varieties ( Beka and Traveller) tested differ in their grain yield and biomass yield, this is because yield and grain quality of barley depends greatly on the varietal characteristics. Seeding rate did not affect grain yield of malt barley. Results of the study also indicated that out of the four Nitrogen levels involved in this study, application of 46 kg N ha$^{-1}$ gave highest grain yield as well as highest malt extract which is needed for quality malt production . In conclusion, based on the results of the current study, Farmers of the area can use100 kg ha$^{-1}$ seeding rate with 46 kg N ha$^{-1}$ to produce quality malt barley yield and attain maximum benefit from malt barley production on Nitisols of West Shoa Ethiopia under rain fed conditions. As the grain quality of malt barley is greatly dependent on varietal characteristics other study should be done in future for others and newly released malt barley varieties.

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