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Research Article

Grain Quality and Yield Response of Malt Barley Varieties to Nitrogen Fertilizer Rates in the West Arsi, Oromia Reginal State of Ethiopia

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Abstract

Grain yield and yield components of malt barley (*Hordeum vulgare* L.) were investigated concerning varieties and nitrogen application rates. A field experiment was conducted to evaluate (i) the optimal fertilizer level for maximum yield and quality of malt barley varieties (ii) to determine the impacts of nitrogen fertilizer rate, vaieties and growing season on yield and yield components of malt barley. Three malt barley varieties (Ibon, Bekoji 1, and EH1847) and four fertilizer rates (RNP kg ha^{-1}, 150% RNP kg ha^{-1}, 200% RNP kg ha^{-1} and RNPS kg ha^{-1}) were studied over two growing season (2019 and 2020) in a factorial arrangement of randomized complete block design (RCBD) and replicated three times. The main effects of variety and fertilizer rate were significantly (P<0.01) variation, on grain yield, biomass yield, hectolitre weight and thousand kernel weight, while plant height, spike length and grain protein content showed significant (P<0.05) variations. The interaction effect of variety and fertilizer rate on the number of grains per spike indicated significant (P<0.001) variation. The use of a 200% RNP kg ha^{-1} fertilizer rate resulted in a higher (4152.9 kg ha^{-1}) grain yield. The highest (33.1) number of grain per spike was produced from the combination of 150% RNP kg ha^{-1} fertilizer rate with Bekoji 1 malt barley variety, Like wise higher (48.6) thousand kernel weight was produced from RNPS. The results of this study indicated that, the importance of using appropriate malt barley variety and fertilizer rate to increase the yield of malt barley with acceptable grain quality in the study area. Hence application of 150% RNP and 200% RNP kg ha^{-1} gave a grain yield of (3582.81 kg ha^{-1}) and (4152.9 kg ha^{-1}, and economic benefit of 5.99 (ETB) and 3.65 (ETB) respectively. Among malt barley varieties highest (4110.4) and (3538.3) kg ha^{-1} grain yield was recorded from EH1847 and Bekoji 1 verities respectively. The production of malt barley with higher yield, optimal kernel protein concentration and higher economic benefit was obtained via EH1847 malt barley varieties along with 150% RNP and 200% kg ha^{-1} fertilizer rate in the study area and similar agro ecologies.

Keywords

Barley Variety, Grain Yield, Fertilizer Rate, Grain Quality

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1. Introduction

Barley (*Hordeum vulgare* L.) is one of the main cereal crops produced in the World, ranking fourth in production after wheat, maize and rice [20, 35, 31]. It is the fifth most important cereal crop in Ethiopia, after teff, maize, sorghum, and wheat in production area [16]. The national area coverage of barley was 799,127.84 ha which, is 6.55% of the land covered by grain crops [16]. The total production of barley was 2.07 million tonnes with an average yield of 2.59 t ha $^{-1}$, while in Oromia region, the area coverage and average yield was estimated about 6,100,987.75 ha and 2.87 t ha^{-1}, respectively [16]. Barely is grown in different environments at an altitude of 1500-3500 meter above sea level (m.a.s.l.), but predominantly cultivated with the range of 2000-3500 m.a.s.l [30].

Barley is one of the most important crop in the world and it is usually used as food for human beings and feed for animals, for poultry and it is also used as an input for industries for extracting malt to be utilized in brewing, distillation, baby foods, cocoa malt drinks and ayurvedic medicines [40]. In Ethiopia barley is one of the major crops grown in the highland area of the country and used in different forms like bread, porridge, roasted grain (kolo) and for preparing alcoholic and non-alcoholic drinks [13]. Barley production in Ethiopia started long years ago and is largely grown as a food crop in the central and northern parts of Ethiopia, with the major regions of production namely Oromia, Amhara, Tigray, and Southern Nations, Nationalities, and People's Region. Food barley is mainly grown for subsistence consumption by the rural farm households while malt barley is largely a commercial crop produced for industrial malt grain production. The malting and brewing industry are taking roots with both international and domestic brands operating in the country [30].

The demand of malt barley has been increased year after year by breweries [3]. However, in Ethiopia the gap between malt barley production and demand is high [23]. This is mainly due to the expansion of breweries and beer consumption levels in Ethiopia [29]. These days considerable efforts have been made to satisfy the ever- increasing demand for raw materials by the beverage industry with domestic production, to save significant foreign currency and to increase farmers income. Despite all efforts however, Ethiopia imports about 50% of the malt from international producers [2].

The low productivity and quality of barley in Ethiopia is mainly constrained by poor soil fertility, inadequate availability and use of inputs such as fertilizers, lack of improved varieties, poor cultural practices/crop management, the influence of several biotic and abiotic stress, poor access to markets and unattractive malt barley price [12, 13, 42]. Fertilizer trials conducted in different parts of Ethiopia indicated that both grain yield and protein content increase with increasing nitrogen [17, 34]. Nitrogen is one of the most important and widely used elements for plant growth and development and crop yield. In addition N is a vital component of nucleon proteins and nucleic acids which carry the heredity matrix control and direct the synthesis of protein and enzymes. However, nitrogen is deficient in most Ethiopian highland soils [12, 15]. On the other hand, the optimum rate of nitrogen varies from location to location. Moreover, application of N at appropriate time of the crop growth stage is also another important agronomic practice to enhance nitrogen use efficiency and increase yield and quality of malt barley.

Although, varieties plays 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 so far on the interaction between Nitrogen fertilizer rates and different released malt barley varieties under West Arsi Zone, Kofele Woreda. 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 Arsi Zone, Kofele district, Ethiopia.

2. Material and Methods

2.1. Description of the Study Area

The experiment was conducted in the West Arsi zones of Oromia regional stat of Ethiopia, Kofele district over two years period. This district is among the zone areas for both food and malting barley production. The experimental site was located close to 7°04' N and 38°47' E and at an altitude around 2685 m above sea level (a.s.l). The dominant soil type of Kofele station is pellic vertisol [24, 25]. The estimated mean annual rainfall of the districts was 1170 mm and it has an extended rainy season, which starts in March and continues to October. The highest rainfall concentrations were in June, July and August. The mean minimum and maximum annual temperature of the experimental site was 8.5° and 19.6°C.

2.2. Experimental Design and Procedure

The experiment consisted of a factorial combination of four levels of fertilizer (RNP, 150% RNP, 200% RNP and RNPS kg N ha^{-1}) and three malt barley varieties (EH1847, Ibon and Bekoji 1). The treatments were arranged in randomized complete block design and replicated three times. Malt barley Seeds were drilled by hand at 0.20 m spacing between rows at the end of July. The experiments had plot sizes of 3m by 4m. The spacing between plots and replications were 0.5 m and 1 m, respectively.

2.3. Data Collection

The measured and computed parameters for yield, yield attributes and quality of malting barley were spike length, plant height, number of grains per spike, grain and above-ground total biomass yields, kernel weights, hectoliter weight and kernel protein concentration. The plant height (from the soil surface to the tip of spike excluding awns) was measured at physiological maturity and taken from ten randomly chosen plants in each plot. Harvesting for yield determination was done manually from the net plot area of 2m by 2m. The harvested samples were air-dried to constant moisture content, threshed manually, cleaned and the grain weight recorded. The weighed samples were adjusted to a standard moisture content of 12.5% and converted into kg ha^{-1} for the purpose of statistical analysis. Harvest Index was calculated as percentage ratio of grain and biological yields. Grain samples were randomly collected from each plot and their respective kernel and hectoliter weights were determined using seed counter and hectoliter weighing devices in the physiology laboratory at KARC. Kernel N concentration was determined using Kjeldahl method in the plant nutrition laboratory of KARC.

2.4. Data Analysis

Data were subjected to analysed using the general linear model (PROC GLM) procedure of SAS version 9.4. The malt barley variety and fertilizer rates were considered as fixed effects and while, 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 at $P \leq 0.05$.

3. Result and Discussion

3.1. Growth Parameters

3.1.1. Plant Height

Statistical analysis revealed that plant height was significantly ($P < 0.05$) influenced by the main effect of malt barley variety and fertilizer rate. However, this parameter was not significantly ($P > 0.05$) affected by the interaction effect of variety and rats of fertilizer. The plant height mean value varied ranges from 102.9 cm to 111.2 cm. The tallest (111.2 cm) plant height was recorded from Ibon malt barley variety; which was statically comparable with the plant height (107.3 cm), recorded from the Bekoji 1 Varity. The shortest (102.9 cm) plant height was recorded from EH1847 malt barley variety. Variation among varieties in the plant height might be due to its genotype. The result obtained from this study was in agreement with [39] reported that, height of the crop is mainly controlled by the genetic makeup of a genotype and it can also be affected by the environmental factors. Likewise, [1, 14, 26] stated that the height of the crop is mainly controlled by the genetic makeup of varieties and effects of environmental.

There was also significant variation among fertilizer rates in plant height (Table 1). The tallest (114.78 cm) plant (112.33 cm) plant height was gained from 200% RNP and 150% RNP respectively wile, the lowest and statically similar result was obtained from fertilization of RNP and RNPS fertilizers with mean value of (102.7 cm) and (98.8) respectively (Table 1). The result showed that plant height increases with increasing nitrogen fertilizer rate. These findings are similar to [45, 34] who reported that plant height of barley increased with increasing nitrogen fertilizer rates. Similarly, [33] 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.

3.1.2. Spike Length

The result of this study showed that, spike length was significantly ($P < 0.05$) affected by the main effects of variety. However, the fertilizer rate and the interaction effects of the two factors didn't show significant difference in spike length. The highest spike length (8.1 cm) was gained from the EH1847 malt barley variety. The lowest spike length (6.9 cm) was gained from Bekoji 1 variety, which was statically comparable with the spike length (7.1 cm), recorded from the Ibon Varity (Table 1). In line with the present finding [4, 18, 38] indicated that plant height and spike length were affected by different genotypes of barley. Similarly the longest (7.48 cm) and shortest (7.32 cm) spike length was recorded from RNP and 150% RNP kg ha^{-1} treatment respectively (Table 1).

Table 1. *Effect of fertilizer rate on different varieties of malt barley.*

Treatments		**Parameters**
Varieties	**Plant height (cm)**	**Spike length (cm)**
EH1847	102.9b	8.1^{a}
Ibon	111.2a	7.1b
Bekoji 1	107.3ab	6.9b
LSD (P<0.05%)	5.41	0.25
Fertilizer rate		
RNP	102.7b	7.48
150% RNP	112.33a	7.32
200% RNP	114.78a	7.34
RNPS	98.8b	7.4
LSD (P<0.05%)	6.24	NS

Treatments		Parameters
Varieties	Plant height (cm)	Spike length (cm)
CV (%)	5.9	8.5

Means in a column followed by the same letter are not significantly different at a 5% level of significance; LSD (0.05%) = Least significant difference at 5% level; CV = Coefficient of variation and NS = non- significant different.

3.2. Yield and Yield Components

3.2.1. Number of Grains Per Spike

The result revealed that the number of grains per spike was significantly (P < 0.01) affected by the main effects of fertilizer rate and varieties of malt barley. Moreover, this parameter was significantly (P< 0.001) influenced by the interaction effects of the two factors. The highest (33.1) grains per spike was obtained from a combination of Bekoji 1 malt barley variety and 150% RNP fertilizer, followed by (30) and (28.8) grains per spikes were gained from the combination of Bekoji 1 variety with RNPS fertilizer rate and Ibon variety with RNPS fertilizer rate respectively (Figure 1). The lowest grain per spike (23.6) was obtained from the combination of EH1847 and RNP treatment. Statically similar with the grains per spike value of (25.2) produced at EH1847 variety treated with 200% RNP fertilizer (Figure 1). Thus variation in number of grains was a result of both fertilizer rats and varietal genetic difference. In line with this result [6] reported genotypic differences of barley in spikelet per spike that in turn resulted in higher number of grains per spike. Moreover; the increment of number of grain per spike with increasing nitrogen fertilizer was elaborated by [44, 14, 8].

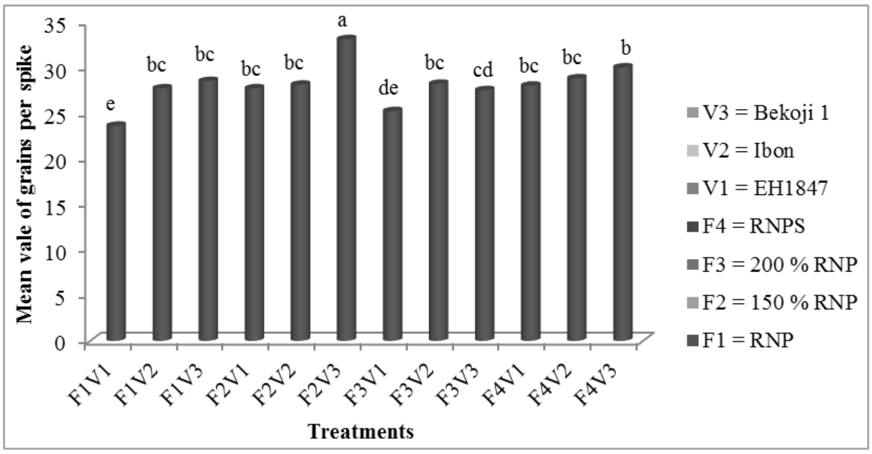

Figure 1. *Mean interaction effect of malt barley varieties and fertilizer rates on Grains per spike.*

3.2.2. Grain Yield kg ha^{-1}

The analysis of variance showed that the mean value of grain yield was significantly ($P \leq 0.01$) affected by the main effects of the malt barley varieties and fertilizer rate, However, this variable was not significantly (P> 0.05) influenced by the interaction effect of varieties and fertilizer rate. The optimum grain yield (4110.4) kg ha^{-1} mean grain yield was obtained from EH1847 malt barley variety, but in statistically parity with the mean value of grain yield (3538.3) kg ha^{-1} was produced from Bekoji 1 malt barley variety, whereas the lowest mean value of grain yield (3095.0) kg ha^{-1} was obtained from Ibon variety. The highest grain yield from the varieties EH1847 and Bekoji 1 might be attributed due to the production of higher thousand-kernel weight than the reset varieties. This result is in line with the finding of [21] who reported that, the yield and quality specifications of a given malting barley variety are determined by its genetic makeup and the physical conditions during growth and harvesting time. Moreover [41, 28] elaborated that productive tillers per plant, number of kernels per spike and thousand kernel weights would be more useful criteria for selecting evolving high yielding varieties.

There was also significant variation among fertilizer rates in grain yield (Table 2). The optimum (4152.9 kg ha^{-1}) mean value of grain yield was produced by the 200% RNP kg ha^{-1} fertilizer rate, but statically comparable grain yield (3582.81 kg ha^{-1}) obtained at 150% RNP kg ha^{-1} fertilizer rate, Whereas the lowest (3209.2 kg ha^{-1}) mean vale of grain yield was recorded from RNPS kg ha^{-1} rate of fertilizer, but in statistically parity with the grain yield (3380.0kg ha^{-1}) produced from RNP kg ha^{-1} fertilizer rate (Table 2). The grain yield of malt barley increased linearly as the level of fertilizer increased from RNP to 200% RNP kg ha^{-1}. The cut off point for the optimum rate of fertilizer was not attained in this study since yield of malting barley increased as the rate of fertilizer increased from RNP to 200% RNP kg ha^{-1} indicating the need for further study. In line with the current result [17] elaborated that significantly increases in grain yields of malt barley with increasing levels of N fertilizer. Malt barley yield increased with fertilizer rates [6, 3, 43, 22].

3.2.3. Above - Ground Biomass Yield kg ha^{-1}

The above ground biomass yield was significantly ($P \leq 0.01$) affected by the main effects of the malt barley varieties and fertilizer rate, However, this variable was not significantly (P> 0.05) influenced by the interaction effect of varieties and fertilizer rate. The highest (18123 kg ha^{-1}) biomass yield of malt barley was attended from Ibon Varity. The lowest (12769 kg ha^{-1}) biomass yield was obtained from Bekoji 1 variety. Likewise, statically equivalent (13529 kg ha$^{-1)}$ biomass yield was recorded from EH1847 malt barley variety (Table 2). The positive association between biomass yield and plant height, in which the taller plants resulted higher biomass yield [47].

The highest (20259 kg ha-1) biomass yield was obtained from the application of corresponding higher rate of 200% RNP kg ha^{-1} fertilizer rate. Likewise, application of 150% RNP kg ha^{-1} also gave statically similar biomass yield of malt barley. The lowest and statically equivalent biomass yield with each other was recorded from RNP and RNPS kg ha- 1 fertilizer rate with a mean value of (11907 kg ha^{-1}) and (11401 kg ha^{-1}) respectively (Table 2).

3.2.4. Harvest Index (%)

The result revealed that the harvest index was significantly (P < 0.05) affected by the main effects of varieties and rates of fertilizers. Moreover this parameter was not influenced by the interaction effects between the two factors. The harvest index reflects the ability of the genotypes to partition their dry matter in to seed and straw, and the ability to maintain the right balance between seed and straw yield [5]. The highest (36.3%) harvest index was obtained from a Bekoji 1 malt barley variety, followed statically the same (30.9%) mean value of harvest index with Bekoji 1 variety was gained from EH1847 variety. There was variation in harvest index of different barley varieties due to barley inherent variability. The lowest harvest index (24.5%) was obtained from Ibon Varity. In this study fertilizer rate showed significant (p < 0.05) variation on harvest index. The highest and statically same harvest index value was obtained from fertilization of RNP and RNPS kg ha^{-1} with harvest index value of (32.42) and (36.03) respectively (Table 2). The lowest and statically same with each other, but lower harvest index value from RNP and RNPS was recorded from application of 150% and 200% RNP kg ha^{-1} fertilizer rates. This result indicated that as increased the applied N rate, harvest index of barley was decreased. In [17] observed higher harvested index at lower rate of nitrogen applications.

Table 2. *Effect of fertilizer rate on yield and yield components of malt barley varieties.*

Treatments	Parameters		
Varieties	**Grain yield**	**Biomass yield**	**Harvest Index**
EH1847	4110.4[a]	13529b	30.95ab
Ibon	3095.0b	18123a	24.54b
Bekoji 1	3538.3ab	12769b	36.23a
LSD (P<0.05%)	587.26	4325.6	7.02
Fertilizer rate			
RNP	3380b	11907b	32.42a
150% RNP	3582.81b	15662ab	23.40b
200% RNP	4152.9a	20259a	30.42ab
RNPS	3209.2b	11401b	36.03a
LSD (P<0.05%)	678.11	4994.8	8.11
CV (%)	15.37	14.35	17.0

Means in a column followed by the same letter are not significantly different at a 5% level of significance; LSD (0.05%) = Least significant difference at 5% level; CV = Coefficient of variation and NS = non- significant different.

3.3. Quality Parameters

3.3.1. Hectoliter Weight (Kg /hL)

The analysis of variance showed that hectoliter weights had significant (P<0.01) difference due to the main factors of varieties and fertilizer rates. However, this variable was not affected by the interaction of varieties and fertilizer rates. Hectoliter weight provides a rough estimate of flour yield potential in wheat [11] and, it is important to millers just as grain yield is important to wheat production.

The highest hector litter weight (69.4 kg/hL) was recorded from the Bekoji 1 malt barley variety, followed by (67.0 kg/hL) hectolitre weight was gained from Ibon variety. The lowest hectolitre weight (63.6 kg/hL) hectolitre weight was produced from EH1847 malt barley variety (Table 3). Thus, variation in hectolitre weight among varieties might be due to their genetic variability which is related to quality of barley such as flour yield and protein content as the dos of N fertilizer increases the plumpness and protein content of the cereal grains. There were also significant differences (P< 0.05) among the fertilizer rate on hectolitre weight. The highest hectolitre weight (68.8 kg/hL) was obtained from application of RNP Kg ha^{-1} fertilizer rate. Statically similar (68.8 kg/hL) hectolitre weight was also gained from RNPS kg ha^{-1} fertilizer rate. Whereas statically Parity with each other, but far apart from the rest two treatment was gained from 150% RNP and 200% RNP kg ha^{-1} with hectolitre weight value of (65.6 kg/hL)) and (64.5 kg/hL)) respectively. Under this study hectolitre weight ranged from (64.3 kg /hL) to (68.8 kg/ hL) which was in agreement [37] reported that the acceptable test weights (hectolitre weight) for barley were in the range 66.1- 72.8 kg/hL. Hectolitre weight may range from about 57.9 kg /hL for poor wheat to about 82.4 kg/hL for sound wheat [9].

3.3.2. Thousand Kernel Weight (g)

The analysis of variance showed that the thousand kernel weight was significantly (P<0.01) affected by the main effects of varieties and fertilizer rate. However, this variable was not significantly (P > 0.05) influenced by the interaction effects of varieties and rates of fertilizer. The highest thousand kernel weight (48.4 g) was obtained from Bekoji 1 variety, followed by (45.9 g) and (45.3 g) thousands kernel weight was recorded from Ibon and EH1847 malt barley variety respectively (Table 3).

Generally thousand kernel weights increased almost linearly in all varieties with increasing nitrogen fertilizer rates in this study. In agreement with this report, [36, 10, 46] reported that, variation in thousand kernel weight as a function on of barley genotype and nitrogen fertilizers. Thousand kernel weight of malt barley should be >45 g for 2- rowed barley and >42 g for 6-rowed barley [7]. Therefore the result of the current study exhibited within the acceptable thousand kernel weight.

3.3.3. Grain Protein

Grain protein content of malt barley grains were significantly (p <0.05) affected by main fertilizer rates, while the effect of variety and interactions were non-significant. Grain protein content linearly increased with N fertilizer increased from RNP to 200% RNP kg N ha^{-1}. The highest (12.3%) grain protein content was recorded from the highest N fertilizer application (200% RNP kg ha^{-1}). The lowest grain protein content (9.9) was gained from RNP fertilizer rate, which was statically comparable with the grain protein content (10.1%) recorded from the RNPS fertilizer (Table 3). The increase in grain protein content of malt barley with increasing N fertilizer rate was supported by [6] who reported that application of N fertilizer increased both grain yield and protein contain. Similarly, [32] found that an increase in N fertilizer application resulted in an increase in grain yield and protein content. However, in grain protein may increase Steep times, consequently creates undesirable qualities in the malt. [27] 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. In addition it also slows down water uptake during steeping and affects final malt quality. According to the Ethiopian standard authority and Asella malt factory (AMF), the protein level of raw barley for malt should be 9-12.5% [19]. 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.

Table 3. *Effect of varieties and fertilizer rate on grain quality parameters of malt barley.*

Treatments		**Parameters**	
Varieties	**Hectolitre weight (Kg/hL)**	**Thousand kernel weight (g)**	**Grain protein (%)**
EH1847	63.6c	45.3b	10.2
Ibon	67.0b	45.9b	10.6
Bekoji	69.4a	48.4a	9.8
LSD (P<0.05%)	2.41	3.77	NS
Fertilizer rate			
RNP	68.80a	47.1b	9.4c
150% RNP	65.6bc	45.3c	10.6b
200% RNP	64.51c	45.1c	12.5a
RNPS	67.8ab	48.6a	10.1c
LSD (P<0.05%)	2.78	1.35	0.75
CV (%)	4.28	2.98	5.4

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 and NS = non- significant different.

3.3.4. 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 sown at a rate of 150% and 200% RNP could enable farmers to earn higher economic return per unit of the investment as well as higher yield (Table 3). However, increasing the fertilizer rate beyond 200% RNP kg ha^{-1} could not bring equivalent economic return to farmers since their marginal rates of return (MRR) were less than 100%. The maximum benefit of 5.99 (ETB) was obtained from 150% RNP kg ha^{-1} fertilizer rate. Applying fertilizer at a rate of 200% RNP kg ha^{-1} also gave a profitable economic return of 3.65 (ETB) (Table 3).

Table 4. *Evaluation of the economic feasibility of the use of different nitrogen fertilizer rates for malting barley production in West Arsi, Ethiopia.*

Fertilizer rate Kg ha^{-1}	AGY kg ha^{-1}	ABY kg ha^{-1}	GFB (ETB/ha)	TVC (ETB/ha)	NB (ETB/ha)	MRR%
RNP	3380	11907	121872	6100	115772	1.68
150% RNP	3582.81	15662	130068	9150	120918	5.99
200% RNP	4152.9	20259	151397	12200	139197	3.65
RNPS	3209.2	11401	115735	4538	111197	D

"D" means dominated demonstrating treatments with higher variable cost, but lower net benefits

4. Conclusion and Recommendation

Filed experiment was conducted during the main cropping season of 2018/19 and 2019/20 at Kofele sub-station of KARC, with the objective of evaluating the optimal fertilizers rate for maximal production of malt barley varieties with acceptable grain quality. Data on growth parameter, yield and yield components as well as quality parameters of malt barley varieties were also collected and analysed. Based on the present finding, among the four fertilizer level the use of 200% RNP and 150% RNP for EH1847 malt barley variety was superior in most of agronomic traits and economic benefit enhanced that 3.65 (ETB) and 5.99 (ETB) respectively. Therefore malt EH1847 malt barley variety along with 150% RNP and 200% RNP kg ha^{-1} is recommended in the study area and other similar agro ecologies for optimal grain yield, acceptable grain protein concentration and economic profit.

Conflicts of Interest

The authors declare no conflict of interest.

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