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Research Article

Growth and Yield Response of Food Barley (*Hordeum vulgare L.*) Varieties to Nitrogen Fertilizer Rates Inkofele District, Southeastern Oromia

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ABSTRACT

Despite the importance of barely, there are several factors affecting its production. Among these inadequate uses of N fertilizer and lack of using improved food barley variety are the most important ones. A field experiment was conducted under rainy season conditions to investigate the effects of food barley varieties and rates of nitrogen fertilizer application in the combinations of three food barley varieties, namely Adoshe, Robera and Abdene and four levels of N (23 Kg N/ha , 46 Kg N/ha , 69 Kg N/ha and 92 Kg N/ha) arranged in randomized complete block design in factorial arrangement with three replications on vegetative growth, yield and yield components of barley (*Hordeum vulgare L.*) at Kofele, Oromia Regional State of Ethiopia. Results indicated that different nitrogen fertilizer rate had a very highly significant ($p<0.001$) effect on day to heading, day to physiological maturity, plant height, spike length, lodging percentage number of kernels per spike, and straw yield. Nitrogen fertilizer rate used highly significantly ($p<0.01$) affected thousand seed weight, number of total tillers per m^2 and number of fertile tillers per m^2 and biomass yields and grain yields were significantly($p<0.05$) influenced by Nitrogen fertilizer rate where us harvesting index was not significantly influenced by the main effect of nitrogen fertilizer rate. The results also revealed that food barley varieties growth, yield and yield components including phonological parameters were highly significantly ($p<0.01$) influenced due to food barley varieties used except harvesting index ($p>0.05$). Moreover, barley phonological, growth, yield and yield components were highly significantly ($p<0.01$) influenced due to interaction effect of rate of nitrogen and food barley varieties used except number of total tillers per m^2 ,number of fertile tillers per m^2 , day to heading , grain yield and harvesting index ($p>0.05$). the maximum and minimum mean values of grain yield production of barley were observed from Adoshe barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate (6.01 tone /ha) and Robera barley variety treated with 23 Kg ha^{-1} nitrogen fertilizer rate (3.29 tone/ha), respectively. The partial budget analysis revealed that, maximum net benefit of Birr 99350.00 ha^{-1} with an acceptable marginal rate of returns (MRR) of 3348.23% with the treatment Adoshe variety with combination of 92 Kg N ha^{-1}. However, the lowest net benefit of (Birr 55225.00 ha^{-1}) was recorded from Robera barley variety treated with 23 Kg ha^{-1} nitrogen fertilizer rate. Therefore, Production of Adoshe variety with combination of 92 Kg N ha^{-1} was economical, and uncertainly recommended for production of food barley in the study area and other areas with similar agro-ecological condition.

Keywords: Food barley; Grain yield; Nitrogen fertilizer; Variety

INTRODUCTION

Barely (*Hordeum vulgare L.*) is one of the most important food crops produced in the world. It was fourth both in terms of quantity produced and in area of cultivation of cereal crops in the world after wheat, rice and maize (FAO, 2009). Many countries grow barley as a commercial crop. Russia, Canada, Germany, Ukraine and France are the major barley producers, accounting for nearly half of the total world production.

In Ethiopia barley is ranked fifth of all cereals, based on area of production, but third based on yield per unit area. It covers 7.56% of the land under grain crop cultivation with a yield of 1.96 t ha^{-1}, whereas the potential yield goes up to 6 t/ha on experimental plots indicating a productivity gap of about 4 t/ha. Filling this gap would make Ethiopia to be among the major barley producing countries. It has many uses, including livestock feed, human food and production of malt. In Ethiopia, the grain is mainly produced for human consumption and sold for cash. About 90% of the grain

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is used for human food and it accounts for over 60% of the food for the inhabitants of the highlands [1]. Despite the importance of barely, there are several factors affecting its production. The most important factors that reduce yield of barley in Ethiopia are poor soil fertility, water logging, drought, frost, soil acidity, diseases and insects, and weed competition [2]. Among the most important constraints that hinder barley production in Ethiopia are poor soil fertility and soil acidity. The major barley producing areas of the country are mainly situated in the highlands, and severe soil erosion and lack of appropriate soil conservation practices in the past have resulted in soils with low fertility and pH [3]. According to Desta Beyene soil fertility status is dynamic and variable from locality to locality, and it is difficult to end up with a blanket recommendation invariably. Some soil amendment studies were undertaken at different times and in some places in Ethiopia

Nitrogen is one of essential plant macro nutrients affecting plant growth, development and yield performance. It is a major component of proteins and nucleic acids. Generally its deficiency consequences stunted plant growth, senescence of leaves and sterility of flowers, poor tiller formation, shriveled seeds and low grain yield. Its excess levels also cause plant lodging, disease susceptibility, and prolonged flowering and maturity dates. Tigre et al. [4] reported that nitrogen significantly increases number of days to heading, maturity and grain filling period; and number of fertile tillers, total biomass and straw yields of barley were also significantly increased by application of N. The growth and yield performance of crop varieties vary from environment to environment because of their differential response to variable environments. The positive response of varieties to the increased rate of fertilizer is essential if the price of the increased yield surpasses its cost of production. Mohammed showed that different varieties and nitrogen levels had significantly affected plant height, 1000 seeds weight, grains per spike, straw yield, grain and biological yields of barley.

There was no research conducted concerning nitrogen fertilizers in kofele distinct. As a result of this fact, most of the farmers in this district do not use nitrogen fertilizer and few others use very much below the blanket recommended rate of 41 Kg N/ha. Therefore, there is a need to study the effect of different N rates on yield and yield components of barely to boost its yield production at kofele district, South Eastern Oromiya having the following specific objectives:

- To evaluate the effect of Nitrogen fertilizer rates on growth, yield and yield components of food barley,
- To determine the optimum rate of Nitrogen fertilizer for food barley production in Kofele distinct and
- To study the extent of interaction effect of varieties-by-Nitrogen fertilizer rates on yield performance of food barley

MATERIALS AND METHODS

Description of study area

This experiment was conducted at Kofele district, west Arsi zone of Oromia regional state, Ethiopia, during 2020/21 cropping season under rain fed condition. The district is located at 38°49' 59.99"E longitude and 07°09 '06.00"N latitude. The altitude of the district ranges from 2450 to 2900 m above sea level. The area receives mean an annual rainfall between 601-1200 mm. The maximum and the minimum temperatures of the area are 22.5°C and 12.6°C, respectively. The dominant crops grown in the district are barley, wheat, faba bean, field pea, and high land maize.

Treatment sand experimental design

The treatments were the combinations of three food barley varieties, namely Adoshe, Robera and Abdene and four levels of N (23 Kg N/ha (50 Kg urea), 46 Kg N/ha (100 Kg urea), 69 Kg N/ha (150 Kg urea) and 92 Kg N/ha (200 Kg urea). In addition, 46 Kg P_2O_5/ha (100 Kg TSPha^{-1}) were applied uniformly to all plots. The experiment was laid out in randomized complete block design in factorial arrangement with three replications.

Data collection and analysis

Data collection was successively done on soil sampling and analysis, plant growth and yield parameters. Soil samples were collected from the experimental site at a depth of 0-20 cm before and after harvesting. The samples were prepared following the standard procedures and analyzed for selected soil physico-chemical properties. Soil samples were analyzed for pH using a ratio of 2.5 ml water to 1 g soil; for available P using Bray-II method; for organic C content using method; for total N content using Kjeldahl method; for exchangeable cations and cation exchange capacity (CEC) using ammonium acetate method at the soil and plant analysis laboratory Data were collected by sampling middle eight harvestable rows excluding the two border rows and one plant from the end of harvestable rows in both sides. Selected phonological, plant growth, yield, and yield component parameters were collected and analyzed. The data were subjected to analysis of variance using the general linear model procedure (PROC GLM) of SAS statistical package version 9.3. Means for the treatments were compared using the MEANS statement with the least significant difference (LSD) test at the 5% probability level. An economic analysis was done using partial budget procedure described by The International Maize and Wheat Improvement Center [5].

RESULTS AND DISCUSSION

Selected soil physical characteristics of the experimental site

Physical soil analysis showed that texture of soil was clay loam with sand, silt and clay percentage of 46%, 23%, and 31%, respectively. Soil texture is the proportion of sand, silt and clay which is an important soil physical characteristic as it determines water intake rate (infiltration), water holding capacity in the soil, the ease of tilling, the amount of aeration, and also influence soil fertility [6]. It is one of the inherent soil properties less affected by management and which determines nutrient status, organic matter content, air circulation and water holding capacity of a given soil.

Based on the soil analysis made, the soil pH-H_2O value was 5.13 (Table 2). The low pH values in cropland could be due to high tillage frequency, high rates of inorganic fertilizer applications (especially ammonium fertilizers), and low amount of organic matter because of erosion or due to aluminum toxicity.

Low soil pH impedes the CEC of the soil by altering the surface charge of colloids (finest clay particles and soil organic matter). Low

CEC implies that soil will have less exchangeable cations required as crop nutrients; nutrients are weekly adsorbed and hence may be leached out. According to Murphy, soil pH level<5.0 is rated as very strong acid, 5.1- 5.5 strong acid, 5.6- 6.0 moderate acidic and, 6.1-6.5 is rated as slightly acidic. Based on the above ratings, soils of the study area were qualified acidic. So that the pH level of the study is conducive for barley production as normal soil pH for barley with amendment of soil with lime.

As indicated in Table 2, the analysis result before sowing was 0.14% for total nitrogen (TN), 4.81% for organic matter (OM) content, 31.21 ppm for available phosphorous (P). The organic matter content of the surface horizon could be rated as medium according to Landon who rated OM contents less than 2% as very low, 2 to 4 as low, 4 to 10 as medium, 10 to 20 as high and greater than 20 as very high. Total nitrogen measures the total amount of nitrogen present in the soil, much of which is held in organic matter and is not immediately available to plants. It may be mineralized to available forms. However, total nitrogen cannot be used as a measure of the mineralized forms of nitrogen (NH_4^+, NO_3^- , and NO_2^-) as much of it is held in the organic matter in the soil. Total nitrogen content in the surface horizon was 0.14 and was rated as low according to Landon.

Available P of the soil could be rated as high. The relatively higher available P in surface as compared to subsurface ones could be also attributed to the difference in organic matter contents of the layers. High organic matter content and a good rate of organic matter mineralization ensure release of phosphate ions, though most of the phosphate released in this way will be in topsoil. According to FAO, the available P contents of the soils in the subsurface soils were rated as very low, where as that of the surface horizon was medium to high.

Cation exchange capacity is the capacity of the soil to hold and exchange cations. It provides a buffering effect to changes in pH, available nutrients, calcium levels and soil structural changes. CEC is one of the most important chemical properties of soils and strongly affects nutrient availability for plant growth. Cation exchange capacity (CEC) of the soil was 21 cmol (+) Kg^1 (Table 2) which could be categorized as medium range. High CEC values could be attributed to the high basic cations content of the soils.

Exchangeable calcium, magnesium and Available potassium are the dominant cations in the exchange sites in the soil of the study area. The magnitude of cations in the soil was 12.28.1.02 and 0.20 for exchangeable calcium, magnesium and Available potassium, respectively. The exchangeable bases were in high range according to FAO except for Available potassium which was small (Table 2). Limited availability of soil nutrients affects crop production and productivity. Thus, addition of single and/or combined fertilizers at the right time and rate might be required whenever there is nutrient deficiency in the study area.

Table 1: Selected physico-chemical properties of the experimental site.

Soil physical properties	Tested results
Sand (%)	46
Silt (%)	23
Clay (%)	31
Particle size	Sandy Clay loam
Soil chemical properties	**Tested results**
pH	5.13
Organic matter content (%)	4.81
Available nitrogen (%)	0.14
Available phosphorus (ppm)	31.21
Calcium (cmol/kg)	12.28
Magnesium (cmol/kg)	1.02
Available potassium (ppm)	0.2
CEC (cmol/kg)	21.00

Table 2: Effect N rate and variety on phonological parameters of barley.

Treatments		DH	DPM
N rates (kg ha^{-1})	23	69.67[b]	122.33[c]
	46	69.77[b]	129.88[b]
	69	71.11[b]	131.00[b]
	92	74.33[a]	134.11[a]
	LSD $_{0.05}$	2.21	2.87
Varieties	Adoshe	71.25[a]	129.83[a]
	Robera	69.41[b]	128.16[b]
	Abdene	70.83[a]	128.83[ab]
	LSD $_{0.05}$	1	1.38
	V*N	NS	***
	CV (%)	3.2	2.27

*Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at p<0.05 level of significance. DH= day to heading and DPM = day to physiological maturity

Effect of N rate and variety on phonological parameters of Barley

Days to heading: The analysis of variance revealed that the main effect of nitrogen rate application and barely varieties had significant (P<0.001) effect on days to heading but non-significant to main effect nitrogen rate and their interaction (Table 1). Days to heading showed an increasing tendency with rising N rates. Increasing rates of nitrogen from 23-92 Kg N ha^{-1}, days to heading was increased from 69.67 to 74.33 days. Having longer days to heading (74.33) of barely was recorded in 92 Kg ha-1 nitrogen fertilizer rate while the lowest days to heading (69.67 Kg ha^{-1}) was recorded in 23 Kg ha^{-1} nitrogen fertilizer rate (Table 2). The shortest days of heading was observed (69.67) at 23` Kg ha^{-1} nitrogen fertilizer rate (Table 2). On other finding, Robera variety was took minimum days to heading (69.41 days) while Adoshe Variety was taken maximum (71.83 days) which is statically similar with that of Abdene variety.

This difference could be attributed to the application different rates of urea for malt barley varieties. The difference in nitrogen fertilizer application time might be related to extended vegetative growth stage that delay days to heading. (18) Also reported that nitrogen application significantly affected days to heading in barley. The result indicates that as the amount of nitrogen fertilizer applied at tillering increases, days to heading also simultaneously increased. This is in line with (18) who reported that plants that received 8 g N m−2at active tillering headed slightly later than those did that received 0 g N m^{-2}. These results also in line with Bekalu & Mamo who reported that, N fertilizer rate and blended fertilizer rate significantly affected days to maturity on.

In general, increasing the rate of nitrogen application significantly prolonged the days to heading of the barley plants across all application rates. This result is also in line with the finding of Getachew and Mekonen who reported that daysto 50% heading was significantly delayed by highest N fertilizer rate compared to the lowest rate on wheat and barley crops, respectively. However, Rashid reported that NP application significantly delayed days to heading of barley. Generally, Yohannis disclosed that the delay in days to heading of wheat plants in response to the increased N rate might be as a result of high N rate application that promoted vigorous vegetative growth and development of the plants possibly due to the availability of sufficient nutrient in the soil for plant uptake.

The interaction effect N rate and variety on days to heading of maize was analyzed and the results obtained are presented in Table 4. The statistical analysis carried out indicated that no significant effect among treatments at ($p<0.05$). Even if no significant effect observed among treatments, the highest days to heading (128days) was recorded from Abdene barley variety under 92Kg ha^{-1}N rate followed by (124 days) obtained from Adoshe barley variety under 92Kg ha^{-1}N rate while the shortest day to heading (83.33 days) was observed at Adoshe barley variety under 23 Kg ha^{-1} N rate (Table 4 and Appendix Table 2).

Days to physiological maturity: A day to physiological maturity was ($P< 0.001$) affected by the main effects of nitrogen rate application and food barely varieties (Table 2). Moreover, this parameter was also significantly ($p<0.001$) affected by the interaction effect of variety and nitrogen rate (Appendix Table 2). Days to maturity followed the same trend as Days to heading. The longest physiological maturity (134.11) and (129.83) was observed at 92 Kg ha^{-1}of N rate application on Adoshe barley variety, respectively. The shortest physiological maturity were (122.33) and (125.16) was observed at 23 Kg ha^{-1} of N rate application on Robera food barley variety, respectively (Table 3 and Appendix Table 3).

This variation may be due to different varieties have different genetic makeup. The maturity of barley plant was hastened under lower N rates than under the higher N rates. Thus, increasing the rate of nitrogen from 23 to 92 Kg N ha-1 prolonged days to maturity by about 9% over that of 23 Kg N ha^{-1} nitrogen rate. However, increasing the rate of nitrogen from 69 Kg N ha^{-1} to 92 Kg N ha^{-1} did not further increase the number of days required to reach maturity (Table 3). More N applied treatments delayed in maturity might be due to extended vegetative growth instead of reproductive growth. Plants treated with N, particularly with the highest level of N, remained slightly green duration while those plants without N showed yellow spike, leaf and stem indicating early physiological maturity which might have been due to depression of cytokinin synthesis or increased production of abscisic acid (ABA) under low N supply. These variations on date of maturity of barley might be, due to shoots maturity was directly affected by the rate of fertilizer application. This result is in line with the report of Brady and Weil that N applied in excess than required delayed plant maturity. In consistent with this finding Tigre et al. [4] revealed that delay in maturity time of barley was greater at higher rates of nitrogen.

This difference could be attributed to the application different rates of N fertilizer rates for malt barley varieties. These results were in line with Bekalu & Mamo who reported that, N fertilizer rate significantly affected days to maturity on barley and wheat. The results are similar to Marschener Who observed when N is applied in excess; the maturity of the crop is delayed by affecting the supply of photosynthesis during critical period of the reproductive phase. Moreover, when N is applied in excess to barley and wheat, the sugar concentration in leaves is reduced during early ripening stage and hence, inhibition occurs in the translocation of assimilated products to spikelet.

Moreover, significant ($p<0.001$) interaction effect was observed between N rates and food barely varieties (Table 3 and Appendix Table 3). Maximum physiological maturity was observed at (140.67days) was recorded from Adoshe barley variety under 92 Kg ha^{-1} N rate followed by (124 days) obtained from Abdene barley variety under 92Kg ha^{-1} N rate.. On the other hand, the minimum physiological maturity (104.33) was obtained at Adoshe barley variety under 23 Kg ha^{-1} N rate applications (Table 4 and Appendix Table 2).

Table 3: Phonological parameters of food barley as influenced by the interaction effect of N rate and variety.

Varieties	N rate (kg N ha-1)	DH	DPM
Adoshe	23	83.33	104.33^{e}
Adoshe	46	87.67	123.67^{d}
Adoshe	69	102.33	139.00^{a}
Adoshe	92	124	140.67^{a}
Robera	23	108	125.00^{cd}
Robera	46	108	124.33^{cd}
Robera	69	116.67	131.33^{b}
Robera	92	108.33	125.67^{cd}
Abdene	23	110.67	126.67^{c}
Abdene	46	114.67	139.00^{a}
Abdene	69	132.67	126.00^{cd}
Abdene	92	128	140.33^{a}
	LSD $_{0.05}$	NS	2.76
	CV (%)	1.69	1.26

Table 4: Effect of N rate and variety on growth parameters of Barley.

Treatments		PH (cm)	SL (cm)	Lodging	NTPM^2
N rates (kg ha^{-1})	23	99.09^{b}	5.15^{c}	2.50^{c}	95.33^{b}
	46	99.15^{b}	6.15^{b}	3.33^{b}	111.89^{a}
	69	102.52^{b}	6.54^{ab}	4.00^{a}	113.33^{a}
	92	120.37^{a}	6.89^{a}	5.00^{a}	120.77^{a}
	LSD$_{0.05}$	8.6	0.57	0.8	16.22
Varieties	Adoshe	106.86	6.41	2.00^{c}	119.33^{a}
	Robera	105.4	6.25	3.50^{b}	109.08^{ab}
	Abdene	103.57	6.01	5.00^{a}	102.50^{b}
	LSD$_{0.05}$	NS	NS	0.98	14
	V*N	***	*	***	NS
	CV (%)	8.36	9.45	12.5	15.04

*Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at $p<0.05$ level of significance. PH= Plant Height= Spike Length and NTPM^2 = Number of Tillers per meter square area

This is in line with Kedir & Ashenafi and Ketema & Mulatu who reported that the variation of physiological maturity of food barley varieties with different nitrogen fertilizer rates.

Effect of N rate and variety on growth parameters of barley

Plant height: The analysis of variance revealed that Plant height was highly significantly (p<0.001) influenced due to different rates of nitrogen fertilizer but barley varieties was exhibited a non-significant effect (Table 5 and Appendix Table 3). Maximum plant height (120.37 cm) was observed for 92 Kg ha^{-1} nitrogen fertilizer rate, whereas the minimum plant height (99.09 cm) was observed at for 23 Kg ha^{-1} nitrogen fertilizer rate. The maximum plant height recorded at 92 Kg ha^{-1} nitrogen fertilizer rate was statistically superior to the rest nitrogen fertilizer rates. On the other hand, the shorter plant height was observed at 23 Kg ha^{-1} nitrogen fertilizer rate and this was statistically not significant with that of nitrogen fertilizer rates except 92 Kg ha^{-1} nitrogen fertilizer rate.

Moreover, this parameter was also significantly (p<0.001) affected by the interaction effect of variety and nitrogen rate (Appendix Table 3). The study revealed that maximum plant height of 164.90 cm was obtained at Adoshe food barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate. On the other hand, the minimum plant height of 86.45 cm was observed at Robera food barley variety treated with 23 Kg ha^{-1} nitrogen fertilizer rate (Table 5). The highest plant height observed Adoshe food barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate had been 47.5% higher than the plant height observed at Robera food barley variety treated with 23 Kg ha^{-1} nitrogen fertilizer rate.

The study revealed that, plant height was increased significantly in response to increasing the rate of N fertilizer from 23 to 92 Kg N ha^{-1}. The possible reason might be that optimum nitrogen supply may have played an essential role in plantgrowth and developmentt. This result is similar with the finding of Biruk and Demelash indicated that highly significant plant height differences resulted by main effect of N rate and varieties. This result is also supported by the finding of Hadi reported that taller barley plants recorded on high N treatments applied. Likewise, Fazal revealed that plant height of barley was significantly affected the N fertilizer applications.

Similar studies also reveal that plant height is affected due to different rates of NPSB and different rates of urea in different crops. Most of the growth parameters results were increased along the application rates of NPSB when supplemented with urea fertilizer. The result showed that plant height increases at an increasing rate of nitrogen levels. Ali also reported similar results of plant height increment with N rate increase and Sofony as reported significant increments in plant height due to application of high nitrogen rate. Similar findings were also reported by Ketema & Mulatu and Kedir & Ashenafi who reported that different nitrogen fertilizer rates significantly affected plant height and higher growth of Food barley varieties.

Spike length: Spike length was not significantly (p<0.05) influenced by the main effects of barley varieties while significantly (p<0.001) influenced by the main effects of nitrogen fertilizer rates. Moreover, this parameter was also significantly (p<0.05) affected by the interaction effect of variety and nitrogen rate (Appendix Table 4). The highest spike length (6.89 cm) was recorded from the plot

Table 5: Growth parameters of food barley as influenced by the interaction effect of N rate and variety.

Varieties	N rate (kg N ha^{-1})	PH (cm)	SL (cm)	Lodging	$NTPM^2$
Adoshe	23	93.56^{cde}	4.99^{cde}	1.00^{d}	114.67
Adoshe	46	90.85^{de}	5.88^{cde}	1.00^{d}	83.33
Adoshe	69	113.03^{b}	6.90^{bc}	1.00^{d}	87.67
Adoshe	92	164.90^{a}	7.10^{ab}	1.00^{d}	124
Robera	23	86.45^{e}	5.09^{e}	1.33^{c}	108
Robera	46	109.40^{b}	5.60^{de}	2.00^{c}	108
Robera	69	112.23^{b}	6.55^{bcd}	4.00^{b}	116.67
Robera	92	108.78^{b}	6.31^{bcd}	5.00^{a}	108.33
Abdene	23	102.03^{bcd}	6.77^{abc}	2.00^{c}	110.67
Abdene	46	164.82^{a}	6.38^{bcd}	3.67^{b}	132.67
Abdene	69	104.18^{bc}	7.63^{a}	5.00^{a}	102.33
Abdene	92	112.20^{b}	6.77^{abc}	5.00^{a}	128
	$LSD_{0.05}$	12.64	0.99	0.58	NS
	CV (%)	6.98	9.42	13.05	14.3

treated with 92 Kg $ha^{-1}$of nitrogen fertilizer rate application which improved by 25% as compared the shortest spike length (5.15 cm) obtained from the 23 Kg $ha^{-1}$of nitrogen fertilizer rate application plot (Table 5). In the combined analysis the maximum Spike length of (7.63 cm) was obtained from abdene variety with combination of 92 Kg N ha^{-1} while the minimum number (4.99 cm) of Spike length was obtained from Adoshe variety with 23 Kg ha^{-1}N rates.

Spike length was also significantly increased with increasing N level. Spike length varied from 5.15 to 6.89 cm as the N level increase from 23 to 92 Kg N ha^{-1} (Table 4). The result of this study similar with reports of Aghdam and Samadiyan indicated that effect of N and variety on spike length was significant at 1% level which means spike length became higher at higher dose of N possibly due to higher availability of nitrogen and genotypic differences between cultivars in terms of their length are concerned. This result agreed with Biruk and Demelash study spike length varied significantly (P<0.001) among the barley varieties. Similarly, Laghari who reported that spike length of wheat crop became higher at the higher doses of nitrogen. Plant height and spike length of food barley as influenced by the main effect of N rate and variety. Bekalu & Mamo reported that optimum amount of fertilizer application has significant effect on spike length growth.

Similar studies also reveal that spike length is affected due to different nitrogen fertilizer rates in different crops. This coincides with the study of Rut-Duga, Kedirand Ashenafi and Ketema and Mulatu who reported applications of nitrogen fertilizer rates leads to the higher yield components and spike length as we compared with the non-nitrogen fertilizer treated treatments.

Lodging percentage: Lodging index was highly significantly (P<0.001) influenced by the main effects of N rate and variety. Moreover, of N rate and variety also interact each other to affect lodging (P<0.001).An increasing the rate of nitrogen application up to 92 Kg N ha^{-1} significantly increased lodging index of across to all varieties. The maximum lodging index (5) was obtained from Abdene barley variety with combination of 92 Kg N ha^{-1} while the minimum number (1) of lodging index was obtained from Adoshe barley variety with 23 Kg N ha^{-1} N rate. The lodging index was increased with increasing nitrogen rates (Table 4 and Appendix

Table 5).

The increasing lodging index with increasing nitrogen fertilizer could be because of the increase in plant height which in turn resulted from abundant supply of nutrients. This result was in line with the findings of Shiferaw who reported highest lodging of teff (74%) at N/P_2O_5 rate of 64/46 Kg ha^{-1}. Likewise, Fayera reported the highest lodging percentage (79.74%) of teff was recorded in the highest rate of NPK application though the rate and Tams also confirmed that abundant supply of nutrients in the soil can contribute to the process of lodging the authors reported is much higher (138 Kg N/ha+55 Kg P/ha) than the present result. Kebebew and Tams also confirmed that abundant supply of nutrients in the soil can contribute to the process of lodging.

Number of tillers per meter square area: The analysis of variance revealed number of tillers per meter square area was significantly ($p<0.05$) affected by both main effect of nitrogen and variety. But non-significantly affected ($p<0.05$) by the interaction effect of variety and nitrogen rates during the study season (Table 5 and Appendix Table 6).

The highest (120.77) number of tillers per meter square was obtained at 92 Kg ha^{-1} nitrogen fertilizer rate and it was statistically superior to the 23 Kg ha^{-1} nitrogen fertilizer rate and similar with that of the rest rates of nitrogen fertilizers. On the other hand, the minimum (95.33) number of tillers per meter square was obtained at 23 Kg ha^{-1} nitrogen fertilizer rate, which was statistically inferior with that of the rest of nitrogen fertilizer rates. The lowest numbers of tillers per plant (95.33) were recorded for barley at 23 Kg ha^{-1} nitrogen fertilizer rate treated plot; which might be due to the role of N in accelerating vegetative growth of plants. The highest number of tillers per meter square was obtained at 92 Kg ha^{-1} nitrogen rate was improved by 21% as compared to the lowest number of tillers per meter square at 23 Kg ha^{-1} nitrogen fertilizer rate.

The results were in agreement with that of Abdullatif who reported that increasing in the number of effective tillers with nitrogen fertilization. Bereket and Abdollahi also reported that nitrogen fertilization have significant effect on effective number of tillers of barley. Giday also reported posetive and significant increase in number of productive tillers with increasing rates of N fertilizer on teff. Similar findings were also reported by Ketema and Mulatu who reported that an increasing the rate of nitrogen application up to 69 Kg N ha^{-1} significantly increased total tillers number of across to all varieties. The maximum total tillers (336.3) was obtained from EH 1493 variety with combination of 69 Kg N ha^{-1} while the minimum number (222.7) of total tiller was obtained from HB 1307variety with nil N rate. An increasing rate of nitrogen from zero to 69 Kg ha^{-1} increased total number of tillers by 40%. Statistically, total tillers number of local (308) and HB 1307 (306.7) varieties combined with 69 Kg N ha^{-1}showed the same with response with that of EH 1493 with 69 Kg N rate. This may be the contribution of N fertilizer, as the treatments that received N responded more total tillers compared with less N received treatments. This as stated by Bakht might be due to nitrogen is an essential nutrient for growth and development of the plant. A similar result was reported by Suleiman [6] N application has significant difference among wheat and barley varieties for tillering respectively.

Besides to these Rashid and Khan disclosed that number of total tillers of barley varieties was significantly increased by e application of nitrogen fertilizer. Similarly, Munir reported that tillers numbers of barley varieties were significantly increased with increasing rate of nitrogen fertilizer application.

Effect of N rate and variety on yield and yield components of barley

Thousand kernel weight: The analysis of variance indicated that different nitrogen rates had a highly significant ($p<0.01$) effect on thousand kernel weight of barley (Table 7), additionally the different food barley varieties had significantly ($p>0.01$) influenced thousand kernel weight. The highest (38.63g) thousand-kernel weight was obtained at to 92 Kg N ha^{-1} nitrogen rates and it was statistically superior to the rest nitrogen rates except 69 Kg N ha^{-1} nitrogen rate. On the other hand, the minimum (34.75 g) thousand-kernel weight was obtained at 23 Kg ha^{-1} nitrogen rate that was statistically similar to that of 46 Kg ha^{-1} nitrogen rate. The average thousand

Table 6: Effect of N rate and variety on yield and yield components of barley.

Treatments		TKW (g)	NKS (cm)	FT PM²
N rates (kg ha^{-1})	23	34.75^{c}	32.66^{c}	88.11^{b}
	46	36.36^{bc}	37.88^{b}	104.44^{a}
	69	37.86^{ab}	38.00^{b}	106.11^{a}
	92	38.63^{a}	43.33^{a}	112.77^{a}
	LSD $_{0.05}$	2.23	2.09	15.92
Varieties	Adoshe	39.58^{a}	41.16^{a}	115.58^{a}
	Robera	33.93^{c}	35.75^{b}	91.33^{b}
	Abdene	37.59^{b}	37.00^{b}	101.66^{b}
	LSD $_{0.05}$	1.93	1.81	13.79
	V*N	**	*	NS
	CV (%)	6.19	5.63	15.83

* Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at $p<0.05$ level of significance. TKW= Thousand kernel weight, NKS = Number of Kernels per Spike and NFT PM2 = Number of fertile tillers per meter square area

Table 7: Yield and yield components of food barley as influenced by the interaction effect of N rate and variety.

Varieties	N rate (kg N ha-1)	TKW (g)	NKS	FT PM²
Adoshe	23	31.39^{f}	30.33^{g}	107
Adoshe	46	37.98^{bcde}	32.67^{fg}	78
Adoshe	69	39.73^{bc}	35.00^{ef}	79.33
Adoshe	92	39.85^{bc}	42.33^{bc}	116.67
Robera	23	38.16^{bcd}	35.33^{ef}	99.33
Robera	46	35.59^{cdef}	36.33^{ef}	102.33
Robera	69	35.82^{bcdef}	40.33^{cd}	112
Robera	92	33.51^{ef}	36.67^{de}	95.67
Abdene	23	34.93^{def}	36.67^{de}	105.67
Abdene	46	40.29^{b}	38.33^{cd}	128
Abdene	69	32.69^{f}	44.67^{b}	92.33
Abdene	92	46.56^{a}	50.00^{a}	119.33
	LSD $_{0.05}$	4.48	3.89	NS
	CV (%)	7.11	6.01	15.45

kernels weight was increasing as the rate of nitrogen increase from 23 to 92 Kg N ha^{-1} (Table 7). In general, thousand-kernel weight is an important yield determining component and reported to be a genetic character that is influenced least by environmental factors.

This is consistent with the suggestion of Biruk and Demelash that suitable genetic behavior of cultivar with environment factors which may led to an increased in photosynthesis process and accumulations of carbohydrate in kernel to produce heavy kernels and consequently increased kernels weight per spike. The finding of Asghari also indicated the increasing rate of nitrogen application was increased thousand kernel weights. Similarly, Biruk and Demelash reported that thousand kernel weight of barley variety also significantly increased with all levels of fertilizers compared to control.

The analysis also revealed that different food barley varieties had a highly significant ($p<0.001$) influence on thousand kernel weight. Maximum thousand kernel weight (39.58 g) was observed at Adoshe food barley variety (Appendix Table 6). The maximum thousand kernel weight obtained at Adoshe food barley variety was statistically superior with that of the rest food barley varieties (Table 7). Moreover, the minimum (33.93 g) thousand kernel weights were obtained at Robera food barley variety which was significantly inferior to both food barley varieties. The highest thousand kernel weight of barley obtained at Adoshe food barley variety lead to an improvement of 14% over the rest food barley varieties. This variation may be due to different varieties have different genetic makeup. The variation of thousand kernel weight of barley with different varieties was reported by different researchers. Ketema and Mulatu they reported as thousand kernels weight of barely was significantly ($P \leq 0.05$) influenced by main effect of N fertilizer rate and highly significantly ($p<0.001$) influenced by the main effect of varieties. The highest thousand kernels weight (44.46 g) was obtained from variety EH 1493 however the lowest thousand kernels weight (39.10 g) was obtained from variety HB 1307. Rut-Duga also supported the current findings as the above the analysis of variance showed that the main effect of varieties and blended fertilizer rates significantly ($p<0.01$) affected thousand kernel weight (TKW), but there was no interaction effect. Wane Variety (37.0 gm) was recorded more than King Bird variety (35.3 gm) in TKW.

Moreover, this parameter was also significantly ($p<0.05$) affected by the interaction effect of variety and nitrogen rate (Appendix Table 6).The study revealed that maximum thousand kernel weights of 46.56 g was obtained at Abdene food barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate. On the other hand, the minimum thousand kernel weight of 31.39 cm was observed at Adoshe food barley variety treated with 23 Kg ha^{-1} nitrogen fertilizer rate (Table 8). The highest thousand kernel weight observed Abdene food barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate had been 32.5% higher than the thousand kernel weight observed at Adoshe food barley variety treated with 23 Kg ha^{-1} nitrogen fertilizer rate. The current steady reveals that an increasing trend of the thousand kernel weight was observed when we are applying higher nitrogen rates combined with different barley varieties as compared to lower application of nitrogen rate in barley varieties.

This may be the contribution of N fertilizer, as the treatments that received N responded more total tillers compared with zero N received treatment. This as stated by Bakht might be due to nitrogen is an essential nutrient for growth and development of the plant. A similar result was reported by Suleiman [6] N application has significant difference among wheat and barley varieties for thousand kernel weight respectively.

Table 8: Effect of N rate and variety on yield and yield components of barley.

Treatments		ABM (T/ha)	GY (T/ha)	SY (kg/ha)	HI (%)
N rate (kg ha^{-1})	23	4.66^{b}	4.13^{b}	0.53^{b}	87.56
	46	5.33^{ab}	4.62^{ab}	0.53^{b}	88.55
	69	5.42^{ab}	4.75^{ab}	0.58^{b}	88.91
	92	6.23^{a}	5.41^{a}	1.04^{a}	89.86
	$LSD_{0.05}$	1	1.01	0.12	NS
Varieties	Adoshe	6.35^{a}	5.49^{a}	0.84^{a}	89.64
	Robera	4.73^{b}	4.07^{b}	0.50^{c}	89.14
	Abdene	4.75^{b}	4.23^{b}	0.68^{b}	87.41
	$LSD_{0.05}$	0.86	0.88	0.1	NS
	V*N	*	NS	***	NS
	CV (%)	19.39	22.62	18.22	3.3

*Means followed by different letters in a column differ significantly and those followed by the same letter are not significantly different at $p<0.05$ level of significance. ABM = Above Ground Biomass per Hectare, GYPHA = Grain Yield Per Hectare, SY = Straw Yield Per Hectare and HI = Harvesting Index

Number of kernels per spike: Analysis of variance had shown that number of kernels per spike was highly significantly ($p<0.001$) affected by both main effect of nitrogen rates and food barley varieties. Moreover, this parameter was also significantly ($p<0.05$) affected by the interaction effect of variety and nitrogen rate (Appendix Table 7).

An increasing the rate of nitrogen application up to 92 Kg N ha^{-1} nitrogen rate significantly increased number of kernels per spike of across to all varieties. The maximum number of kernels per spike (50.00) was obtained from Abdene variety with combination of 92 Kg N ha^{-1} rate while the minimum (30.33) number of kernels per spike was obtained from Abdoshe variety with 23 N ha^{-1} rates. An increasing rate of nitrogen from 23 to 92 Kg ha^{-1} increased the number of kernels per spike by 24.6%. Statistically, a different response was observed on number of kernels per spike of Abdoshe, Robera and Abdene varieties combined with 92 Kg N ha^{-1} nitrogen rate (Table 7).

Increasing trends of number kernels per spike was observed when rates of fertilizers increased. This might be due to the addition of fertilizer application rates in the experimental site there was increased the appearance of seeds in their spikes. The results were in conformity with that of Tigre et al. [4] who stated that increasing N rates up to optimum level significantly increased number of seed spike-1.

Several authors, Dewal & Pareek, Arif, Gupta, Bereket report that macro and micro nutrients (Nitrogen, Phosphorous with Sulfur and Born) fertilizers application can increase plant height, spike length, number of tillers and number of kernel with increasing doses and combination.

Number of fertile tillers per meter square area: The analysis of variance indicated that the main effect of variety and nitrogen fertilizer rate exhibited significant ($p<0.05$) differences on number of fertile tillers per meter square area, but their interaction was not significant over factors evaluated (Table 7 and Appendix Table 8).

The highest number of on number of fertile tillers (112.77) was obtained by the application of 92 Kg N ha^{-1} nitrogen rate whereas the lowest number of fertile tillers (88.11) was obtained by the application of 23Kg N ha^{-1} nitrogen rate. The maximum number of fertile tillers recorded at 92 Kg N ha^{-1} nitrogen rate was statistically superior to 23Kg N ha^{-1} nitrogen rate. On the other hand, the shorter plant height was observed at 23 Kg N ha^{-1} nitrogen rate and this was statistically inferior with that of rest nitrogen rates.

Regarding to food barley varieties, the highest number of on number of fertile tillers (115.58) was obtained by Adoshe barley variety whereas the lowest number of fertile tillers (91.33) was obtained by Robera barley variety. The maximum number of fertile tillers recorded at Adoshe barley variety was statistically superior to both barley varieties. On the other hand, the shorter number of fertile tillers was observed at Robera barley variety and this was statistically inferior with that of Adoshe barley variety and similar with Abdene barley variety.

This revealed that Contribution of N fertilizer, as the treatments that received N responded more fertile tillers compared with zero and less N received treatment and number of fertile tillers significantly affected with variation of food barley varieties (Table 7). The lowest numbers of effective tillers were recorded for all varieties at lower nitrogen rate treated plot; which might be due to the role of N in accelerating vegetative growth of plants. Number of fertile tillers plant is the most important character, which ensured highest yield.

According to Mangle and Kirkby, nitrogen stimulates tillering, may be due to its effect on cytokine synthesis. Others reported that barely reacts to early N by producing more tillers per plant and by exhibiting a higher percentage survival of tillers. This result is consistent with finding of Biruk and Demelash number of fertile tillers highly significantly affected by the difference between barley varieties and rates of nitrogen. It also agreed with Alam **et al.** [1] study N applied treatments were produced highest number of fertile tillers plant-1 irrespective of cultivars and N treatment. Increased level of nitrogen increased number of fertile tillers plant-1. Similarly, Tigre et al. [4] indicated that highly significant differences were observed between plant heights, productive tillers m^{-2}.

The results were in agreement with that of Diriba, who reported that increasing in the number of effective tillers with nitrogen fertilization.

Grain yield production: Different rates of nitrogen fertilizer has significantly influenced the grain yield of barley per hectare production ($P<0.05$) from the result obtained highest yield was scored (5.41 tone/ha) from 92 Kg ha^{-1} nitrogen fertilizer rate and it has a significant difference with 23 Kg ha^{-1} nitrogen fertilizer rate and statistically the same with that of rest nitrogen fertilizer rates (Table 9 and appendix Table 9). Contrary to this, minimum grain yield (4.13 tone/ha) was obtained at 23 Kg ha^{-1} nitrogen fertilizer rate. The minimum grain yield obtained at control was statistically inferior with that of 92 Kg ha^{-1} nitrogen fertilizer rate but statistically the same with that of rest nitrogen fertilizer rates.

The highest grain yield of barley obtained at 92 Kg ha^{-1} nitrogen fertilizer rate lead to an improvement of 23.7% than 23 Kg ha^{-1} nitrogen fertilizer rate. The reduction of fertilizer from 92 Kg ha^{-1} nitrogen fertilizer to 23 Kg ha^{-1} nitrogen fertilizer rate leads to reduction of grain yield by 23.7%. The data reveal that higher amount of fertilizer application associated with larger amount of grain yield production and less amount of fertilizer application leads to less amount of grain yield production per hectare.

The analysis also revealed that different varieties on barley had a highly significant ($p<0.01$) influence on grain yield (Table 9 and appendix Table 9). Maximum grain yield (5.49 tone/ha) was observed at Adoshe barley variety. The maximum grain yield obtained at Adoshe barley variety was statistically different with that of the rest treatments. Moreover, the minimum (4.07 tone/ha) grain yield obtained at Robera barley variety it was significantly inferior to Adoshe barley variety and similar with Abdene barley variety. The highest grain yield of barley obtained at Adoshe barley variety lead to an improvement of 26% over Robera barley variety.

The increased shoot dry matter yield in response to the increased rate of nitrogen application may probably be attributed to increased concentration of nitrogen fertilizer in the soil that may have enhanced root uptake of the nutrient possibly resulting in increased concentration of chlorophyll in the leaves, heightened rate of photosynthesis, high rate of leaf expansion, increased leaf number and dry matter accumulation in the aboveground biomass. This result is consistent with the result of Gemechu that, nitrogen fertilizer plays an important role in canopy development, which in turn increases shoot dry matter.

The increase in grain yield in response with increasing rate of nitrogen could be attributed to enhanced availability of the nutrient for uptake by the plants and increased photo assimilate production that would eventually lead to improved partitioning of carbohydrate to the grains. The results of this study have indicated that application of nitrogen enhanced the grain yields of all food barley varieties. All tested varieties continued responding up to the highest N level.

The significant increase in grain yield in response to the increased

Table 9: Yield and yield components of food barley as influenced by the interaction effect of N rate and variety.

Varieties	N rate (kg N ha-1)	ABM (T/ha)	GY (T/ha)	SY (kg/ha)	HI (%)
Adoshe	23	3.99^{de}	3.63	0.35^{d}	85.19
Adoshe	46	4.88^{cde}	4.19	0.56^{cd}	89.32
Adoshe	69	5.13^{bcde}	4.58	0.59^{cd}	88.19
Adoshe	92	6.84^{a}	6.01	1.07^{a}	92.65
Robera	23	3.73^{e}	3.29	0.47^{cd}	88.86
Robera	46	3.79^{e}	3.75	0.49^{cd}	86.84
Robera	69	6.64^{ab}	4.3	0.63^{c}	89.95
Robera	92	6.11^{abc}	5	0.63^{c}	89.83
Abdene	23	4.90^{cde}	4.39	0.51^{cd}	89.6
Abdene	46	5.45^{abcd}	4.97	0.53^{cd}	87.53
Abdene	69	5.75^{abcd}	4.42	0.99^{b}	87.23
Abdene	92	6.10^{abc}	4.92	1.01^{a}	88
	$LSD_{0.05}$	1.56	NS	0.27	NS
	CV (%)	17.65	20.53	23.12	3.3

application of N fertilizer could be attributed to enhanced availability and uptake of N by the roots of barley plants. Grain yield is a complex character depending upon a large number of environmental, morphological and physiological characters. Grain yields also depend upon other yield components. The highest grain yield of any crop is the result of all positive relationships of the yield components.

Improvement in barley yield with fertilizer application can be attributed to the stimulating effects of nutrients on plant growth that provides ideal condition for crop as the fertilizer N supply to plants need FAO, which ultimately increased the grain yield of crop. The current result is in agreement with the achievements of Ahmad, Ahmad & Rashid and Imran who suggested that an introduction of high yielding crop variety with balanced application of NP fertilizer can be increase the grain yield of the crop. On the other hand, highly significant differences were observed between number of tillers and productive tillers m^{-2}, biomass and grain yield as main effect of nitrogen fertilizer rate Amare and Adane. Similarly, Grain yield of wheat was highly significantly influenced by the rate of N fertilizer application.

The highest grain yield at the highest NPSB rates might have resulted from improved root growth and increased uptake of nutrients and better growth favored due to the synergistic effect of the four nutrients, which enhanced yield components and yield. Nitrogen affects the vegetative as well as yields whereas phosphorus plays a fundamental role in metabolism and energy producing reaction and can withstand the adverse environmental effects, thus resulting in enhanced grain yield.

Nitrogen is an integral component of many compounds essential for plant growth processes including chlorophyll, which is responsible for the dark green color of stems and leaves, which enhances vigorous vegetative growth, plant height, branching and/or tillering, leaf production and size enlargement and many enzymes. Nitrogen also mediates the utilization of potassium, phosphorus and other elements in plants. The result affirmed that addition of supplementary N at growing stage attributed to partition of N to grain yield for subsequent growth and development.

The current finding is also in line with Ketema and mulatu they reported fertilizer supply had a marked effect on the aboveground biomass, grain yield, and straw yield. The maximum aboveground biomass (12.35 t ha^{-1}) was obtained from 69 Kg ha^{-1} of nitrogen fertilizer application. However, the lowest (7.78 t ha^{-1}) aboveground biomass was recorded from control or unfertilized plot. Moreover, this result agrees with the previous finding of Woubshet who reported that application of 150 Kg ha^{-1} NPSB blended fertilizer with compost increase the grain yield by 4.8 t ha^{-1}. Klikocka also found that a positive reaction of N and S fertilization on grain yield, which was the highest grain yield (5.40 t ha^{-1}) was obtained due to application of 80 N Kg ha^{-1} increasing by 1.30 t ha^{-1} (13.1%) with respect to the control and S fertilization. increased grain yield by 3.58%. Besides, Khan reported 43% raise in grain yield with the addition of 90 Kg P and 60 Kg ha^{-1} S. Likewise, according to Malakouti reported that the grain yield increased due to application of boron was also witnessed by the combined application of boron with micronutrients, with the benefits 4 to 11% wheat yield. Bereket, also reported that increasing rate of nitrogen fertilization increased grain yield of wheat.

The interaction effect of nitrogen fertilizer rates and type of verities on grain yield production of barley was analyzed and the results obtained are presented in Table 10. As shown on analysis of variance (Appendix Table 9), there was no significant interaction between nitrogen fertilizer rates and type of verities on grain yield production of barley. However, the maximum and minimum mean values of grain yield production of barley were observed from Adoshe barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate (6.01 tone /ha) and Robera barley variety treated with 23 Kg ha^{-1} nitrogen fertilizer rate (3.29 tone/ha), respectively (Table 10).

Aboveground biomass: The different rates of nitrogen fertilizer on barley have shown a significant ($p<0.05$) influence on aboveground biomass production (Table 9 and Apendix Table 10). According to the data, there is also association between variety and aboveground biomass production significantly ($p<0.01$). Furthermore, their interaction also did show significant effect on aboveground ($p<0.05$) (Table 9 and Appendix Table 10). The highest aboveground biomass (6.23 tone ha^{-1}) was observed at 92 Kg ha^{-1} nitrogen fertilizer rate. The maximum aboveground biomass obtained at 92 Kg ha^{-1} nitrogen fertilizer rate was statistically superior to 23 Kg ha^{-1} nitrogen fertilizer rate and similar with that of the rest nitrogen fertilizer rates. Contrary to this, minimum aboveground biomass (4.66 tone ha^{-1}) was obtained at 23 Kg ha^{-1} nitrogen fertilizer rate.

The minimum aboveground biomass obtained at 23 Kg ha^{-1} nitrogen fertilizer rate was statistically similar with that of 46 and 69 ha^{-1} nitrogen fertilizer rates. The highest aboveground biomass of barley obtained at 92 Kg ha^{-1} nitrogen fertilizer rate lead to an improvement of 25% than the 23 Kg ha^{-1} nitrogen fertilizer rate. This might be significant increases in plant height, tillering, spike length, number of spikelets per spike and grain yield from N application ultimately contributed to the increased crop biomass yield.

The maximum of biomass yield (6.35 tone ha^{-1}) was obtained from variety Adoshe while minimum of biomass yield was attained at Robera variety which produced (4.73 tone ha^{-1}) (Table 9). Statically Robera and Abdene varieties the same while superior effect of

Table 10: Partial budget analysis of barely yield production under barley varieties and N fertilizers rate in Kofele District.

Varieties	N rate (kg ha-1)	Yield (kg/ha)	Total Return (Birr/ ha)	Total cost (Birr/ ha)	Net Income (Birr/ ha)	MRR (%)
Adoshe	23	3630	61710	705	61005	0
Adoshe	46	4190	71230	1410	69820	1250.35
Adoshe	69	4580	77860	2115	75745	840.43
Adoshe	92	6010	102170	2820	99350	3348.23
Robera	23	3290	55930	705	55225	2086.29
Robera	46	3750	63750	1410	62340	1009.22
Robera	69	4300	73100	2115	70985	1226.24
Robera	92	5000	85000	2820	82180	1587.94
Abdene	23	4390	74630	705	73925	390.31
Abdene	46	4970	84490	1410	83080	1298.58
Abdene	69	4420	75140	2115	73025	1426.24
Abdene	92	4920	83640	2820	80820	1105.67

N.B: MRR = Marginal Rate of Return, Sale Prices of Urea: 14.10 birr/kg, Sale price of food barley: 17 birr/kg in local market. Family labor cost was not assigned because similar labor time was used on each treatment.

Adoshe variety was observed over the two varieties. Biomass yield has positive correlation with growth parameters like; total number of plants, tillers per unit area and final plant height. Variety EH1493 superior in biomass yield because it has higher total tillers and fertile tillers in relation to two tasted barley varieties. Likewise, biomass yield of barley varieties also significantly influenced by nitrogen rate.

The interaction effect of nitrogen fertilizer rates and type of verities on biomass yield of barley was analyzed and the results obtained are presented in Table 10. As shown on analysis of variance (Appendix Table 10), there was a significant ($p<0.05$) interaction between nitrogen fertilizer rates and type of verities on biomass yield of barley was observed. The current study revealed that, the maximum and minimum mean values of biomass yield of barley were observed from Adoshe barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate (6.84 tone /ha) and Robera barley variety treated with 23 Kg ha^{-1} nitrogen fertilizer rate (3.73 tone/ha), respectively (Table 10).

In general, aboveground dry biomass was increased with increase in N rate, which might be due to improved root growth and increased uptake of nutrients favoring better growth, and delayed senescence of leaves of the crop due to synergetic effect of the nutrients (N). In addition, this might be due to highest blended fertilizer rates in the root zone due to high nutrient amount in 92 Kg ha^{-1} N rates leads to make a favorable condition for barley physiological and photosynthesis processes. Different studies revealed that an adequate nutrient in the root zone leads to improve aboveground biomass and grain yield of barley.

This result is consistent with study of Mohammad who reported that significance differences were observed on total biomass yield of barley due to various levels of nitrogen fertilizer application. Besides this result also agreed with the finding of Tigre et al. [4] the highest biomass yield of 8.78 t ha^{-1} was recorded at treatment received 120 Kg N ha^{-1} while the lowest biomass yield of 6.51 t ha^{-1} was obtained at treatment received zero nitrogen rate. Similarly, authors in [7-19] who indicated that increasing nitrogen level increased total dry matter irrespective of cultivars. Further increase in N levels significantly enhanced the biological yield as nitrogen at 120 Kg ha^{-1} yielded maximum (11642.78 Kg) biological yield followed by 80 Kg ha^{-1} (9392.22 Kg). Minimum (7224.11 Kg) biological yield was provided by N at 40 Kg ha^{-1}.

The current finding is also in line with Ketema and mulatu they reported fertilizer supply had a marked effect on the aboveground biomass, grain yield, and straw yield. The maximum aboveground biomass (12.35 t ha^{-1}) was obtained from 69 Kg ha^{-1} of nitrogen fertilizer application. However, the lowest (7.78 t ha^{-1}) aboveground biomass was recorded from control or unfertilized plot. This result also agrees with the finding of Woodshed et al. (2017) who found that application of 150 Kg ha^{-1} NPSB blended fertilizer with compost increased the biomass by 11.5 t ha^{-1}. This due to Sulfur enhanced the formation of chlorophyll and encouraged vegetative growth and B helps in N absorption.

Straw yield: The straw yield of Food barley was very highly significantly ($p<0.001$) influenced due to different food barley varieties and different nitrogen fertilizer rates (Table 9 and Appendix Table 11). The highest straw yield was observed at Adoshe food barley variety (0.84 Kg /ha) and it was superior to both food barley varieties. The minimum straw yield was observed at Robera food barley variety (0.50 Kg /ha) and this is also has a significant difference with both food barley varieties (Table 9). This difference might be attributed to the higher productivity of yield and yield components of Adoshe variety.

Similarly, higher straw yield of 1.04 Kg/ha was obtained at 92 Kg ha^{-1} nitrogen fertilizer rate (Table 9) and which was statistically superior with that of the rest fertilizer rates. Contrary to this, the lower straw yield of 0.53 Kg/ha was observed at no mulch condition and it was statistically inferior to 92 Kg ha^{-1} nitrogen fertilizer rate and the same with 46 and 69 Kg ha^{-1} nitrogen fertilizer rates.

The highest straw yield observed at 92 Kg ha^{-1} nitrogen fertilizer rate is 40.47% which is higher than the straw yield observed at 23 Kg ha^{-1} nitrogen fertilizer rate. Moreover, Adoshe food barley variety improved Straw yield by 53% than Robera food barley variety. The study reveals that there is a positive relationship between the amounts of nitrogen fertilizer along with food barley varieties on the straw yield production. The mean separation revealed that increasing rate of nitrogen was increased straw yield of barley varieties up to higher level of nitrogen application. Similar to the grain yields, the straw yields continued increasing significantly with the increase in N fertilizer rate.

This might be significant increases in plant height, tillering, spike length, number of spikelets per spike and grain yield from N application ultimately contributed to the increased crop biomass yield. Additionally, might be due to the increase in N fertilizer rate in the root zone leads to make a favorable condition for barley physiological and photosynthesis processes. As far as N fertilizer is one of the main components of Essential nutrient for growth and development of the plant for plants to produce their food, supplying adequate N fertilizer could leads to increase both aboveground biomass and straw yield. This may be due to the increase in physiological or physical growth contributes to the total above ground biomass production for 92 Kg ha^{-1} nitrogen fertilizer rate treatment, which has a direct relation with growth and development.

Moreover, the interaction effect of straw yield of Food barley was very highly significantly ($p<0.001$) influenced due to combined effect of different food barley varieties and different nitrogen fertilizer rates (Table 10 and Appendix Table 11). The maximum straw yield (1.07 Kg ha^{-1}) was obtained from Adoshe variety with combination of 92 Kg N ha^{-1} while the minimum number (0.35 Kg ha^{-1}) of straw yield was obtained from Adoshe variety with 23 Kg N ha^{-1} rates. An increasing rate of nitrogen from 23 to 92 Kg ha^{-1} increased straw yield by 67%. Statistically, straw yield of Abdene and Adoshe varieties combined with 92 Kg N ha^{-1} rate showed the same (Table 10). This may be the contribution of N fertilizer, as the treatments that received N responded more straw yield compared with zero or less N received treatment.

Many researchers such as Kedir & Ashenafi, Zelalem, and Ketema & Mulatu have reported similar results in barley straw yield production. The current result is in line with the finding of Shafi who reported that straw yield of barley affected by different N levels. In consistent with this result Biruk and Demelash reported that considerable difference in straw yield was attained between barley varieties and nitrogen rates. Similarly, the rate of fertilizer application was significantly affected straw yield of wheat. According to Abebe, straw yield increased with increasing the fertilizer rates, where by the lowest and nitrogen increases vegetative growth of plants, especially at higher doses. Besides, the significant increase in plant height, spike length and number of fertile tillers by N rate contributed to the significant increase in straw yield. Bereket, also reported that wheat straw yield increased with N rates.

Harvest index: Analysis of variance revealed that, harvest index was not significantly affected by main effect of nitrogen fertilizer rates and Food barley varieties. Moreover, the interaction effect of nitrogen fertilizer rates and varieties was not significant on the harvest index (Appendix Table 12).

Partial budget analysis of barely yield production

The market price of food barley grain was 17.00 Eth-birr Kg^{-1} and a price for Urea was 14.10 Eth-birr Kg^{-1}. While the cost of other production practices like cost of labor, seed and weeding were assumed to remain the same or insignificant among the treatments. Partial budget analysis of the combination of nitrogen levels with different barley varieties was presented in Table 11. Partial budget analysis was done using procedure described by CIMMYT Economics Program recommendations, which stated that application of fertilizer with the marginal rate of return above the minimum level (100%) is economical.

Information on costs and benefits of treatments is a prerequisite for adoption of technical innovation for farmers. The results in this study indicated that the application of N fertilizer rate along with food barley varieties resulted in higher net benefits than the unfertilized/low N fertilizer level treated treatments (Table 11). As a result, the partial budget analysis revealed maximum net benefit of Birr Birr 99350.00 ha^{-1} with an acceptable marginal rate of returns (MRR) of 3348.23% with the treatment Adoshe variety with combination of 92 Kg N ha^{-1} (Table 11). However, the lowest net benefit of (Birr 55225.00 ha^{-1}) was recorded from Robera barley variety treated with 23 Kg ha^{-1} nitrogen fertilizer rate (Table 11). Therefore, Production of Adoshe variety with combination of 92 Kg N ha^{-1} was economical, and uncertainly recommended for production of food barley in the study area and other areas with similar agro-ecological condition.

CONCLUSION

Barley is the most important staple food crop in the study area. However large numbers of farmers are not using improved technologies such as, improved variety and fertilizer. It has been selected as one of the target crops in the strategic goal of attaining national food self- sufficiency, income generation, poverty alleviation and achieving socio-economic growth of the county. In Kofele district, barley is a major crop produced by small holder farmers. However, its production and productivity is low due to the use of inappropriate nitrogen fertilizer rate and local low yielding varieties in the study area. This indicates that the need to conduct research and determine the optimum nitrogen rate for maximum productivity of food barley crop. Therefore, this study was conducted at Kofele District, West Arsi Zone, Oromiya region to investigate response of food barley varieties to rates of nitrogen fertilizer with the objectives of to evaluate the effects of mineral nitrogen fertilizer rates on growth, yield and yield components of food barley varieties and, to determine economic optimum rates of nitrogen fertilizer for the productivity of the crop.

The experimental design of the trial was Randomized complete block design in factorial arrangement with three replications, in which nitrogen fertilizer rates were used as the one factor and three barley varieties were used as another factor. The treatments are the combinations of three food barley varieties, namely Adoshe, Robera and Abdene and four levels of N (23 Kg N/ha (50 Kg urea), 46 Kg N/ha (100 Kg urea), 69 Kg N/ha (150 Kg urea) and 92 Kg N/ha (200 Kg urea). Crop phonological, growth and yield parameters such as day to heading, days to physiological maturity, plant height, spike length, lodging percentage, number of total tillers per m^2, number of fertile tillers per m^2, number of kernels per spike,1000 seed weight, straw yield, biomass yields and grain yields and harvest index were tested.

The result of this study revealed that the phonological, growth and yield trait parameters were positively responded to barley vanities and nitrogen fertilization. The study revealed that nitrogen fertilization with 92 Kg ha^{-1} nitrogen fertilizer rate improved barley yield than the rest nitrogen fertilizer rates. Moreover, barley variety Adoshe was more superior to the other varieties on most of the phonological, growth, yield and yield components of barley.

The different barley varieties and nitrogen fertilizer has shown a highly significant ($p<0.01$) influence on maize yield production. On the other hand, interaction effect of barley varieties and nitrogen fertilizer didn't show significant variation maize yield production. The highest aboveground biomass and grain yield of maize obtained at 92 Kg ha^{-1} nitrogen fertilizer rate lead to an improvement of 25% and 23.7% than the 23 Kg ha-1 nitrogen fertilizer rate, respectively. Yield parameters like straw yield and seed weight were significantly affected in main effects and significantly affected in the interaction effect also. The maximum straw yield and 1000-seed weight due to 92 Kg ha^{-1} nitrogen fertilizer rate was 40.47% and 10.0% higher than that observed under 23 Kg ha^{-1} nitrogen fertilizer rate, respectively. Moreover, the analysis of variance also revealed that barley varieties have shown a highly significant ($p<0.01$) influence on maize yield production. The highest aboveground biomass, grain yield, straw yield and seed weight of maize obtained at Adoshe barley variety lead to an improvement of 25.5%, 26%, 40.47% and 38% over the Robera barley variety, respectively. The maximum and minimum interaction mean values of grain yield were observed from Adoshe barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate (6.01 tone /ha) and Robera barley variety treated with23 Kg ha^{-1} nitrogen fertilizer rate (3.29 tone/ha), respectively. The highest interaction mean values of aboveground biomass, straw yield and seed weight of barley obtained at Adoshe barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate followed by Abdene Adoshe barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate.

Growth and phonological parameters of barley significantly affected due to different barley varieties and nitrogen fertilizer. Moreover, the interaction effect of different barley varieties and nitrogen fertilizer show significant variation except day to heading and number of tillers per meter square area. Nitrogen fertilization with 92 Kg ha^{-1} nitrogen fertilizer rate leads to an improvement of day to heading, day to physiological maturity, plant height, spike length and number of tillers per meter square area by 6.26%, 9%, 17.67%, and 25.25% and 21.06% than 23 Kg ha^{-1} nitrogen fertilizer rate, respectively. In addition to the main effects, the highest interaction means values of day to heading, day to physiological maturity, plant height, spike length and number of tillers per meter square area of barley obtained at Adoshe barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate followed by Abdene Adoshe barley variety treated with 92 Kg ha^{-1} nitrogen fertilizer rate.

The partial budget analysis revealed maximum net benefit of Birr Birr 99350.00 ha^{-1} with an acceptable marginal rate of returns (MRR) of 3348.23% with the treatment Adoshe variety with combination of 92 Kg N ha^{-1}. However, the lowest net benefit of (Birr 55225.00 ha^{-1}) was recorded from Robera barley variety treated with 23 Kg ha^{-1} nitrogen fertilizer rate. Therefore, Production of Adoshe variety with combination of 92 Kg N ha^{-1} was economical and uncertainly recommended for production of food barley in the study area and other areas with similar agro-ecological condition.

RECOMMENDATIONS

- Based on the findings obtained from one cropping season, the following recommendations are made:
- Production of Adoshe variety with combination of 92 Kg N ha^{-1} was economical, and uncertainly recommended for production of food barley in the study area and other areas with similar agro-ecological condition.
- This experiment was conducted at a given site in one season. Therefore, conducting the same experiment for one or more seasons, and initiating similar experiments with different environmental conditions with the inclusion of more nitrogen rates and varieties with consideration of the economic evaluation, under diverse management practices is recommended for the validity of this finding.

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