

Effects of Fertilizer Level on Yield and Yield Components of Different Food Barley Varieties at Arsi Zone, Ethiopia

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Abstract
A field experiment was conducted at Lemu-bilbilo wereda, Arsi Zone, Ethiopia, from June to December 2017/18 cropping season, with the aim of evaluating the optimal rate of fertilizers rate for maximal production of food barley varieties on two farmer's site. Four levels fertilizer (RNP (100 kg / ha urea + 150 kg / ha DAP) (73N, 69 P2O5), 150%RNP, 200%RNP and RNPS (100 kg / ha) (19 N 38 P2O5 + 7S) and three food barley varieties (HB42, HB1307 and EH1493) were tested in Randomized complete Block Design replicate three times. The main effects of fertilizer rate on spike length, grain per spike and biomass yield showed significant ($P< 0.05$) variation. The use of 200%RNP resulted in highest (8.6 cm) spike length, (49.8) grain per spike and (7149.2 kg ha^{-1}) biomass yield. The interaction effect of fertilizer level and food barley varieties showed significant ($P<0.01$) variation on grain yield , hectolitre weight and thousand kernel weight. The highest (3345.8 kg ha^{-1}) grain yield was obtained from the combination of HB1307 food barley variety with 200%RNP fertilizer level, followed (2964.5 kg ha^{-1}) grain yield was recorded fromHB1307 variety at fertilization of 150%RNP,while the lowest(1860 kg ha^{-1}) grain yield was recorded from HB42 variety at a RNP fertilizer level. Likewise the highest (60.5 gm) thousand kernel weight and (71.6 kg hL^{-1}) hectolitre weight was recorded from HB42 food barley variety fertilized with RNP and from variety EH1493 with 200%RNP fertilizer respectively. Therefor the most cost-effective variety and fertilizer level for farmers with low cost of production and higher benefits were identified to be the variety HB1307 at the fertilizer level of 150%RNP as first option for the study area and similar agro ecological conditions.
Keywords: food barley, fertilizer rate, variety, grain yield
DOI: 10.7176/JBAH/12-15-03
Publication date: August 31st 2022

1. Introduction

Agriculture is the backbone of the Ethiopian economy. The majority of the Ethiopians are farmers but they have not yet secured food at large. Among crop diversity barley is the forth in the world in terms of area and production. Many countries grow barley as a commercial crop. Globally European Union, Russia, Canada, USA and Argentina are the top five largest world barley producers (CSA, 2019 and USDA, 2017).

When we come to Africa, Ethiopia is the second largest producer of barley next to Morocco. It accounts 5.6 percent of the total cereal production in the country (FAO, 2014, Shahidur *et al.,* 2015). In Ethiopia barley is the fifth important cereal crop next to teff, maize, sorghum and wheat with a domestic production with total area coverage of 959,273.36 hectares and total annual production of about 2.03 million tons in main season, the mean barley productivity was 2.1 tons ha^{-1} (CSA, 2019).

Barley can grow in varied environmental condition with the altitude range from 1,500 to 3,500 masl but predominantly grown from 2000 to 3000 masl (Birhane. L, 1993).

It is the fourth most cultivated crop of the world (Giraldo.P *et al*., 2019). Barley including both food and malt barley species is cultivated in Ethiopia. Ethiopia produces mostly food barley, with its share estimated to be 90% while that of malt barley having a share of 10% (Alemu. D. *et al*, 2015). Barley grain in Ethiopia is mostly used as feed for animals, malt and food for human consumption, and sold for cash. Traditionally barley is used for making local recipes and drinks and other types of food. Its straw is a good source of animal feed (Yosef G.H, *et al*, 2011).

Despite, barley can grow with in a wide environmental condition ,but its production is stil below the national average level () .The major constraint that reduced yield production of food barley in Ethiopia are soil nutrient degradation, Acidity, lack of improved varieties, continuous cropping, high soil erosion and low insect pest management.. Soils in the highlands of Ethiopia usually have low levels of essential plant nutrients, low availability of nitrogen and it is the major constraint to cereal crop production (Taye et al., 2002, Assefa et al. 2017). Among plant nutrient nitrogen (N) and phosphorus (P) are the most essential macro nutrient that govern food barley production in southeaster part of Ethiopia (ATA, 2016), while the amendment external impute to maintain soil fertility and increase food barley production is too low.The optimum supply of N is very crucial due to its influence on yield, kernel protein content and malting quality (Spaner et al., 2001). The low N also produced low yield and low kernel properties such as lower seed size and plumpness, which translate into lower amounts of carbohydrate (MAGB, 2018).

Moreover, recently acquired soil inventory data revealed that the deficiencies of most of nutrients such as, nitrogen (86%), phosphorus (99%), sulfur (92%), are widespread in Ethiopian soils and similarly in study area (Ethio-SIS, 2016). However, information on the application of rate NPS and nitrogen, especially for barley, was not determined for the study area. Therefore, this particular experiment was designed to investigate the effects of NPS and nitrogen fertilizers on yield and yield components of food barley (*Hordeum vulgare* L.) at West Aresi Zone of Ethiopia with the objectives of evaluate the response of different food barley varieties to the application of Urea and NPS fertilizer rates.

2. Material and Methods

2.1. Description of the study area

The field experiment was conducted during the main cropping season of 2017/18 at Lemu Bilbilo wereda Arsi Zone. The study site is Located from 07° 30‟ 37" N - 39° 11‟ 31‟‟‟E and from 7° 37‟ 19" N -39° 23‟ 40‟‟‟E with altitude range 2400- 2780 m.a.s.l. It receives mean annual rainfall of 951.5 mm, with minimum and maximum temperatures of 4.05 and 19.88°C, respectively. The dominant soil type of experimental area is luvisoil and slightly acidic (pH = 6).

2.2. Treatment and Experimental Deign

A factorial combination of four levels fertilizer rate (RNP, 150%, 200%RNP and RNPS) and three food barley varieties (HB42, EH1493 and HB1307) laid out in randomized complete block design and replicated three times. The gross and net plot area was 7.8 m^2 and 6 m^2 respectively. The land was ploughed using oxen and plots was level manually Malt barely varieties was sown at the recommended rate of 125 kg ha^{-1} and planted in rows by using a manual row marker. Proper hoeing and weeding of the experimental fields were carried out uniformly as per research recommendations.

2.3. Agronomic data collection

2.3.1. Spike Length (Cm)

It was measured from five randomly selected spikes per net plot at physiological maturity and the mean value of five plants was taken as length of spikes.

2.3.2. Number of grains per Spike

It was taken five times from five randomly selected spikes per net plot at harvest and counts them. Finally, the mean value of five plants was taken as number of kernels per spike.

2.3.3. Plant Height (cm)

It was recorded by measuring the plants from the surface of the soil to the tip of the spike own at physiological maturity and the average was calculated.

2.3.4. Number of Spikes 0.5 m

Number of spikes was recorded five times from the middle row of at harvest and was averaged to per 0.5 m length basis. This was done manually by trained workers in order to measure the plant stand percent in each of the plots. It was counted randomly from the selected row spikes within the harvestable area.

2.3.5. Bio Mass Yield (kg ha^{-1})

Harvesting was done by hand using sickles. The Bio Mass Yield was recorded from net plot area after sun drying to a constant weight. Plants from each net plot area were manually harvested and sun dried in the open air. Dried plants were weighed to determine the biomass yield on plot basis and converted into hectare basis to determine total biomass yield per hectare.

2.3.6. Grain Yield (kg ha^{-1})

The grain yield was measured by taking the weight of the grains threshed from the net plot area of each plot and converted to kilograms per hectare after adjusting the grain moisture content to 12.5%.

2.3.7. Harvest Index (%)

Harvest index values of each treatment were computed as the percent ratio of grain yield to the total biomass yield per plant from the respective treatments and expressed in percentile terms by using the formula of Donald as, HI = Grain yield ha^{-1} / biological yield ha^{-1} x 100.

2.4. Grain Quality

2.4.1. Thousand Kernels Weight (gm)

The thousand kernels weight (TKW) was determined by counting the grains by using an electronic counter and weighing 1000 kernels sampled from the net plot using a sensitive balance of precision + 0.001g. The thousand kernels weight was recorded after the grain was adjusted to 12.5% moisture content.

2.4.2. Hecto Litter Weight (Kg hl^{-1})

The hectolitre weight (HLW) was determined by measuring 1000 ml kernel and weighing with the sensitive balance and then changed to kg/ litter in order to measure the density of the grains powdering or milling capacity.

2.5. Data Analysis

The data was subjected to analysis of variance (ANOVA) following the standard procedure for factorial arrangement in Randomized complete block design. Varieties and fertilizer interaction were performed using PROC GLM Procedure of SAS software version 9.2. Mean separation was employed following the significance of mean squares using Least significant difference (LSD) at 5% level of significance.

3. Result and Discussion

3.1. Food barley agronomic parameter and yield components

The major agronomic parameters such as plant height, number of grains per spike, spike per 0.5 m, spike length, biomass yield, thousand grains weight, hector litter weight and harvest index were undermine for this study.

3.2. Growth parameters of Food barley

3.2.1. Plant Height (cm)

The analysis result shows that a significant difference ($p < 0.05$) on the plant height was observed among the tested food barley varieties, but fertilizer rate and the interaction of varieties and fertilizer rates didn't show significant variation (table 1).The longest (122.7 cm) plant height was observed from HB42 variety, while the shortest plant height (110.9cm) was recorded from the variety EH1493 (table 1).Mean variation among varieties in plant height were observed due to the attributed to difference in their genetic combination with environmental condition, which were suitable for variety HB42. The result was in line with the finding of El-banna *et al* (2011) who elaborated that there was variation in plant height among varieties of barley and wheat.

3.2.2. Spike Length (cm)

The analysis result of variance reveals that spike length (cm) had significant ($P < 0.05$) variation among varieties and fertilizer rate, but hadn't significance due to interaction effect on both main factors (table 1). Mean variation among food barley varieties might be the combined effect of genetic variation and environmental conditions. In this case different scientist elaborated there research output among them Otteso B.N. *et al*.,(2008) who stated that a genotypes respond variation to spike length for different variety of wheat and barley. The characteristics of Different varieties have its own different genetic potential regarding to spike length was presented by Khan *et al*., (2001).

Statically significant variation was observed on spike length among the tested fertilizer rate in the study area. The longest spike length was recorded from the fertilization of 200%RNP, while the remaining three fertilizer rate were produce comparatively short and statically insignificant spike length each other. In agreement with this result Biruk .G and Demelash .K (2016), Aghdam and Samadiyan (2014), Laghari *et al.,* (2010) who stated that spike length of wheat and barley crop became higher at the higher doses of nitrogen.

3.2.3. Number of spikes per 0.5 m

The analysis of variance shows that number of spike per 0.5 m was significant ($P< 0.05$) variation on the main effect of varieties, while fertilizer rate and interaction effect was not significant difference on number of spikes per 0.5m (table 1).The maximum (38.6) number of spike per 0.5 m was obtained from the variety HB1307, which was found to be significant with variety HB42 but, statically not significant difference with variety.

Table 1. The effects of fertilizers and varieties on plant height, spike length and number of spikes per 0.5 m of food barley averaged over sites.

	Tested parameters		
Treatments	Plant height (cm)	Spike length (cm)	Number of spike per 0.5m
Varieties			
HB42	122.7a	7.8a	30.1b
HB1307	113.6b	7.3b	38.6a
EH1493	110.9b	8.1a	37.7a
LSD (0.05%)	6.5	0.4	5.1
Fertilizer rate			
RNP	115.1	7.3b	34.8
150%RNP	116.7	7.4b	35.8
200%RNP	116.6	8.6a	37.1
RNPS	114.5	7.5b	34.3
LSD (0.05%)	Ns	0.5	Ns
CV	**9.9**	**9.8**	**14.6**

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of significance, NS: Not significant

3.3. Yield and yield components of food barley

3.3.1. Number of grains per spike

The analysis result of variance reveals that number of grains per spike had significant ($p<0.05$) variation among varieties and fertilizer level, but hadn't any significance due to interaction effect on both main factors. The highest (49.8) thousand kernel weigh was obtained from a fertilization of highest, 200% RNP fertilizer rate, While the lowest (39.1) was recorded from the RNP fertilizer application (figure 1).Number of grains per spike, which was recorded from 200% RNP was statically not significant with the value, that obtained from 150% RNP and RNPS, but it showed significant difference form the value that obtained with application of RNP. The present research result is similarly with the finding of Shafi *et al*., (2011) reported that nitrogen applied at the rate of 60 kg ha-1 resulted in maximum number of grains spike^{-1}. Schulthess *et al.,* (1997) also reported a higher response of number of grains per spike to nitrogen application. Moreover, Tilahun *et al.,* (1996a) reported the existence of greater variation in grains per spike between the highest and the lowest level of application.

On the other hand a significant difference was observed among the tested food barley varieties. Among the tested varieties the highest (48.1) and the lowest (40.6) number of seed per spike was recorded from EH1493 and HB42 food barley variety respectively (figure 1). The result that was obtained from HB1307 was statically similar with the value of the two other varieties. But variety EH1493 and HB42 were statically different with each other. This variation of number of grains per spike might be comes from genotypic variation of food barley. In line with this result Adane (2015), reported genotypic differences of barley in spike that in turn resulted in higher numbers of grains per spike.

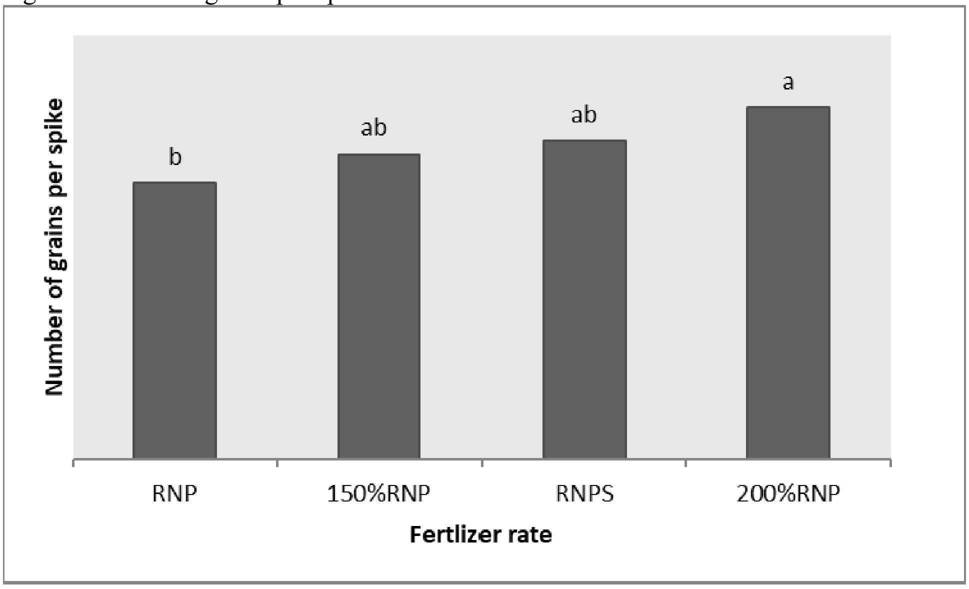

Figure 1.Effect of fertilizer level on number of grains per spike average over site

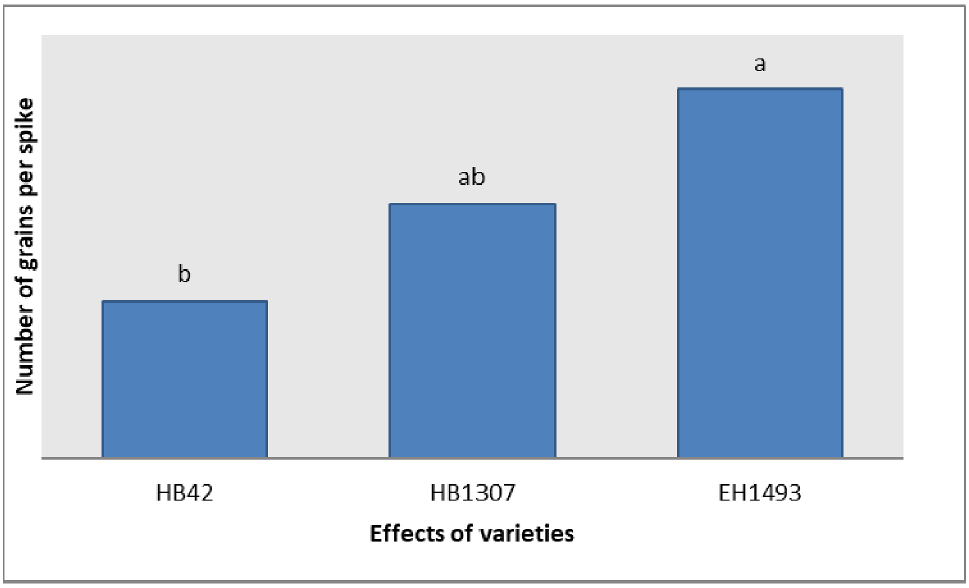

Figure 2. Effect of varieties on number of grain per spike average over site

3.3.2. Grain yield (kg ha^{-1})

The analysis of variance revealed that the interaction effect of varieties and fertilizer level had significant (P<0.01) different on grain yield as shown in (figure 3).The highest (3345.8 kg ha^{-1}) grain yield was recorded from HB1307 food barley variety at a fertilization of 200%RNP, followed by the grain yield 3`(2964.8 kg ha^{-1}) was recorded from HB1307 variety at a fertilization of 150%RNP and the lowest (1860 kg ha^{-1}) grain yield was obtained from a combination of RNP fertilizer level with HB42 food barley variety(figure 3).The result of grain yield that obtained from this study is in line with the finding of Bereket *et al*. (2014) who elaborated that increasing nitrogen fertilizer rate consequently increased grain yield of bead wheat and barley. Moreover, Pandy *et al.* (2001) and Singh *et al*. (2002) indicated that application of 150 kg N/ha gave the highest grain yield The present finding was supported by many scientists (Yohannes E. (2014), Pržulj, N. and Momcilovic, V. (2011), Minale L., Alemayehu A. and Tilahun T. (2005) who indicated that significant increases in grain yields of bread wheat with increasing application levels of fertilizer.In most the time some varieties showed better performance in grain yield might be due to the highest response of varieties to nitrogen and nitrogen use efficiency Derebe *et al.,* (2018).

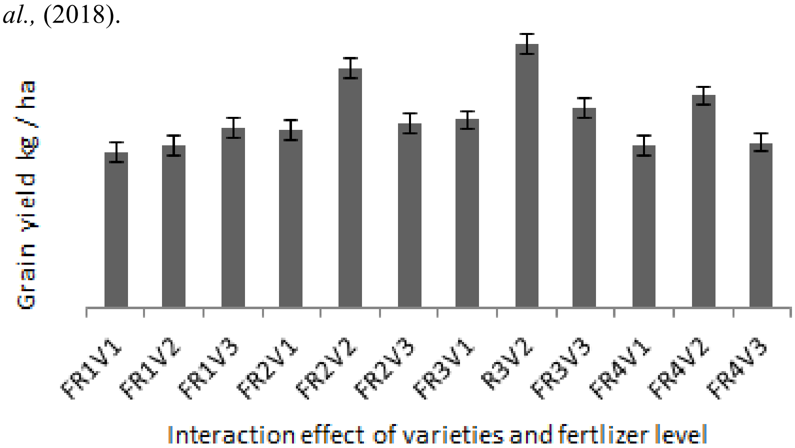

Figure 3.Interaction effect of varieties and fertilizer level on grain yield average over site

3.3.3. Biomass yield (kg ha^{-1})A

The analysis of variance revealed that the main effects of varieties and fertilizer rate had significant different on biomass yield, while the interaction effect was not significant (Table 2). Statics shows that significant variation was observed among fertilizer rates, but the highest (7149.2 kg ha^{-1}) and the lowest (5367.3 kg ha^{-1}) biomass yield was recorded from 200%RNP and RNP respectively. Increase in straw yield in response to application of fertilizer rates might be due to the enhanced, uptake resulting in induction of vigorous vegetative growth with more leaf area leading to higher photosynthesis and more dry matter accumulation. In line with the research result Amsa*l et al*., (2000) who elaborated that increased nitrogen fertilizer level significantly enhanced the straw yield of wheat and barley, since nitrogen (N) usually promotes the vegetative growth of plants. Similar with the present finding Noori *et al*., (2014) and Wakene *et al*., (2014), who stated that the highest total biomass at the highest phosphorus (P) level, used and the lowest biological yield is obtained from the control treatment.

3.3.4 Harvest Index (%)

The harvest index had a correlation with the grain yield and the aboveground biomass yield in that the highest harvest index was the result of a higher grain yield and the lowest harvest index was mainly due to a higher plant height, which increased the biomass yield extremely, and not to the grain yield which led to a decrease in harvest led index. The analysis of varience showed that the main effects of food barley varieties had significant ($P<$ 0.05) difference on harvest index, but main effect of fertilizer level and interaction of both factors had not significant (Table 2). The highest (41.1%) harvest index was obtained from HB1307 food barley variety. The harvest index (39.3%) of EH1493 variety was statically similar with the harvest index of HB42, which was (34.4 %).The current result of harvest index are agree with those of Abebe Megersa *et al*., (2020) and Abiot M., (2017) who elaborated that the higher the harvest index value, the greater the physiological potential of the culture to convert dry matter into grain yield.

Table 2. The effects of fertilizers and varieties on grain yield, biomass yield and harvesting index of food barley averaged over sites.

Treatments	By (kg ha^{-1})	HI (%)
Fertilizer		
RNP	5367.3b	40.80
150%RNP	5757.1b	38.77
200%RNP	7149.2a	36.3
RNPS	5380.2b	37.20
LSD (0.05%)	1111.4	Ns
Varieties		
HB42	5722.5b	34.4b
HB1307	6764.1a	41.1a
EH1493	5415.5b	39.3ab
LSD (0.05%)	962.4	5.1
CV (%)	10.17	13.29

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of significance, NS: Not significant

3.4. Grain Quality Parameters

3.4.1. Hectolitre weight (kg hL^{-1})

The analysis of variance showed that the interaction effect of varieties and fertilizer rate had significant effect ($P<0.01$) on hectolitre weight. The highest (71.6 kg hL^{-1}) was obtained from the variety EH1493 at the fertilizer rate of 200%RNP followed by (70.8 kg hL^{-1}) hectolitre weight was obtained from the variety EH1493 at the fertilizer rate of 150% RNP and the lowest (56.3 kg hL^{-1}) hectolitre weight was obtained from the variety HB42 at fertilizer rate of 150%RNP (Table 3). Variety EH1493 was relatively produced higher hectolitre weight at highest level of fertilizer, while variety HB42 and HB1307 had no uniformity through fertilizer level. This might be due to the genetic make-up of Eh1493 food barley variety that increases hectolitre weight with increasing fertilizer level at a maximum level. Similar result was obtained by (Tayyar, 2010) who elaborated that hectolitre weight of the varieties was significantly influenced by genotype which means a group of cultivars having the same genetic composition. The present result was also in line with Biruk and Demelash (2016) who stated that at favourable environmental condition hectolitre weight is slightly increase with nitrogen level. Rick *et al*., (2014) reported that the acceptable hectolitre weight for barley were in the range 66.1- 72.8 kg. Thus the current results exhibited acceptable hectolitre weight in all varieties and fertilizer level except hectolitre weight that produced from the combination of HB42 with 150% RNP and RNPS fertilizer levels (Table 3).

3.4.2. Thousand Kernel weight (gm)

The analysis of variance showed that the interaction effect of varieties and fertilizer rates had significant effect ($P<0.001$) on thousand kernel weight. The highest (57.03 gm) thousand kernel weight was observed from the variety (HB42) at the fertilizer rate of Recommended rate of NP followed by the thousand kernel weight (49.23) was recorded from the variety (HB42) at the fertilizer rate of recommended rate of NPS and the lowest thousand kernel weight (36.33) was obtained from the variety (EH1493) at a fertilizer rate of 200%recommended rate of NP (Table 3.). This might be due to the suitable genetic behaviour of HB42 food barley variety with the environmental factors which may led to an increased in photosynthesis process and accumulation of carbohydrates in grain to produce heavy grains and consequently increased grains weight per spike. Similarly, Rashid and Khan (2008); and Yetsedaw *et al.,* (2013) elaborated that variation of thousand grain weight as a function of barely genotype. Thousand seed of barley weights had a linear and negative response to N fertilizer rates as you see in table 3. Thousand seed of malt barley weight should be >45 g for 2-rowed barley and > 42 g for 6-rowed barley (Anonymous, 2012).

Table 3. The effects of fertilizers and varieties on hectolitre weight and thousand kernel weight, of food barley averaged over sites**.**

Treatment		Parameters	
Varities	Fertlizer rate	HLW(kg/hL)	TKW(gm)
HB42	RNP	62.4cd	60.5a
	150%RNP	56.3e	50.5bc
	200%RNP	67.5bc	52.3bc
	RNPS	58.1de	52.2b
HB1307	RNP	61.3cde	46.1d
	150%RNP	62.9cd	47.4d
	200%RNP	64.3c	45.2d
	RNPS	64.8c	48.9cd
EH1493	RNP	66.5bc	40.4e
	150%RNP	70.8ab	42.1e
	200%RNP	71.6a	39.3e
	RNPS	62.7cd	41.7e
	LSD (0.05%)	5.71	2.85
	CV (%)	7.75	6.38

Means followed by the same letter(s) within a column are not significantly different from each other at 5% level of significance, NS: Not significant

4. Summary and Conclusion

Filed experiment was conducted during the main cropping season of 2017/18 at two different farmer sites of Arsi Zone, Ethiopia with the objective of *evaluating the optimal rate of fertilizers rate for maximal production of food barley varieties*. Data on phonological growth, yield and yield components as well as quality parameters of food barley varieties were also collected and analyzed.

Based on the present finding, among the four fertilizer level the use of 200%RNP and 150% RNP for HB1307 food barley variety was superior in most of agronomic traits. The interaction of fertilizer level and food barley varieties show the most economically and profitable grain yield 2964.5 kg ha^{-1} and 3345.8 kg ha^{-1} was achieved with fertilization of 150%RNP and 200%RNP respectively.

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