academicresearchJournals

Vol. 8(6), pp. 609-618, August 2020
DOI: 10.14662/ARJASR2020.565

ISSN: 2360-7874
http://www.academicresearchjournals.org/ARJASR/Index.htm

Academic Research Journal of Agricultural Science and Research

Full Length Research

Effect of Blended NPS Fertilizer Levels and Row Spacing on Yield Components and Yield of Food Barley (*Hordeum Vulgare* L.) at High Land of Guji Zone, Southern Ethiopia.

Yared Tesfaye*, Seyoum Alemu, Kabna Asefa, Girma Teshome and, Obsa Chimdesa

Oromia Agricultural Research Institute (OARI), Bore Agricultural Research Center, P O Box 21, Bore, Ethiopia.
Corresponding author's Email: yaredtesfa1990@gmail.com

Accepted 30 August 2020

Barely (Hordeum Vulgare L.) is one of the most important food crops produced in the world in general and in specific in Ethiopia. Even though it is such an important cereal crops in Ethiopia, it is giving low yield due to many production constraints such as lack of improved varieties, poor agronomic practice (inappropriate fertilizer rate and row spacing), diseases, weeds and low soil fertility in Ethiopia in general and in Guji zone in particular. Therefore, field experiment was conducted during the 2016-2017 main cropping season at Bore and Ana sora to assess the effect of NPS rate and row spacing on yield components and yield of barley; and to determine appropriate NPS rates and row spacing for barley. The experiment was laid out RCBD in a factorial arrangement with three replications using a barley variety known as 'HB-1307' as a test crop. The treatments consisted of five levels of NPS rate (0, 30, 60 and 120 kg ha^{-1}) and four levels of row spacing (15, 20, 25 and 30 cm) consisting a total of 20 treatments. Analysis of the results revealed that days to 50% heading, days to 90% maturity, spike length and number of tiller per plant were significantly ($P<0.05$) affected by the interaction of NPS x location well as the interaction of spacing x location. Similarly the interaction of the three factors (NPS x Spacing x location) were significantly ($P<0.05$) affected grain yield and thousand kernel weight of barley. The maximum grain yield (3618kg/ha) and the highest kernels weight (53.47g) was recorded at combined application of 120 kg/ha NPS and 20 cm spacing at Bore and 120kg/ha NPS and 25cm spacing at Ana sora respectively. But the interaction effect of NPS x Spacing x location, NPS x location, Spacing x location and the main effect of NPS, Spacing and location did not significantly affected plant height and number of productive tiller. The partial budget analysis revealed that combined applications of 120 kg NPS kg/ha and 20cm spacing gave the best economic benefit 18855.45 Birr ha^{-1} with MRR of 1071.9%. Therefore, on economic grounds application of NPS 120kg/ha with 20cm spacing would be best and economical and can be recommended for production of barley in the study area.

Keywords: Fertilizer, Interaction, Interaction effect, Main effect, Nutrient

Cite this article as: Yared T., Seyoum A., Kabna A., Girma T., Obsa C. (2020). Effect of Blended NPS Fertilizer Levels and Row Spacing on Yield Components and Yield of Food Barley (*Hordeum Vulgare* L.) at High Land of Guji Zone, Southern Ethiopia.. Acad. Res. J. Agri. Sci. Res. 8(6): 609-618

INTRODUCTION

Barely (*Hordeum Vulgare* L.) is one of the most important food crops produced in the world. It assumes the fourth position in total cereal production in the world after wheat, rice and maize. 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 (Edney and Tipples, 1997).

It is also one of the most important staple food crops produced in the highland areas of Ethiopia. Its grain is used for the preparation of different foodstuffs, such as *injera, kolo,* and local drinks, such as *tela, borde* and beer. The straw is used as animal feed, especially during the dry season.

Ethiopia is also considered to be the origin and center of diversity for barley. Besides its use as food, feed and beverage barely has many important features. It is adapted to wide environmental condition, matures soon and has high yield potential. (Hailu and Van Leur Joop, 1996).

Despite, the importance of barely and its many useful characteristics, 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 (ICARDA, 2008). Poor soil fertility and low pH are among the most important constraints that threaten barley production in Ethiopia. Since the major barley producing areas of the country are mainly located in the highlands, severe soil erosion and lack of appropriate soil conservation practices in the past have resulted in soils with low fertility and pH (Grando and McPherson, 2005). Particularly deficiency of nitrogen and phosphorus is the main factor that severely reduces the yield of barely. According to Desta Beyene (1987), although 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 places.

Even though several researches have been conducted on high land areas of Ethiopia, like Bale, Arsi, Gojam, and central part of the country, there are as yet much barley producing highland areas starving of new technology, including improved varieties and appropriate rate of fertilizer, among which highland area of Guji Zone is one. In this area barley is a staple food crop for large number of people. In Bore Woreda, from the total 16531.36 ha area of land under cultivation, barley covers 6568.79 ha which accounts 39.74% of the total. To feed this large number of people and ever increasing population, increasing crop productivity per unit area should be given due emphasis. According to some informal surveys and information from Bureau of Agriculture and Rural Development, the area was very far from research (Personal communication). There were no research conducted concerning fertilizers, spacing and other agronomic researches, breeding etc. As a result of this fact, the farmers rely on traditional practices and local cultivars. Most of the farmers in Guji highland particularly Ana sora and Bore do not use fertilizer and spacing; few others use very much below the recommended rate and sow broadcasting. Therefore, there is a need to study the effect of different NPS rates & row spacing on the yield components and yield of barely to determine biological and economic optimum NPS rate and row spacing for barley production at highlands of Guji zone.

OBJECTIVES

- To elucidate the effects of blended NPS fertilizer rates and row spacing on yield and yield components of barley at highlands of Guji zone southern Ethiopia.
- To assess the most economic benefits of NPS fertilizer application rate and row spacing for barley production at study areas.

MATERIALS AND METHODS

Description of Study Area

The experiment was conducted on Bore Agricultural Research Center experimental field at Songo Bericha kebele and Ana sora district Yirba Buliyo kebele on farmer field for two years 2016 and 2017 main cropping season. Bore and Ana sora districts are situated at a distance of about 383 km and 410 km from Addis Ababa in the Southern direction. It is found at longitude of 038^{o} 37' 54.1"E and latitude of 06o 1' 06.7"N. The altitude of the district ranges from 1450 to 2900 m.a.s.l (meters above sea level) with a rugged topography, and the altitude of the specific site is 2712 m.a.s.l.

The climatic condition of the area is a humid moisture condition, with a relatively longer growing season. According to climate data from National Meteorological Agency, Robe Branch Directorate (2008-2017), the area receives total annual rainfall of 1640.5 mm with a bimodal pattern that extends from April to November. The mean annual minimum and maximum temperatures are 9.58^{o}C and 18.6^{o}C at Bore and 9.74^{o}C and 21.41^{o}C at Ana sora districts. According to meteorological information recorded in the last ten years at the districts. The Bore district soil is clay loam in textural class and strongly acidic with pH value of 5.04 and Ana sora district soil is also clay loam in texture and moderately acid with 5.85 pH value (Table 1 and 2).

Soil Sampling and Analysis

The soil of the experimental site was analyzed before planting. The composite surface soil samples (0-30 cm depth) were collected from fourteen spot in a zigzag pattern before planting randomly from the experimental site using an auger throughout the experimental units two weeks before the field was ploughed for determination of selected physico-chemical properties of the soil. Then, the collected samples were air-dried at room temperature under shade and ground to pass through a 2 mm sieve, For determination of organic carbon (OC) and total nitrogen (N) the soil was ground to pass through a 1 mm sieve. The soil samples were analyzed for particle size distribution (soil texture), soil pH, cation exchange capacity (CEC) (Meq/100g soil), organic carbon (%), available sulfur (ppm), available phosphorus (ppm) and total nitrogen (%).

The pH of the soil was determined in 1:2.5 (weight/volume) soils to water dilution ratio using a glass electrode attached to digital pH meter (Page, 1982). Soil texture was determined by using Bouyoucos Hydrometer Method (Bouyoucos, 1962) following the textural triangle of (USDA, 1987) system as described by Rowell (1994). Soil organic carbon content was determined by using the Walkley and Black method (Walkley and Black, 1934) and soil organic matter content was calculated by multiplying the OC% by a factor 1.724. Total nitrogen of the soil was determined by ES ISO 11261: 2015 Kjeldhal Method (Jackson, 1958). The Available sulfur content in the soil was determined turbidimetrically using a spectrophotometer method (Singh *et al*., 1999). Available phosphorus was determined by Bray II methods (Bray and Kurtz, 1945). Cation Exchangeable Capacity (CEC) was determined by Ammonium Acetate Method (Taye *et al*., 2000).

Experimental Methods

The treatments consisted of five rates of blended NPS (0, 30, 60, 90, and 120 kg NPS ha^{-1}) and four planting space (15, 20, 20 and 30 cm). The experiment was laid out as a Randomized Complete Block Design (RCBD) in a 5 x 4 factorial arrangement and replicated three times. There were 20 treatment combinations, which were assigned to each block randomly. The total number of plots was 60 and each plot had a gross area of 7.2 m^2 with 2.4 m length and 3 m width. Each plot contained different rows number according to its spacing distance with Spacing of 1.5 m between blocks and 1 m between plots was used.

Data Collection and Analysis

All phonological, yield component and yield data collected were subjected to Analysis of Variance (ANOVA) using SAS (9.0) statistical software version 9.2. Mean separation was done using (LSD) test at 5% probability level.

RESULTS AND DISCUSSIONS

Soil Physico-Chemical Properties of the Experimental Site before planting

The laboratory results of the analysis of the selected physico-chemical properties of the soil before sowing is presented in Table 1 and 2. The analytical results of the experimental soil indicated that the soil textural class is clay loam with a particle size distribution of 42% clay, 28% silt and 30% sand at Bore and 36% clay, 30% silt and 34% sand at Ana sora respectively. Thus, the soil of experimental site is suitable for barley. FAO (2000) reported that the preferable pH ranges for most crops and productive soils are 4 to 8. Mengel and Kirkby (1996) reported optimum pH range of 4.1 to 7.4 for wheat production. Thus, the pH of the experimental soil was within the range in productive soils.

According to Tekalign (1991), the soil organic carbon content (3.47% and 4.76%) of the experimental site was rated high at both locations. The analysis further indicated that the soil has high total nitrogen (0.35% and 0.63%) at Bore and Ana Sora according to the rating of Tekalign (1991). The results of the analysis also indicated that the soil has medium available phosphorus content (12.93 and 12.84 mg/kg) at Bore and Ana Sora respectively. This is according to the rating of Cottenie (1980). The analysis for available sulfur also indicated that the experimental soil had values of 11.51 and 12.23 mg/kg which are low according to Ethiosis (2014) at both locatins. The CEC value of the soil sample is high (32.86 [Cmol (+) kg^{-1} soil] at Bore and also high (34.88 [Cmol (+) kg^{-1} soil]) at ana sora according to the rating of Landon (1991) which indicates that the soil has high capacity to hold exchangeable cations.

Table 1. Physical and chemical properties of the experimental site before-planting at Bore on-station during 2016 and 2017 main cropping season

Properties	Result	Rating	References
1. Physical properties (%)	Bore		-
Sand (%)	30		-
Silt (%)	42		-
Clay (%)	28		-
Textural Class	Clay loam		USDA, (1987)
2. Chemical Properties			-
pH (1: 2.5 H_2O)	5.04	Strongly Acidic	EthioSIS, (2014)
Organic Matter /OM/ (%)	5.98	High	Tekalign, (1991)
Organic Carbon /OC/ (%)	3.47	High	Tekalign, (1991)
Carbon Nitrogen ratio (C:N)	9.91	Very low	Newey, (2006)
CEC (meq/100 g soil)	32.86	High	Landon, (1991)
Total Nitrogen /TN/ (%)	0.35	High	Tekalign, (2014)
Available Phosphorus /P/ (ppm)	12.93	Medium	Cottenie, (1980)
Available Sulfur /S/ (ppm)	11.51	Low	EthioSIS, (2014)

Table 2. Physical and chemical properties of the experimental site before-planting at Ana sora on farmer field during 2016 and 2017 main cropping season

Properties	Result	Rating	References
1. Physical properties (%)	Ana sora		-
Sand (%)	34		-
Silt (%)	36		-
Clay (%)	30		-
Textural Class	Clay		(USDA,1987)
2. Chemical Properties			-
pH (1: 2.5 H_2O)	5.85	Moderately Acidic	EthioSIS, (2014)
Organic Matter /OM/ (%)	8.20	High	Tekalign, (1991)
Organic Carbon /OC/ (%)	4.76	High	Tekalign, (1991)
Carbon Nitrogen ratio (C:N)	7.56	Very low	Newey, (2006)
CEC (meq/100 g soil)	34.88	High	Landon, (1991)
Total Nitrogen /TN/ (%)	0.63	High	Tekalign, (2014)
Available Phosphorus /P/ (ppm)	12.84	Medium	Cottenie, (1980)
Available Sulfur /S/ (ppm)	12.23	Low	EthioSIS, (2014)

Phenological and Growth Parameters

Days to 50% heading

The analysis of variance revealed that the three-factor interactions of NPS x Row spacing x location as well as main effect of NPS, row spacing and location did not significantly ($P<0.05$) affect days to 50% heading of barley. The lack of significant effect on days to heading might be due to counteracting effects of P nutrition on N and S nutrition because N and S tends to increase vegetative growth, while P hastens it.

In line with this result Firehiwot, (2014) reported no significant result of NP fertilizer on days to 50% heading of bread wheat. Similarly Beena *et al.* (2012) also reported no significance effect of S application on days to flowering and physiological maturity among wheat varieties.

Days to 90% physiological maturity

The two-factor interaction of fertilizer rate x spacing and main effect of fertilizer rate and spacing did not significantly (P<0.05) affect days to physiological maturity. This might be due to use of similar variety.

Table 3. Mean pooled data analysis (2016-2017) results of interaction effect of blended NPS and row spacing on days to 50% heading and 90% days to maturity of barley.

Fertilizer rate(kg/ha)	Date to heading				Date to mature			
	Row spacing(cm)				Row spacing(cm)			
	15	20	25	30	15	20	25	30
0	76	76.5	77.5	77	127.8	129.1	130.8	125.5
30	75.5	75.67	74.83	75.17	122.2	124.5	121.1	121.1
60	75.67	74.67	74.67	75.33	120.8	119.2	125.6	121.6
90	74.33	75.33	74.67	75.67	123	121	121.9	125.8
120	74.67	74.17	74.67	74.83	124.7	121.4	121.2	122.4
Mean	75.23	75.27	75.27	75.60	123.70	123.04	124.12	123.28
LSD(0.05)	NS				NS			
CV (%)	7.9				10.3			

Plant height

The interaction of fertilizer rate x spacing x location, spacing x location, fertilizer x location and main effect of fertilizer rate, spacing and location did significantly (P<0.05) affect plant height. The result indicated that height of barley plants did not increased or decreased as NPS rate and spacing decreased or increased. This might be due to the fact that height of the crop is mainly controlled by the genetic makeup of a genotype.

Spike length

The two-factor interaction of fertilizer rate x spacing were highly significantly (P<0.01) affected spike length of barley the main effect of fertilizer rate and spacing significantly (P<0.05) affect spike length.

The longest spikes (7.071 cm) were obtained at the rate of 90 kg NPS ha^{-1} and 20cm spacing which was statically at par with other combination except control (0kg NPS ha^{-1}) whereas the shortest spikes were produced at the lowest rate/control (Table 4). This results was corroborated by that of Melkamu Hordofa Sigaye et al., (2019) who reported that highest spike length was recorded at highest application rates of blended fertilizer on food barley. This result agrees with the findings of Muluneh and Nebyou (2016) who reported the highest spike length (7.7cm) for wheat at the rate of 50/150 kg N/P_2O_5 ha^{-1}. Firehiwot (2014) also reported the maximum spike length (8.29 cm) at combined application of 64 kg P_2O_5 + 46 kg N ha^{-1}. Similarly, Iqbal *et al.* (2002) reported longer spikes in response to increased application of phosphorus.

Table 4. Mean pooled data analysis (2016-2017) results of interaction effect of blended NPS and row spacing on plant height and spike length of barley at Bore and Ana sora districts.

Fertilizer rates	Row spacing(cm)							
	Plant height				Spike length			
	15	20	25	30	15	20	25	30
0	111	110.9	107.1	110	4.135b	6.531a	6.524a	6.666a
30	108	113.9	112.3	108.8	6.81a	6.61a	6.767a	6.224a
60	110	109.8	109.2	113.8	6.667a	6.593a	6.385a	6.565a
90	108.7	114.2	105.7	111.8	6.417a	7.017a	6.451a	6.496a
120	114.1	111.8	108.7	106.7	6.365a	6.596a	6.506a	6.443a
Mean	110.36	112.12	108.6	110.22	5.96	6.60	6.55	6.61
LSD(0.05)	NS				0.90			
CV (%)	6.2				17.3			

Yield Component and Yield

Number of tillers per plant

The analyzed data revealed that main effect of fertilizer rate and spacing significantly ($P<0.05$) affected number of tillers per plant of barley. But the interaction of the the two factors (fertilizer rate x spacing) did not significantly ($P<0.05$) affect spike length.

Number of tiller per plant increased as spacing decreased even though statistically no difference between 20-30 kg/ha. This might be due to less competition at narrow spacing. The highest number tiller per plant (3.98) was recorded at 25cm whereas the minimum tiller (3.24) was 15cm spacing.

In other words, the tiller number per plant was increased significantly across the increased rates of NPS fertilizer (Table 5). The maximum number of tillers per plant (4.09) was produced by plants treated with 90kg NPS ha^{-1} whereas the minimum number of tillers per plant (3.26) was produced at the lower rates (0 kg NPS ha^{-1}). The improvement in total number of tillers with NPS application might be due to the role of P found in NPS in emerging radical and seminal roots during seedling establishment in barley (Cook and Veseth, 1991). Generally, number tillers per plant recorded over all the treated plots was significantly higher than the unfertilized plot/control

In agreement with this result, Iqbal *et al.,* (2010) reported significant effect of row spacing on on number of tiller and productive tiller of bread wheat. Likewise, Firehiwot (2014) reported higher tillers per plant (5.58) at combined application of 32 kg N and 46 kg P_2O_5 ha^{-1} in bread wheat. Similarly, Daniel *et al.* (1998) also reported enhanced number of tillers in wheat with increased rate of P application.

Number of productive tillers

The analyzed data revealed that main effect of fertilizer rate and spacing significantly ($P<0.05$) affected number of productive tillers per plant of barley. But the interaction of the two factors (fertilizer rate x spacing) did not significantly ($P<0.05$) affect spike length.

Number of tiller per plant increased as spacing decreased even though statistically no difference between 20 - 30kg/ha. This might be due to less competition at narrow spacing. The highest number tiller per plant (3.28) was recorded at 25cm whereas the minimum tiller (2.50) was 15cm spacing.

In other words, the tiller number per plant was increased significantly across the increased rates of NPS fertilizer (Table 5). The maximum number of tillers per plant (3.29) was produced by plants treated with 90kg NPS ha^{-1} whereas the minimum number of tillers per plant (2.59) was produced at the lower rates (0 kg NPS ha^{-1}). The improvement in total number of tillers with NPS application might be due to the role of P found in NPS in emerging radical and seminal roots during seedling establishment in barley (Cook and Veseth, 1991). The results were in agreement with that of Diriba Shiferaw G, *et al*., (2019) who reported that increasing in the number of effective tillers with Blended fertilization on bread wheat. The result also agree with the result obtained by Wakene *et al.,* (2014) and Prystupa *et al.,* (2004), who reported that number of productive tillers per plant was affected significantly by NP fertilizer application. Generally, number of productive tillers per plant recorded over all the treated plots was significantly higher than the unfertilized plot/control.

Table 5. Mean pooled data analysis (2016-2017) results of main effect of blended NPS and row spacing on number of tillers and productive per plant of barley

Row spacing(cm)	Number of tiller per plant	Number of productive tiller per plantpt
15	3.242 ^{b}	2.532 ^{b}
20	3.784 ^{a}	3.097 ^{a}
25	3.982 ^{a}	3.287 ^{a}
30	3.924 ^{a}	3.218 ^{a}

Table 5. continues

LSD(0.05)	1.03	0.99
Fertilizer rate (kg/ha)		
0	3.263 b	2.592 b
30	3.787 a	3.163 a
60	3.858 a	3.14 a
90	4.091 a	3.295 a
120	3.667 ab	2.977 ab
Mean	**3.73**	**3.03**
LSD(0.05)	**1.03**	**0.99**
CV (%)	**24.2**	**30.6**

Means with the same letter(s) in the columns and rows are not significantly different at 5% level of significance, CV (%) = Coefficient of variation, LSD= Least Significant Difference at 5% level

Thousand Kernels weight

The three-factor interaction of NPS rate x spacing were significantly (P<0.05) affected thousand kernel weight of barley. But the main effect of spacing, NPS rate and location did not significantly (P<0.05) affected thousand kernel weight of barley.

Increased rate of NPS and spacing increased thousand kernels weight of barley even though there was no consistency (Table 6). The highest thousand kernels weight (42.57 g) was recorded at combined application of 60 kg NPS ha^{-1} and 15cm spacing. On the other hand, the minimum thousand kernel weight (35.17 g) was observed at combined application of 90 kg NPS ha^{-1} and 25cm spacing. This might be due to the improvement of seed quality and size due to the interaction and synergic effect of the three nutrients. The effect of both NPS and row spacing on thousand seed weight might be attributed to the positive effect of NPS and row spacing on grain yields of plants. Similar result was reported by Mesfin Kassa Zemach Sorsa, (2015) on barley.

Table 6. Mean pooled data analysis (2016-2017) results of interaction effect of blended NPS and row spacing on thousand kernels weight (g) of barley.

Fertilizer rate (kg/ha)	Row spacing(cm)			
	15	**20**	**25**	**30**
0	38.28 b-f	39.31 a-e	40.51 a-d	38.61 a-f
30	39.71 a-e	38.89 a-f	37.45 c-f	36.75 def
60	42.57 a	37.81 c-f	38.31 b-f	40.27 a-e
90	42.11 ab	36.62 def	35.17 f	36.21 ef
120	37.58 c-f	40.29 a-e	36.98 c-f	40.88 abc
LSD(0.05)	12.72			
CV (%)	25.6			

Grain yield

The three-factor interaction of NPS rate x spacing x location highly significantly (P<0.01) affect grain yield of barley whereas the main effect of spacing and location significantly (P<0.05) affected grain yield of barley. But the main effect of seeding rate and NPS rate did not significantly (P<0.05) affected grain yield of barley.

Increasing the rates of NPS fertilizers and row spacing significantly increased grain yields even though there was no consistency. Thus, the highest grain yield (3618 kg ha^{-1}) was obtained at combined application of 120 kg NPS ha^{-1} + 20 cm spacing at Bore on station whereas the lowest grain yield (1938 kg ha^{-1}) was recorded at the combinations of 0 kg NPS + 25 cm spacing at Ana sora (Table 7). The highest grain yield at the highest NPS rate might have resulted from improved root growth and increased uptake of nutrients and better growth favored due to interaction/synergetic effect of the three nutrients which enhanced yield components and yield.

In line with the result of this study, Mesfin and Zemach (2015) reported that increasing NP rate increase grain yield of barley where the application of 69/30 NP ha^{-1} had 57.4% more grain yield than control. Iqbal et al (2010) also reported maximum yield at 22.5cm row spacing. Similarly, Dejene Kassahun Mengistu and Fetien Abay Abera, (2014) found that increasing NP rate increased grain yield of barley

Table 7. Mean pooled data analysis (2016-2017) results of interaction effect of blended NPS, row spacing and location on grain yields of barley

Location	Fertilizer rate (kg/ha)	Raw spacing(cm)			
		15	**20**	**25**	**30**
Bore	0	3026 $^{a-k}$	2921 $^{a-l}$	2405 $^{j-n}$	2856 $^{b-m}$
	30	3143 $^{a-i}$	3072 $^{a-j}$	2820 $^{c-m}$	3426 $^{a-d}$
	60	3085 $^{a-j}$	3007 $^{a-l}$	3204 $^{a-g}$	2966 $^{a-l}$
	90	3566 ^{ab}	3279 $^{a-f}$	3198 $^{a-g}$	3342 $^{a-e}$
	120	3166 $^{a-h}$	3618 ^{a}	2792 $^{d-m}$	3529 ^{abc}
Ana Sora	0	2701 $^{e-m}$	2762 $^{d-m}$	1937 ^{n}	2796 $^{d-m}$
	30	3100 $^{a-j}$	2865 $^{b-m}$	2787 $^{d-m}$	2578 $^{f-n}$
	60	2461 $^{h-n}$	2599 $^{f-n}$	2433 $^{i-n}$	2316 $^{k-n}$
	90	2600 $^{f-n}$	2149 ^{mn}	2704 $^{d-m}$	2498 $^{g-n}$
	120	2563 $^{f-n}$	2611 $^{f-n}$	2300 ^{lmn}	2768 $^{d-m}$
Mean		**2941.1**	**2888.3**	**2658**	**2907.5**
LSD(0.05)		**723.59**			
CV (%)		**22.3**			

Partial Budget Analysis

Analysis of the net benefits, total costs that vary and marginal rate of returns are presented in Table 10. Information on costs and benefits of treatments is a prerequisite for adoption of technical innovation by farmers. The studies assessed the economic benefits of the treatments to help develop recommendation from the agronomic data. This enhances selection of the right combination of resources by farmers in the study area. The results in this study indicated that the combined application of NPS and row spacing resulted in higher net benefits than the unfertilized/control treatments (Table 8).

As indicated in Table 10, the partial budget analysis showed that the highest net benefit (Birr 18855.45 ha^{-1}) was recorded at the rate of combined application of 120kg NPS + 20 cm followed by 90 kg NPS + 25cm (19668.26Birr ha^{-1}), and lowest was from control treatment. To use the marginal rate of return (MRR %) as basis of fertilizer recommendation, the minimum acceptable rate of return should be between 50 to 100% (CIMMYT, 1988). In this study application of 120kg NPS ha^{-1} and 20 cm gave the maximum economic benefit (18855.45 ha^{-}) with marginal rate of return (1071.9%). Therefore, on economic grounds, combined application of 120 kg NPS ha^{-1} and 20cm would be best and economical, and recommended for production of food barley in the study area and other areas with similar agro-ecological conditions.

Table 8. Partial budget and marginal rate of return analysis for response of bread wheat to NPS and N fertilizers.

Treatments		Adjusted grain yield down wards by 10% (kg ha^{-1})	Gross Benefit (Birr ha^{-1})	Total variable cost (Birr ha^{-1})	Net return (Birr ha^{-1})	MRR (%)
NPS (kg ha^{-1})	Row spacing (cm)					
0 (control)	15	2037.210	16297.68	0	16297.68	-
0	30	2543.518	20348.15	0	20348.15	-
0	25	2177.217	17417.74	0	17417.74	-
0	20	2287.092	18296.73	0	18296.73	485.73
30	15	2809.247	22473.98	860	21613.98	-
30	30	2702.003	21616.03	860	20756.03	-

Table 8. continues

30	20	2671.825	21374.60	860	20514.60	-
30	25	2523.098	20184.78	860	19324.78	-
60	15	2495.859	19966.87	1220	18746.87	-
60	30	2376.999	19015.99	1220	17795.99	-
60	25	2313.370	18506.96	1220	17286.96	-
60	20	2522.614	20180.91	1220	18960.91	560.95
90	15	2775.040	22200.32	1580	20620.32	-
90	20	2442.571	19540.57	1580	17960.57	-
90	30	2627.740	21021.92	1580	19441.92	-
90	25	2656.033	21248.26	1580	19668.26	278.74
120	15	2781.466	22251.73	1940	20311.73	-
120	30	2833.881	22671.05	1940	20731.05	-
120	25	2291.382	18331.06	1940	16391.06	-
120	20	2599.43	20795.45	1940	18855.45	1071.9

SUMMARY AND CONCLUSION

Barely (*Hordeum Vulgare* L.) is one of the most important food crops produced in the world. It assumes the fourth position in total cereal production in the world after wheat, rice and maize. 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 (Edney and Tipples, 1997). Therefore, field experiment was conducted during the 2016 and 2017 main cropping season at Bore Agricultural Research Center and Ana sora district to assess the effect of rates of blended NPS and row spacing on yield components and yield of barley; and to determine economically appropriate rates of blended NPS and row spacing for barley production.

The experiment was laid out as a Randomized Complete Block Design (RCBD) in a factorial arrangement with three replications using a wheat variety known as ‘HB-1307’ as a test crop. The treatments consisted of four levels of NPS (0, 30, 60, 90 and 120 kg NPS ha^{-1}) and four levels of row spacing (15, 20, 25 and 30 cm).

Analysis of the results revealed that days to 50% heading, days to 90% maturity, spike length and number of tiller per plant were significantly affected by the interaction of NPS x location well as the interaction of spacing x location. The maximum days to 50% heading (75.6, 76.75), days to 90% maturity (128.2, 130.3), spike length (7.143, 7.156) and number of tiller per plant (4.418, 4.428) were obtained at 30cm at Bore, 30cm at Ana sora, 20cm at Bore and at 25cm at Bore respectively while the minimum days to 50% heading (76.75), days to 90% maturity (130.3), spike length (7.156) and number of tiller per plant (4.428) were obtained at 0kg/ha at Bore, 90kg/ha at Ana sora, 90kg/ha at Bore and at 90kg/ha at Bore respectively.

Similarly the interaction of the three factors (NPS x Spacing x location) significantly affected grain yield and thousand kernels weight of barley. The maximum grain yield (3618kg/ha) and the highest kernels weight (53.47g) was recorded at combined application of 120kg/ha NPS and 20cm spacing at Bore. But the interaction effect of NPS x Spacing x location, NPS x location, Spacing x location and the main effect of NPS, Spacing and location did not significantly affected plant height and number of productive tiller.

The partial budget analysis revealed that combined applications of 120 kg NPS kg/ha and 20cm spacing gave the best economic benefit 18855.45Birr ha^{-1} with MRR of 1071.9%. Therefore, application of NPS 120kg/ha with 20cm spacing would be best and can be recommended for production of barley in the study area.

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