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Effects of Seed and N Rate on Grain Yield and Yield Components of Barley

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Abstract
A field experiment was conducted at Alicho District, Silti Zone, SNNPRS to evaluate the response of barely to seed rate and nitrogen fertilizer application since the response varies from location to location due to several factors. Thus, there is a need to determine seed rate and specific nitrogen fertilizer requirement of barely. The barley varieties (HB1370) were used as test crop and the experiment contained factorial combination of five levels of N (0, 23, 46, 69, 92kg ha-1) and was laid out in randomized complete block design with three replications. The results from this study indicated that seed rate showed no significant effect on total biomass and harvest index while the remaining traits were significant. All parameters except plant height were reduced due to 100kg ha^{-1} seed rate. All tested parameters were improved due to increasing nitrogen fertilizer levels. In general, grain yield tended to be higher under N 69 (4.90 t/ha) and 92kg ha-1 (5.29 t/ha) treatments with no significant difference. In contrast, the lowest grain yield (2.05 t/ha) was obtained from control treatment, maximum grain yield was obtained due to 92kg ha-1 followed by 69kg ha-1 with 80kg ha^{-1}. The future studies should articulate towards the studies involving more varieties and multi-location under diverse management practices such as research and farmer’s field’s conditions, which may facilitate finetuning of fertilizer recommendations.
Keywords: Seed rate, N rate, Barley, Grain yield

Introduction

Barley (*Hordeum vulgare* L.), a member of the grass family, is a major cereal grain. It was fourth both in terms of quantity produced and in area of cultivation of cereal crops in the world (FAO, 2009). Barley grain 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 is used for human food and it accounts for over 60% of the food for the inhabitants of the highlands (Alam *et al*, 2007)

The rest is used for local and industrial beverages. The straw is the second preferred animal feed next to teff straw. Stem stubs of barley are also used for roof thatching (Anonymous, 1996). 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 1.96t ha-1 (CSA, 2016). Where as the potential yield goes up to 6 t/ha on experimental plots (Habtamu *et al*, 2014) indicating a productivity gap of about 4 tones/ha. Filling this gap would make Ethiopia among the major barley producing countries. Several abiotic and biotic factors have contributed to this low productivity, such as poor crop management practices; the use of low yielding cultivars; the limited availability of the very few improved cultivars released; weeds, insects and diseases; and the inherently low yield potential of the prevalent local varieties (Woldeyesus and Chilot, 2002). This low productivity is mainly due to traditional methods of production and poor soil fertility. 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 (Grandson and Macpherson 2005).

Seed rate and fertilizers, particularly those containing nitrogen, are the major inputs affecting the yield and quality of barley (Alemu, 2001). Grandson and Macpherson, (2005) reported that soils in the highlands of Ethiopia usually have low levels of essential plant nutrients and low organic matter content especially low availability of nitrogen that has been demonstrated to be the major constraint to cereal production. Barley yields are low in the southern Ethiopia especially in alicho-wuriro districts. Therefore, determine optimum level of seed and N rate for maximum grain yield of barley is essential in order to understand and prepare optimum agronomic packages.

Material and methods

Description of the Study Site

This study was carried out at Allicho-woriro district, Silte zone, which is found in the Southern Nations Nationalities and Peoples Regional State, Ethiopia. The study area is located on latitude of 8^0 02 ' 36.1" N and longitude of 38^0 10’8" E, with an elevation of 2750 m.a.s.l. The area receives annual rainfall of 1150.6 mm and has average annual temperatures of 13.5°c

Treatment and experimental details

Treatments was comprised of two factors: namely three seed rate levels (60,80,100 kg/ha), and four levels of nitrogen (0, 23,46, 69 and 92 kgha-1) and barely varieties (HB-1307, and Shage). The treatments will be arranged in a RCB design with three replications. A plot size of 3m^2 with 20 cm spacing between rows and spacing of 1m between blocks and 0.5 m between plots were used. Nitrogen was applied in the form of urea, while P was applied in the form of triple supper phosphate. Nitrogen was applied in split, half during sowing and half at booting stage.

Data Collection and Analysis

The data were collected as plant height, spike length, number of fertile tillers per plots, thousand seed weight, and total above ground biomass.

Soil Sampling and Analysis

For soil analysis, before planting soil samples were randomly taken from the experimental site at a depth of 30cm using an auger and the samples were mixed thoroughly to produce one representative composite sample of 1kg.The soil samples were air-dried and ground to pass 2 and 0.5 mm (for total N) sieves. Then it was analyzed at the soil laboratory for soil texture, pH, OC,CEC, P, N, by following standard procedures for each parameter.

Statistical Analysis

The data collected on different parameters were statistically analyzed using PROC ANOVA function of SAS program. After performing ANOVA the differences between the treatment means were compared by LSD test at 5% level of significance.

Result and discussions

Soil texture was determined by hydrometer method (Bouyoucos, 1962). The soil pH was measured using a glass combination electrode pH meter with the electrode inserted in the filtered supernatant solution of a 1:2.5 soil to water suspension, whereas soil organic carbon was determined by dry combustion method using a LECO CR-12 carbon determinator (LECO instruments Ltd, Mississauga, ON l5T 2H7).

Total nitrogen of the soil was determined by wet acid Kjeldahl digestion method, and available P was determined using the standard Olsen extraction method (Olsen *et al*., 1954). the exchangeable base cations (K^+, Ca^+, Mg^+ and Na^+) were extracted with 1M ammonium acetate at soil pH 7.0 (Chapman, 1965). Cation exchange capacity of the soil was estimated by measuring the sum of exchangeable cations from the ammonium acetate extracted sample.

Analytical results of the composite surface soil indicated that the soil was sandy loam in texture and It was slightly acidic (pH 5.6) in reaction, low in total N (0.12%), organic carbon and available P. Total Nitrogen (TN %) is rated by Harlan *et al*. (1999) as very low (<0.1), low (0.1 to 0.15), medium (0.15 to 0.25), and high (> 0.25). The Netherlands commissioned by Ministry of Agriculture and Fisheries (1985) also reported soil total N (%) of > 0.300, 0.226-0.300, 0.126-0.225, 0.050-0.125 and < 0.050 as very high, high, medium, low and very low, respectively, and total C (%) of greater than 3.50, 2.51-3.5, 1.26-2.50, 0.60-1.25 and < 0.60 as very high, high, medium, low and very low, respectively. Moreover, Tekalign *et al*. (1991) classified soil N availability of < 0.05%, 0.05-0.12%, 0.12-0.25%, > 0.25% as very low, poor, moderate and high respectively.

Accordingly, considering the respective limits set by the Netherlands commissioned by the Ministry of Agriculture and fisheries (1985) and Tekalign *et al*. (1991), the total N and organic carbon contents of the soil were low. The reason for the low level of total N and organic carbon contents of the soil might be due to continuous removal of the crop residues and organic matter oxidation, which is aggravated by tillage activities (Wakene, 2001). which indicating nitrogen application is needed for optimum plant growth.

The nutrient class range identified by Olsen et al. (1954) rating, P (mg Kg-1) content is: (< 3) very low, (4 to 7) low, (8 to 11) medium, (>11) high. Thus, the experimental soil is medium in available P.

According to Landon (1991), topsoils having CEC > 40, 25-40, 15-25, 5-15 and < 5 cmol (+)/kg of soil are classified as very high, high, medium, low and very low respectively, in CEC. Accordingly, the soils of the study site have medium CEC.

Table 1. Selected physico-chemical properties of the experimental soil

Parameters	pH	TN (%)	OC (%)	available P (mg /kg soil)	CEC(cmol(+)/kg soil)
Value	5.6	0.12	0.85	8.67	23.25

Number of fertile tillers

ANOVA showed that both main effects of seed rate and N rate were significant effect on number of tillers of barely (Table 2). Maximum number of fertile tillers (2.84) was obtained in plots where 60 kg/ha was applied, and no significant with 80 kg/ha. While, statistically minimum number of fertile tillers (1.48) was obtained with 100 kg seed/ha (Table 3). In line with Turk, (2002) who reported that number of tillers increase with decreasing seed rate. This may be due to a better water, radiation and nitrogen use efficiency (Masle, 1985). Light acts as an early signal for cell division and determines higher leaf growth, which is correlated with the emission of new leaves and tillers (Skinner and Nelson, 1994; Skinner and Nelson, 1995). Also, it enables an increase in the plant green area, resulting in higher radiation capture ability (Whaley *et al*., 2000).

Table 2. Estimation of mean square for tested parameters of barley

Source	DF	NOFT	PH	SL	BM	GY	TSW	HI
Rep	2	0.269ns	27.269ns	0.338ns	3.557ns	2.980**	0.349ns	0.010**
Seed rate	2	7.209**	276.248**	7.629**	4.423ns	1.091*	5.454**	0.001ns
N rate	4	11.361**	126.105**	30.403**	48.929**	15.885**	9.335**	0.011**
Seed*N rate	8	0.534ns	10.613ns	1.168ns	1.811ns	0.780ns	0.406*	0.002ns
Error	28	0.592	21.918	0.998	1.882	0.429	0.175	0.002
CV		34.33	4.68	10.65	17.13	17.26	0.78	8.49

*, ** significant at 0.05 and 0.01 level respectively; ns= non-significant; DF = degree of freedom; NOT = number of fertile tillers; PH = plant height; SL = spike length; BM = biomass; GY = grain yield; TSW = thousand seed weight; HI = harvest index

In the main effect of N rate maximum number of fertile tillers was obtained with 92 kg/ha and no significant with 69 kg/ha. While statistically minimum number of fertile tillers (0.71) was obtained with control (Table 4). It agrees with the result obtained by Maqsood *et al* (1999) who reported that the increase in the number of fertile tillers with increasing nitrogen levels could be attributed to the well-accepted role of nitrogen in accelerating vegetative growth of plants. However, the interaction effects of seed and N rate hadn't significant effect on number of fertile tillers.

Table 3. Growth, yield and yield component response of barely to different seed rates

Seed rate	NOFT	PH(cm)	SL(cm)	BM(ton/ha)	GY(ton/ha)	TSW(g)	HI
60	2.84a	96.19b	9.64a	7.72a	3.68ab	53.49a	0.46911a
80	2.40a	99.13b	9.93a	8.63a	4.10a	53.55a	0.46537a
100	1.48b	104.64a	8.57b	7.65a	3.60b	52.47b	0.46429a
LSD(.05)	0.5754	3.5017	0.7472	1.026	0.4904	0.3128	0.0296

Plant height

Maximum plant height (104.64 cm) was obtained when seed was applied at 100 kg/ha (Table 3). These results, coincide with Sulieman (2010) who reported that increase in the seeding rate resulted in a slight increment in the heights of the plants. Minimum plant height (96.19 cm) was obtained in plots where 60 kg/ha was applied, and no significant with 80 kg/ha. Similarly, nitrogen levels affected the plant height significantly. The tallest plant height was recorded with 92 kg/ha nitrogen level followed by 69 kg/ha (Table 4). While the shortest plant height was recorded with no nitrogen application treatments (control). In line with this, Rashid et al (2007) indicated that plant height was linearly increased with increasing levels of N fertilization. It may be due to the effect of nitrogen which promotes vegetative growth. However, the interaction of seed and N rate hadn't significant effects on plant height of barley.

Spike length

ANOVA showed that both main effects of seed rate and N rate were significant effect on spike length of barely. However, their interactions were not significant effects (Table 2). Maximum height of spike (9.93cm) was recorded in 80 kg seed /ha though the differences were not significant with 60 kg/ha (Table 3). While, significantly minimum height was recorded with 100 kg/ha. In the main effects of Nitrogen levels the longest spike was obtained from 92 and 69 kg/ha treatments with no significance. In contrast, significantly shortest spike length was recorded with control treatments (Table 4). In line with Mohammadi and Samadiyan, (2014) who reported that nitrogen applications increases spike length of barley.

Biomass

Results of the ANOVA for biomass revealed that only main effects of nitrogen levels were significant (Table 2). Nitrogen level of 0 kg/ha recorded significantly lowest biomass than remaining doses while 92 kg/ha though at par with 69 kg nitrogen per hectare recorded the highest biomass over rest of the nitrogen levels (Table 4). Nitrogen increases vegetative growth of plants, especially at higher doses. Besides, the significant increase in number of tillers, plant height, spike length, and grain yield by N contributed for the significant increase in TBM. This is in agreement with Alam and Haider (2007) who indicated that increased nitrogen level increased total dry matter.

Table 4. Growth, yield and yield component response of barely to different seed rates

N rate	NOFT	PH(cm)	SL(cm)	BM(ton/ha)	GY(ton/ha)	TSW(g)	HI
0	0.71c	96.28c	7.47c	5.06c	2.05c	51.63d	0.40835b
23	1.71b	96.96c	7.96bc	6.56b	3.07b	52.80c	0.46723a
46	2.13b	98.87bc	8.86b	7.733b	3.68b	53.28b	0.47321a
69	3.47a	103.23ab	11.52a	10.18a	4.90a	53.96a	0.47896a
92	3.18a	104.60a	11.10a	10.49a	5.29a	54.17a	0.50354a
LSD(.05)	0.7428	4.5207	0.9647	1.3248	0.633	0.4039	0.0382

Grain yield

ANOVA showed that both main effects of seed rate and N rate were significant effect on grain yield of barely (Table 2). The highest grain yield was obtained from 80 kg/ha seed rate. While the lowest grain yield was obtained from 100 kg/ha seed rate (Table 3). The result was supported by Dofing and Knight (1992) who reported that reductions in barley grain weights have been associated with increasing seeding rates. Maximum grain yield was with 92 kg being at par with 69 kg nitrogen per hectare but significantly different with rest of the doses. Minimum weight of grain yield was obtained with 0 kg nitrogen per hectare which was significantly inferior to all the treatments (Table 4). The increase in yield was directly related to more number of fertile tillers, longer spikes and other yield attribute parameters. These results are in line with that reported by Turk, (2002), (Mohammadi and Samadiyan, 2014) and (Mesfin and Zemach, 2015).

Thousand seed weight

Maximum weight of this attribute (53.55 g) was obtained when seed was applied at 80 kg/ha, and no significant with 60 kg/ha. While, Minimum weight of thousand seed (52.47 g) was obtained in plots where 100 kg/ha was applied (Table 3). In line with Baloch *et al,* (2010) who reported that increasing seed rate decrease thousand seed weight of wheat. Similarly, N rate affected thousand seed weight of barley. Maximum weight of thousand seed (54.17g) was obtained when N level was applied at 92 kg/ha which was statistically at par to 69 kg/ha. Minimum weight of thousand seed (51.63) was obtained in plots where no nitrogen was applied (Table 4). Similar result was reported by Mesfin and Zemach, (2015). In addition, the interaction effects of seed and N rate had significant effect on thousand seed weight of barley. Heavier thousand seed weight was obtained from 80 kg/ha seed rate with 92 kg/ha nitrogen applications. While, minimum thousand seed weight was obtained from 100 kg seed /ha with 0 kg/ha nitrogen application.

Harvest index

Results of the ANOVA for harvest index revealed that only main effects of nitrogen levels were significant (Table 2). Maximum harvest index (0.50354) was obtained when N was applied at 92 kg/ha which was statistically at par to all treatments except 0 kg N per hectare which was gave the lowest value of harvest index (Table 4).

Economic analysis

To assess the costs and benefits associated with different treatments the partial budget technique as described by CIMMYT (1988) was be applied on the yield results. Economic analysis was done using the prevailing market prices for barley seed, N and its application costs at planting and for grain yields at the time the crop was harvested. All costs and benefits was calculate on hectare basis. The GFB (gross field benefit) ha-1, a product of a real price and yields of receiving from each plot for each treatment after adjusting the grain yield of barley downwards by 10% to represent the yield obtained by farmers. The highest net benefit (53430 ETB) was recorded from the seed and nitrogen dose of 80 and 92 kg/ha respectively followed by a plot received 80 kg/ha seed and 92 kg/ha N , while minimum net benefit obtained with 100 and 0 kg/ha (16830 ETB). The maximum MRR(%) (73.51) was recorded with 80 and 69 kg seed and N per hectare respectively (Table 5).

Table 5. Economics of barley as influenced by seed and nitrogen rates under rain fed conditions at Alicho-wuriro district.

Seed rate	N Rate	AGY (Qtl /ha)	GFB (ETB /ha)	TVC (ETB /ha)	NB (ETB/ ha)	MRR (%)
60	0	19.197	19197	828	18369	
80	0	19.197	19197	1104	18093	D
100	0	16.83	16830	1380	15450	D
60	23	25.83	25830	1762.5	24067.5	22.53
80	23	28.17	28170	2038.5	26131.5	7.46
60	46	34.65	34650	2297	32353	24.07
100	23	28.8	28800	2314.5	26485.5	D
80	46	31.05	31050	2573	28477	D
60	69	43.83	43830	2831.5	40998.5	48.44
100	46	33.57	33570	2849	30721	D
80	69	52.83	52830	3107.5	49722.5	73.51
60	92	42.03	42030	3366	38664	D
100	69	35.73	35730	3383.5	32346.5	D
80	92	53.43	53430	3642	49788	67.47
100	92	47.34	47340	3918	43422	D

AGY = adjusted grain yield; GFB = growth field benefit; TVC = total variable cost; NB = net benefit; MRR = marginal rate of return; D = dominated

Conclusion and recommendations

In this study maximum grain yield and yield components obtained when seed and N was applied at 80 and 92 kg/ha respectively. However, grain yield hadn't significant variation between 69 and 92 kg N/ha. Therefore, further increment of N beyond 69 kg/ha couldn't improve the grain yield of barley. Accordingly, partial budget analysis shows slightly higher net benefit was obtained from 80 and 92 kg/ha of seed and N respectively. But maximum marginal rate of return was obtained from 80 and 69 kg/ha of seed and N respectively. So, tentatively recommended seed and N rate for maximum grain yield of barley at alicho wuriro district are 80 and 69 kg/ha respectively. However, it needs conducting over seasons and locations for final recommendations.

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