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Response of Food Barley (*Hordeum Vulgare* L.) to Various Levels of P Fertilizer

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ABSTRACT

The experiment was conducted to study the effect of different P levels on barley at Gumer and Allicho-wuriro districts during 2016 cropping season. It was conducted in a complete randomized block design with five treatments which were replicated three times. These treatments were different doses of P, that is, 0, 10, 20, 30 and 40 kg/ha. Except days of heading and thousand seed weight all tested parameters were significantly higher at Gumer districts than at Allicho-wuriro. P application is directly related to days of heading, growth parameters, yield and yield components in barley. Results showed that application of different P levels gave varying yield. Lowest yield (1.2 ton/ha) was obtained with the application of 0 kg/ha and highest yield (5.47 ton/ha) was obtained with the application of 40 kg/ha followed by 30 kg/ha P (4.92ton/ha). It is concluded that the application of 30 kg/ha potassium gave highest marginal rate of return of barley and looks more remunerative in Gumer and Allicho-wuriro districts.

Keywords: *Phosphorus, barley, grain yield.*

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 (Edney and Tipples, 1997).

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 1.96t 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.

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 is used for human food and it accounts for over 60% of the food for the inhabitants of the highlands (Alam *et al*, 2007). Although, 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 (ICARDA, 2008). Among the most important constraints that threaten barley production in Ethiopia are poor soil fertility and low pH. 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).

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 much barley producing highland areas starving of new technology such as Siltie and Guraghe barley producing highlands. According to Desta Beyene (1987) 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.

Barley yields are low in Gumer and alicho-wuriro districts because most of the farmers in these areas do not use fertilizer and few others use very much below the recommended rate. Therefore, there is a need to study the effect of different P rates on the yield and yield components of barely to determine biological and economic optimum P rate for barley production at gumer and alicho-wuriro districts of southern Ethiopia.

Material and Methods

Description of the Experimental Site

The experiment was conducted during the 2016 main cropping season under rain-fed conditions at two locations (i.e. Gumer and Alicho-wuriro districts).

The experimental site of the Gumer district is situated at 7^0 56' 24" N latitude, 38^0 04' 40" E longitudes and at an altitude of 2890.2 meter above sea level. The seasonal rainfall during the experiment was 1350 mm. The mean maximum and minimum annual temperatures are 17.5^0c and 10.25^0c, respectively. The experimental soil test results from the laboratory revealed that the soil texture is loam with organic carbon content of 1%, total nitrogen content of 0.35%, available phosphorus content of 15.14 mg kg-1 soil, soil, CEC 23.25 (cmol(+)/kg soil) and pH of 6.5. The experimental site of Alicho-wuriro district is located at 8^0 02 ' 36.1" N latitude and 38^0 10' 8" E longitudes and at an altitude of 2750 meter above sea level. The area receives mean annual rainfall 1150.6 mm. The average temperature of the area is 13.5^0c. The soil texture of Alicho-wuriro is sandy loam with the organic carbon content of 0.85%, total nitrogen content of 0.12%, available phosphorus content of 8.67 mg kg-1 soil, CEC 23.25 (cmol(+)/kg soil) and pH of 5.6.

Table1. *Estimations of mean square of Phenological and growth parameters*

Source of variations	DF	DH	NOT	PH	SL
Rep	2	6.400ns	3.038**	6.588ns	0.310ns
Loc	1	1.200ns	0.979*	11.719*	75.00**
P rate	4	151.28**	28.535**	107.250**	25.227**
Loc*P rate	4	1.116ns	0.0049ns	0.0001ns	0.0001ns
Error	18	2.067	0.157	2.632	0.408
CV (%)		2.15	6.91	1.66	7.51

**, ** significant at 0.05 and 0.01 level respectively; ns= non-significant; DF = degree of freedom; DH = days of heading; NOT = number of tillers; PH = plant height and SL = spike length*

Table2. *Estimations of Mean square of yield and yield components of barley*

Source of variations	DF	BM	NSPS	TSW	GY	HI
Rep	2	1.902**	11.268**	1.899**	0.460*	0.0023ns
Loc	1	2.241**	33.075**	0.690ns	3.347**	0.0362**
P rate	4	71.79**	169.99**	6.283**	19.186**	0.013**
Loc*P rate	4	0.000ns	0.000ns	0.0623ns	0.0026ns	0.0022ns
Error	18	0.194	1.733	0.279	0.109	0.0025
CV (%)		5.77	2.81	0.992	9.65	11.49

**, ** significant at 0.05 and 0.01 level respectively; ns= non-significant; DF = degree of free dom; BM = biomass; NSPS = number of seed per spike; TSW = thousand seed weight; GY = grain yield and HI = harvest index*

Treatment and Experimental Details

The treatment consisted of five levels of phosphorus (0, 10, 20, 30 and 40 kg ha-1) and barely varieties HB-1307. 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 in split, half during sowing and half at booting stage., while P was applied in the form of triple supper phosphate only during sowing according to treatments.

Data Collection

The data were collected as days of heading, plant height, spike length, number of tillers per plants, number of seed per spike, total above ground biomass, grain yield, thousand seed weight and harvest index.

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.

RESULTS AND DISCUSSION

Phenological Parameter

Days to heading was not significantly affected by locations and location with P interaction effects (Table 1). Whereas increase in P application rate up to 30 kg/ha P led to a significant reduction in the number of days required to heading of barley. Maximum days of heading were recorded with 0 kg/ha P rate (control). While minimum days of heading were recorded with 40 kg/ha followed by 30 kg/ha P application with no significant difference (Table 4). This might be attributed to the role of P in plants, which is used in dry matter distribution that facilitates plant development. In addition, P is vital to plant growth and is found in every living plant cell. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, and nutrient movement within the plant. Ahn (1993) indicated that P is concentrated in the fast growing parts of the plant and, therefore, it hastens the maturing period of crops. Similar result was also reported by Ottman (2009) who reported that increase in P rate decreased time to heading, anthesis and maturity.

Table3. *The effects of locations on phenology and growth parameters of barley*

Loc	DH(days)	NOT	PH(cm)	SL(cm)
Gumer(1)	66.60a	5.92a	98.17a	8.99a
Alicho(2)	67.00a	5.55b	96.92b	7.99b
LSD (0.05)	1.10	0.30	1.24	0.49

Growth Parameters

The analysis of variance showed significant ($P < 0.05$) differences in number of tiller, plant height and spike length of barley due to locations and P levels (Table 1). However, there were no interaction effect on those parameters. Number of tiller was higher at Gumer compared to Alicho-wuriro (Table 3). Number of tiller was increased with increasing of P levels. The top two levels, 30 and 40 Kg P ha-1, were at par with each other but they were significantly different from the remaining treatments (Table 4). It agrees with the result obtained by Wakene *et al* (2014) who reported that number of productive tillers/plant was affected significantly by P fertilizer application. They indicated that highest number of tillers was recorded at P level of 46 Kg ha-1 which was not statistically different from P level of 69 Kg ha. These results also correspond to Sisie and Mirshekari (2011) who showed the increase of wheat tillers with the increase of P fertilizer until optimum rate. Similar results were also reported by Prystupa *et al* (2004) from their research on barley.

Table4. *The effects of locations on yield and yield components of barley*

Loc	BM (ton/ha)	NSPS	TSW (g)	GY (ton/ha)	HI
Gumer(1)	7.91a	47.86a	53.41a	3.77a	0.47a
Alicho(2)	7.37b	45.76b	53.11a	3.10b	0.39b
LSD (0.05)	0.34	1.01	0.4	0.25	0.04

Table5. *The effects of P levels on phenology and growth parameters of barley*

P levels	DH (days)	NOT	PH (cm)	SL (cm)
0	72.33a	2.75d	90.71c	5.63d
10	70.50b	4.61c	96.37b	7.08c
20	68.00c	5.65b	99.62a	9.33b
30	62.17d	7.71a	99.64a	10.17a
40	61.00d	7.96a	101.37a	10.27a
LSD (0.05)	1.74	0.48	1.97	0.77

Plant height was significantly affected by location and P levels. But their interaction effect was not significant. Plant height was taller in gumer than Allicho-wuriro (Table 3). Maximum plant height was obtained when P was applied at 40 kg/ha which was statistically at par to all treatments except 0 and 10 kg P per hectare. Minimum plant height was obtained in plots where no P was applied, and no significant with 10 kg/ha (Table 4). In line with Wakene *et al*

(2014) who reported that application of P slightly increased plant height. This result also In line with this, Rashid *et al* (2007) indicated that plant height was linearly increased with increasing levels of P fertilization. Similarly, Taye Bekele *et al* (1996) reported that the yield of barley increase with increasing P fertilizer application at many locations.

Gumer site produce taller spike than Allico-wuriro experimental site (Table 3). P dose of 0 kg/ha produced significantly shortest spike length than all other doses. Tallest spike was observed at 40 kg P per hectare yet the differences were remained on par with 30 kg/ha (Table 4). This could be due to the fact that phosphorus being essential constituent for sugar metabolism and energy storage of plant tissue (Kumar and Chandra, 2008).

Yield And Yield Components

The analysis of variance showed significant ($P < 0.05$) differences in biomass, number of seed per spike, grain yield and harvest index due to locations and P levels. However, there was no interaction effect on those attributes of barley (Table 2). Gumer site produce higher biomass than Allico-wuriro experimental site (Table 5). Biomass of barley significantly increased with increasing P levels. This trait was highest at 40 kg P application per hectare. While the lowest value of biomass was obtained at 0 kg P application per hectare (Table 6). Similar results were obtained by Noori *et al.* (2014) and by Wakene *et al.* (2014), who obtained the highest total biomass at the highest P level, used and the lowest biological yield in the control.

Table6. *The effects of P levels on yield and yield components of barley*

P levels	BM (ton/ha)	NSPS	TSW (g)	GY (ton/ha)	HI
0	3.23e	40.32d	51.61d	1.20e	0.36c
10	5.14d	42.28c	53.03c	2.24d	0.42bc
20	7.98c	47.88b	53.57bc	3.32c	0.44ab
30	10.46b	51.62a	53.87ab	4.92b	0.47ab
40	11.39a	51.95a	54.23a	5.47a	0.48a
LSD (0.05)	0.53	1.59	0.64	0.40	0.06

Table7. *Economics of barley as influenced by various P levels under rain fed conditions at Gumer and Alicho-wuriro district.*

P levels	AGY (kg/ha)	GB (ETB/ha)	TVC (ETB/ha)	NB (ETB/ha)	MRR (%)
0	1080	10800	0	10800	0
10	2016	20160	1000	19160	8.36
20	2988	29880	1600	19160	15.2
30	4428	44280	2200	42080	23
40	4923	49230	2800	46430	7.25

AGY = adjusted grain yield; GB = gross benefit; TVC = total variable cost; NB = net benefit and MRR = marginal rate of return

Significantly maximum number of seed per spike was obtained at Gumer compared to Allicho-wuriro experimental site (Table 5). Maximum number of seed per spike was obtained when P was applied at 40 kg/ha which was statistically at par to 30 kg P per hectare. Minimum number of seed per spike was obtained in plots where no P was applied (Table 6).

Thousand seed weight was not significantly affected due to locations. However it was affected by different levels of P fertilizer (Table 2). The heaviest thousand seed was obtained at 40 kg/ha as par as 30 kg/ha P application while significantly lightest thousand seed was obtained at 0 kg/ha P (Table 6).

Higher grain yield obtained from Gumer site compared to Allico-wuriro experimental site (Table 5).

Grain yield of barley significantly increased with increasing P levels. This trait was highest at 40 kg P application per hectare. While the lowest value of grain yield was obtained at 0 kg P application per hectare (Table 6). In line with Mesfin Kassa and Zemach Sors (2015) who reported that applications of P fertilizer significantly increase the grain yield of barley. This result was similar to that found previously by Turk *et al.* (2003) and recently by Naceur *et al.* (2017) for barley. This may be due to the fact that the important roles of phosphorus on photosynthesis, respiration and nutrient uptakes (Uchida, 2000).

Gumer site produce maximum value of harvest index than Allico-wuriro experimental site (Table 5). P dose of 0 kg/ha being at par with 10 kg/ha produced significantly lowest harvest index than all other doses. Highest harvest index was observed at 40 kg P per hectare yet the differences were remained on par with 30 and 20 kg/ha (Table 6).

Economic Analysis

To assess the costs and benefits associated with different treatments the partial budget technique as described by CIMMYT (1988) was applied on the yield results. Grain yields of receiving from each plot for each treatment was adjusting the grain yield of barley downwards by 10% to represent the yield obtained by farmers. It is evident from the data that maximum and minimum gross benefit recorded 49260 and 10800 ETB ha^{-1} from P level of 40 kg and 0 kg P per hectare respectively. Data indicates that the total cost of cultivation also followed the same trend. The highest net benefit 46430 ETB was recorded from the potassium dose of 40 kg/ha, while minimum net return obtained with 0 kg/ha 10800 ETB. The maximum marginal rate of return (23) was recorded with 30 kg P per hectare (Table 7).

Conclusion

Growth and yield performance of barley was high at Gumer compared to Allico-wuriro experimental site because the initial status of soil and environmental conditions are more favorable for barley production at Gumer experimental site. Significant response observed in growth, yield and yield components up to P application level of 30 kg/ha and marginal rate of return was also found maximum, so it is recommended that farmers should use 30 kg P per hectare in barley at Gumer and Allicho-wuriro barley producing highlands.

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