

Effect of Nitrogen and Phosphorus Fertilizer Rates on Yield and Yield Components of Barley (*Hordeum Vugarae* L.) Varieties at Damot Gale District, Wolaita Zone, Ethiopia

Mesfin Kassa¹, Zemach Sorsa²

¹Soil science, Wolaita Sodo University, College of Agriculture, Wolaita Sodo, Ethiopia

²Plant Breeding, Wolaita Sodo University, College of Agriculture, Wolaita Sodo, Ethiopia

Email address:

mesfine2004@gmail.com (M. Kassa), zemachsorsa@yahoo.com (Z. Sorsa)

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Abstract: A field experiment was conducted at Damot Gale District, Wolaita Zone, SNNPRS to evaluate the response of barely varieties to nitrogen and phosphorus fertilizer application since the response varies from location to location due to several factors. Thus, there is a need to determine specific nitrogen and phosphorus fertilizer requirement of specific variety. The barley varieties (HB1370 and Shage) were used as test crop and the experiment contained factorial combination of four levels of N/P (0/0, 23/10, 46/20, 69/30 kg ha⁻¹) and was laid out in randomized complete block design with three replications. The results from this study indicated that nitrogen and phosphorus fertilizer showed no significant effect on number of days to heading while number of fertile tillers, total biomass and yield were significantly increased by application of nitrogen and phosphorus. However, the effects of nitrogen and phosphorus were significant ($P < 0.05$) on plant height, spike length, number of seeds per spike and grain yield. In general, grain yield tended to be higher under NP 69/30 kg ha⁻¹ treatment (2.02t/ha). In contrast, the lowest grain yield (0.86t/ha) was obtained from 0/0 NP treatment, although the interaction effects of nitrogen and phosphorus were significant on treatments with varieties and balanced amount of nitrogen and phosphorus. The future studies should articulate towards the studies involving more varieties, multi-location and additional rates of nitrogen and phosphorus applications, under diverse management practices such as research and farmer's field's conditions, which may facilitate fine-tuning of fertilizer recommendations.

Keywords: Fertilizer, Phenology, Growth, Yield

1. Introduction

Barley (*Hordeum vulgare* L.) is cultivated in every region of Ethiopia implicating its wide ecological plasticity and physiological amplitude (Lakew *et al.*, 1996). Barley ranks fourth in worldwide production of all cereals (FAO, 2004). In Ethiopia, barley is ranked fifth of all cereals, based on area of production, but third based on yield per unit area (CSA, 2004). Within Ethiopia, the highest levels of barley consumption occur in highlands where it is widely cultivated, accounting for the bulk of the total crop harvest (Kiros, 1993). In Ethiopia, barley covers 10% of the land under crop cultivation with a yield of 1.2t ha⁻¹ (CACC, 2002), where as the potential yield goes up to 6 t/ha on experimental plots (Berhane Lakew, Habtamu *et al.*, 2014; Hailu Gebre and

Fekadu Alemayehu, 1996). Several a biotic 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 (Asfaw Negassa *et al.*, 1997; Hailu Gebre and Fekadu Alemayehu, 1996; ChilotYirga, Fekadu Alemayehu and Woldeyesus Sinebo, 1998; Woldeyesus Sinebo and Chilot Yirga, 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 (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, Wello, North Shewa and some parts of Arsi region have bimodal pattern of rainfall permitting production of barley twice a year both on summer and winter seasons (Alemayehu, 1994). The soils that are mostly under cereal cultivation in the study area are Nitisols and Vertisols (Solomon, 2006). Barley yields are increased also by phosphorus and potash fertilizers on some soils (Bulman and Smith, 1993). In addition to fertilizer rates, soil acidity also affects the productivity of the land by affecting availability of nutrients and hindering the activity of microorganisms. Also nitrogen is commonly the most limiting nutrient for crop production in the major world's agricultural areas and therefore adoption of good N management strategies often result in large economic benefits to farmers. Among the plant nutrients, nitrogen plays a very important role in crop productivity (Zapata & Cleenput, 1986; Ahmad, 1999; Miao *et al.*, 2006; Oikeh *et al.*, 2007; Assefa and Chekole, 2015; Worku *et al.*, 2007). Soil fertility is one of the major production constraints in the Southern region of Ethiopia (Getahun and Tenaw, 1990). The various factors accounting for the poor soil fertility include topography, soil erosion, deforestation, population pressure, and continuous cultivation without proper soil fertility maintenance (Tenaw, 1996). This area under barley cultivation is about 123000 ha and production is estimated to be about 150000 t, with a mean yield of 1.2 t/ha in the main cropping season (MOA, 2000). In the Wolaita zone, where the experiment was conducted, barley is the fourth most important cereal after maize, sorghum and tef in area coverage (BOA, 1998). Despite its importance and cultivation of the yield and productivity of barley in the country, Region and in the Wolaita zone have low yields compared with its potential. Among the major constraints on increased production of barley are poor soil fertility, limited supply of production inputs, low prices for the produce, and undeveloped markets (Hailu Gebre, 1978). Furthermore, phosphorus has a high nutritional value, with high concentrations of nitrogen, and potassium, while the contamination by heavy metals and other toxic substances are very low (Asghar *et al.*, 2006). There was no research conducted concerning fertilizers rates as a result of this fact, the farmers rely on traditional practices and local cultivars. Most of the farmers in experiment site do not use NP combination above the recommended rate. Therefore, there is a need to study the effect of different NP rates on the yield and yield components of barely with the following specific objectives:

- To examine the effect of NP fertilizer on yield and yield components of barley varieties.
- To evaluate barley varieties in the study area

2. Materials and Methods

2.1. Description of the Study Site

This study was carried out at Damote Gale, Wolaita zone, which is found in the Southern Nations Nationalities and Peoples Regional State. It is located 375 km south of Addis Ababa. The study area is located on latitude of 6° 55' 36.1" N and longitude of 37° 50' 12.1" E, with an elevation of 2110 m.a.s.l.

2.2. Treatments and Experimental Design

The treatments consisted of combination of four levels of phosphorus and nitrogen (0/0, 10/23, 20/46 and 30/69 kg/ha-1) and barely varieties (HB-1307, and Shage). The twenty four treatment combinations were replicated three times in factorial RCBD design. A plot size of 3m² 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 super phosphate. Nitrogen was applied in split, half during sowing and half at booting stage.

2.3. Data Collection and Analysis

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

2.4. 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. All samples were analyzed following standard laboratory procedures as outlined by Sahlemedhin and Taye (2000). Organic carbon and total N contents of the soil were determined following the wet combustion method of Walkley and Black, and wet digestion procedure of Kjeldahl method, respectively. The available P content of the soil was determined following Olsen method. Soil texture was analyzed by Bouyoucos hydrometer method. The cations exchange capacity (CEC) of the soil was determined following the 1N ammonium acetate (pH 7) method. Ca and Mg contents were measured by using EDTA titration, the pH (1:2.5 solid: liquid ratio) of the soils was measured in water using pH meter with glass-calomel combination electrode.

2.5. 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.

3. Result and Discussion

3.1. Physical and Chemical Properties of the Soil

Soil analysis before sowing showed that soil pH, available P, CEC and Total N found in the range of slightly acidic based on Herrera (2005) classification, however a result of some soil physical and chemical properties of the experimental site were showed that medium. The soil analysis result indicated that texture of the soil was clay loam and pH of the soil was 6.0 slightly acidic, this range is suitable for different crops have different requirements but the optimum pH range for barley is 6.0 - 7.0. Therefore, the pH of soil is suitable for barley (CLDB, 2001). Other soil chemical properties were total Nitrogen (TN %) is rated by Havlin et al. (1999) as very low (<0.1), low (0.1 to 0.15), medium (0.15 to 0.25), and high (> 0.25). According to Olsen et al. (1954) rating, P (mg Kg⁻¹) content is: (< 3) very low, (4 to 7) low, (8 to 11) medium, (>11) high. Then available P at the site was within medium and low respectively. It might be because of this that some growth and yield components responded better to P than to N. In line with this M. Osundwa et al. (2013) reported liming of acidic soils reduces the P sorption thus increasing its availabilities. However, over all residual soil P of the treatments were categorized under very low status

3.2. Effects of Nitrogen and Phosphorus Fertilizer Rates on Plant Growth and Yield Parameter

Plant height was significantly affected by different rates of NP application (Table 1.) In line with this, Rashid et al (2007) indicated that plant height was linearly increased with increasing levels of NP fertilization. The maximum plant height (86.02cm) was recorded from application of 69/30 kg NP ha⁻¹ and zero application of NP result the minimum plant height, which was significantly lower than the effect of other rates. Such increment of plant height along with increase of NP rate might be related to the effect of nitrogen which promotes vegetative growth as other growth factors are in conjunction with it. This result is in line with the report of Wakene et al. (2014) who stated that plant height of barely was increase with increasing rates of NP from 0/0 to 69/30 kg ha⁻¹. The experiment by Rashid et al. (2007) was conducted in arid zone which received 182 mm rain fall during the growing period. Most of the time, arid zone soils are salt affected soils in which nutrient availability is influenced and application of P slightly increased plant height. The maximum plant height of 83.1cm was recorded at the highest NP rates of 69/30 kg ha⁻¹ and the minimum plant height of 61.3cm was recorded in NP rates of 0/0 kg ha⁻¹. Similarly, Taye Bekele et al. (1996) and Woldeyesus Sinebo (2005) reported that the yield of barley increase with increasing N/P fertilizer application at many locations.

Interaction between varieties and Plant height was no significant (Table 1). Maximum days (100 days) were recorded from plants which received 0 kg N/P ha⁻¹. Similar results were reported by Kernich and Halloran (1996), who

observed that nitrogen fertilizer considerably influenced duration of the pre-anthesis period and spike in barley. The probable reason might be that optimum NP supply played an essential role in plant growth and development. Maqsood et al. (2001), Kenbaev & Sade (2002), Salwa et al. (2005), Soylu et al. (2005), Arif et al. (2006) and Pervez et al. (2009) reported significant increase in plant height of wheat with application of nitrogen. In case of NP levels, maximum no of tillers (51.9) was produced with the application of 69/30 kg NP ha⁻¹ when compared with other treatments (Table1). The probable reason might be that optimum nitrogen availability plays an essential role in plant growth whereas low or very high dose of nitrogen caused reduction in above ground vegetative growth of plant. Increase in the number of tillers of wheat due to N application was also reported by Rajput et al. (1993) and Ahmad (1999). Non significant (P<0.05) differences were observed in two varieties, spike length, grains spike⁻¹, 1000 grain weight, grain yield, straw yield, biological yield, harvest index, grain and straw N due to various levels of N and varieties (Table 2). Cantero et al., (1995), Le Gouis et al., (1999) and Oweis et al., (1999) observed similar results for grains spike⁻¹ in barley was significantly increased with increasing N fertilization as reported by Moselhy & Zahran (2002). They further revealed that application of nitrogen fertilizer significantly increased spike length, number of grains spike⁻¹, 1000 grain weight, grain yield and N uptake by the crop (Chaudhary & Mahmood, 1998; Bakhsh et al., 1999; Wakene et al., 2014; Tilahun et al., 2000)

Both N and P significantly influenced total biomass but their interaction effect was not significant (Table 1). The highest TBM of 3.9 t ha⁻¹ was recorded in the treatment which received 69/30 NP kg N ha⁻¹ though not significantly different to the TBM obtained from 0/0NP Kg N ha⁻¹ (2.4 t ha⁻¹) (Table 1). Nitrogen and phosphorus increases vegetative growth of plants, especially at higher doses. Besides, the significant increase in spike length, number of seeds per spike, number of fertile tillers, non fertile tillers and grain yield by NP contributed for the significant increase in TBM. This is in agreement with Alam and Haider (2006) who indicated that increased nitrogen level increased total dry matter irrespective of cultivars. The highest TBM of 3.91 t ha⁻¹ was obtained from the highest level (69/30 NP kg ha⁻¹) though not significantly different from 3.2 t ha⁻¹ obtained at 46/20 NP tha⁻¹. Other authors also reported similar results from researches conducted on wheat Alcoz et al. (1993); Tilahun Geleto et al. (1996) indicating that P significantly increased TBM. On the other hand, application of NP fertilizer as well as its interaction with varieties had non-significant effect on growth and yields components. It was increased with increasing application rates of NP up to 69/30 kg NP ha⁻¹. The minimum value (52.4 g) was obtained from application of zero NP (P < 0.05) (Table 1).

The effect of both nitrogen and phosphorus on thousand seed weight might be attributed to the positive effect of N and P on biomass production of plants. Analysis of variance showed that application of both nitrogen and phosphorus

fertilizer had significant ($p < 0.05$) interaction effect on total above ground dry mass (Table 1). Total above ground dry mass increased significantly when NP rates increased while combined with all rates of P but significant increase was observed when N rate increased from 0 kg ha⁻¹ to 69 kg ha⁻¹ with combination of P 0 to 30 kg ha⁻¹. Similarly, significant increment of total above ground dry mass was observed as application rates of P increased and combined with all rates of N. Number of tillers per plots were not significantly to NP rates. According to this experiment, NP did not significantly affect number of tillers and infertile tillers. Maqsood et al (1999) 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. But, according to this experiment, the contributions of NP were also very high, it agrees with the result obtained by Prystupa et al (2004), who reported that number of productive tillers/plant was affected significantly

by NP fertilizer application. The yield response of barley to NP application rates was determined for 2 years (2003–2004) in the Arjo, Gedo and Shambo highlands of Ethiopia. Results of the combined analysis of variance over 2 years showed that the mean grain yield of barley was not significantly affected by NP, nor by N×P interactions at Arjo, in which the application of 10/30 kg ha⁻¹ N/P resulted in the highest mean grain yield of barley (BARC, 2006). At Gedo, the grain yield of barley was significantly affected by N application, the application of 10 kg ha⁻¹ N resulted in a better grain yield (2469 kg ha⁻¹) than the control and other N rates. Nevertheless, the combined application of NP at a rate of 10/30 kg/ha resulted in the highest yield. At Shambo, the grain yield of barley was significantly ($P < 0.05$) affected by P application but not by N or N×P interactions. The application of 20/30 kg ha⁻¹ N/P doubled the barley grain yield compared with the unfertilized (BARC, 2006).

Table 1. Effect of NP fertilizer on barley yield and yield components in Damot Gela, 2014.

Treatments	Plant height (cm)	Spike length (cm)	No seed/spike	No of Infertile tillers	No of fertile tillers	Yield t/ha	Biomass t/ha	Days to heading	1000seed weight	Harvest index
0/0	61.3	6.3	36.3	34.5	253.6	0.86	2.4	65	52.4	9.3
23/10	69.6	6.3	37.8	31.5	241.1	0.106	2.6	60	53.2	13.0
46/20	74.8	6.3	39.5	12.6	300.6	1.77	3.2	52	54.1	14.2
69/30	83.1	6.6	42.6	15.8	338.0	2.02	3.9	55	54.8	15.5
LSD (0.05)	8.5	0.5	7.0	42.3	73.4	2.3	0.4	15.4	5.2	6.9
CV (%)	9.6	7.8	14.8	45.5	16.2	17.2	12.5	13.2	5.6	14.8

Table 2. Interaction effects on barely varieties in Damote Gela, 2014.

Varieties	Plant height (cm)	Spike length (cm)	No seed/spike	No of Infertile tillers	No of fertile tillers	Yield Qt/ha	Biomass t/ha	
HB-1307	71.0	6.5	37.3	17.3	275.5	22.2	2.9	NS
Shage	73.4	6.3	40.8	29.9	291.0	21.4	3.1	NS
LSD5%	5.8	0.4	4.9	29.9	51.9	0.6	0.3	

4. Conclusion

Nutrient application of plants can be varied from location to location depending on different factors such as soil and other agro-ecologies. For sustainable production of crops for a particular area, specific fertilizer recommendation is very crucial. For this reason a field experiment was conducted in Damot Gale District, Ethiopia in 2013/14. The soil was clay loam with pH of 6 (slightly acidic). This experiment was conducted to assess the effect of N and P on yield and yield components of barley. The treatments consisted of combination of four levels of phosphorus and nitrogen (0/0, 10/23, 20/46 and 30/69 kg ha⁻¹) and barely varieties (HB-1307, and Shage). The twenty four treatment combinations were replicated three times in factorial RCBD design. Many of the growth and development parameters observed responded to NP fertilization. Days to heading, number of fertile tillers and total biomass were non significantly influenced by NP application and also there is no interaction effect in varieties. Other parameters, such as, plant height,

number of fertile tillers, and TBM, were no significantly increased by NP rates. Therefore, N and P fertilizers are very important nutrients in limiting the growth and development of crops which has direct effect on productivity of the crops. The future studies should articulate towards and studies' involving more varieties, multi-location and additional rates of N and P application, under diverse management practices, which may facilitate fine-tuning of fertilizer recommendations.

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