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Nitrogen Response of Barley in Dolakha district, Nepal

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ABSTRACT

Barley is the fifth most important cereal crops of Nepal and serves as the staple food of high hill people.The low productivity of barley in Nepal is largely associated with improper nutrient management. A field experiment was conducted to study the response of six different nitrogen doses on barley variety 'Muktinath Jau' at Hill Crops Research Program (HCRP), Kabre, Dolakha during 2022 and 2023. The field experiment consists of six nitrogen levels (0, 30, 60, 75, 90 and 105 kg/ha) as treatments replicated four times and laid out in randomized complete block design. The results revealed that the plant height, days to maturity, number of tillers per m^2, spike length, grain yield, and straw yield were significantly influenced by nitrogen doses. The highest grain yield (2.85 t/ha) was produced at 90 kg N/ha and did not significantly differ with 75 kg N/ha and 105 kg N/ha. The results clearly indicated that 75 kg N/ha could be optimum in Kabre station of Dolakha district and in areas with similar soil types and climate of Nepal.

Keywords: Barley, Muktinath, Nitrogen, Optimum, Yield

सारांश

जौ नेपालको पाँचौं सबैभन्दा महत्त्वपूर्ण अन्नबाली हो र उच्च पहाडी मानिसहरूको मुख्य खानाको रूपमा काम गर्दछ। नेपालमा जौको कम उत्पादकत्व मुख्यतया अनुचित पोषकतत्व व्यवस्थापनसँग सम्बन्धित छ। २०२२ र २०२३ मा दोलखाको काब्रेस्थित पहाडी बाली अनुसन्धान कार्यक्रममा जौको प्रजाति मुक्तिनाथ जौमा नाइट्रोजन खाध्यतत्वहरूको प्रतिक्रिया अध्ययन गर्न प्रयोग गरिएको थियो। नाइट्रोजन स्तरहरू (०, ३०, ६०, ७५, ९० र १०५ किलोग्राम/हेक्टर) समावेश छन्, उपचारहरू चार पटक दोहोऱ्याइएको थियो र Randomized Complete Block Design मा राखिएको थियो। नतिजा अनुसार बिरुवाको उचाइ, परिपक्वताका दिनहरू, प्रति वर्ग मीटर टिलरहरूको संख्या, स्पाइक लम्बाइ, अन्न उत्पादन र नल उत्पादनमा नाइट्रोजन खुराकहरूले उल्लेखनीय रूपमा प्रभाव पारेको थियो। उच्चतम अन्न उत्पादन (२.८५ टन/हेक्टर) ९० किलोग्राम नाइट्रोजन/हेक्टरमा पाइयो र ७५ किलोग्राम नाइट्रोजन/हेक्टर र १०५ किलोग्राम नाइट्रोजन/हेक्टरसँग उल्लेखनीय रूपमा फरक थिएन। नतिजा अनुसार दोलखा जिल्लाको काब्रे केन्द्र र नेपालको समान माटो प्रकार र हावापानी भएका क्षेत्रहरूमा ७५ किलोग्राम नाइट्रोजन/हेक्टर प्रयोग गर्न उपयुक्त हुन्छ।

INTRODUCTION

Barley is the fifth most important cereal crops of Nepal and it is the staple food of high hill people. According to MoALD (2025), it is cultivated in 18599 hectares in Nepal and the total production is 24931 MT and yield is 1.34 t/ha. It provides food and nutrition security in high-hills of Nepal since it is grown under the harsh environmental conditions by marginalized farmers (Bajracharya et al 2012). It is grown from Terai up to an elevation of 4000m above mean sea level. It is a staple food of hills and high hills where the crop is cultivated in steep slopes and terraces. It has great potentiality in drought prone areas and for agro-based industries like beverages, noodles, bakery, baby foods and other non-alcoholic drinks.

Two-row barley (*H. disticum*) and six-row barley (*H. hexasticum*) are generally cultivated in Nepal (Pokharel et al 2022) Varieties include with husk and without (naked). Till date seven varieties (Solu Uwa -naked barley, Ketch, CI-10448, Galt, HBL-56, Bonus and Muktinath) of barley have been released in Nepal (HCRP 2024). Among them, Solu Uwa and Bonus got popularity in the farmers and newly released variety Muktinath also preferred by farmers but need to extend to farmers of remote areas. But the barley growing area and production is not increased as expected. One of the factors of the low productivity of barley in Nepal is associated with crop management practice particularly nutrient management. Among the nutrients, nitrogen is most important and shows frequent deficiency and reduces grain yield. Barley is sensitive to nitrogen and the effect of nitrogen is distinctly observed. Some study suggested that barley grain yield, protein content in grain and grain appearance are related to available nitrogen (Amanullah et al 2008b; Shafi et al 2011). However, excess level of nitrogen causes lodging, susceptible to diseases and insect, prolong flowering and maturity (Singh and Uttam 1992).

Barley is cultivated in diverse environment and geographical area. Location specific nutrient management is necessary to harness production potential. There is very limited study on nitrogen response to barley in Nepal. Therefore, this study was carried out to know the optimum nitrogen level in barley under loamy soil of mid hill, HCRP, Kabre, Dolakha.

MATERIALS AND METHODS

Climate

The experiments were conducted at HCRP, Kabre, Dolakha, Nepal during winter seasons of 2022 to 2023. Agro-climatically, this location represents mid hill region of Nepal and characterized by warm temperate climate with moderate rainfall. HCRP is located at 86°9‘E Longitude, 27°38‘N Latitude and with elevation of 1740 m above sea level. Based on many years data average annual rainfall was 2323 mm. Similarly average minimum temperature was 7.0°C and average maximum temperature 27.5°C. Generally, November and December fall under drought.

Soil

Initial experimental soil texture was loamy and soil pH was 5.07 (very acidic), soil organic matter content 2.49% (low), total nitrogen content 0.11% (Low), available phosphorus content 13.65 ppm (low) and exchangeable Potassium content 76.16 ppm (low). The total nitrogen was determined by Kjeldhal distillation unit (Bremner and Mulvaney 1982), available phosphorus (P) by modified Olsen‘s method (Olsen et al 1954) by using spectrophotometer and available potassium (K) by ammonium acetate method (Jackson 1967). Organic matter was determined by Walkely and Black method (Walkely and Black 1934), pH (1:1 soil: water suspensions) by Beckman Glass Electrode pH meter (Jackson 1973) and soil texture by hydrometer method (Bouyoucos 1927).

Experimental design

The field experiment consists of six N levels in treatments, replicated four times and laid out in randomized complete block design. The tested variety was Muktinath which is recently released variety for mid and high hill of Nepal. The experiment was conducted during 2022 and 2023. Six N levels treatments were 0

kg N/ha, 30 kg N/ha, 60 kg N/ha, 75 kg N/ha, 90 kg N/ha and 105 kg N/ha, respectively. Among the fertilizer P_2O_5 and K_2O, total dose of 30:30 P_2O_5:K_2O kg/ha and half dose of N applied at sowing time and remaining half dose applied in two splits doses, first at tillering stage and second split dose before heading stage. Sowing was done on November first week with the seed rate of 100 kg/ha and seeding was done continuously in rows with row to row distance of 25cm. Each plot size was 2.5 m X 3.0 m. Optimum plant population was maintained by thinning extra dense plants. Weeding was done at tillering stage. Irrigation was applied at particularly at maximum tillering stage and heading stage.

Observation and data analysis

Agronomic and morphological data such as plant height (cm), days to 50% heading, days to 75% maturity, tillers number/m^2, spike length (cm), spike number/m^2, thousand grains weight (g), grain yield adjusted at 13% moisture (t/ha), straw yield (t/ha) were recorded (HCRP 2024). Analysis of variance (ANOVA) was carried out to assess the treatment effects and mean comparisons among treatment means were estimated by the least significant difference (LSD) test at 5% levels of significance (Gomez and Gomez 1984). Agronomic nitrogen use efficiency (ANUE) was calculated by dividing the additional grain yield produced with total amount of N fertilizer applied. Partial factor productivity of nitrogen (PFPN) was calculated by dividing total amount of grain produced by total amount of N fertilizer applied (Moll et al 1982).

RESULTS

Effect of N doses on plant growth and phenology

There was no significant effect of nitrogen levels on days to heading but the days to maturity was significantly affected (**Table 1**). The longest maturity period (155 days) was recorded at 75 kg N/ha, however there was not clear trend seen. The plant height was significantly affected by nitrogen doses. The highest plant height was recorded at 90 kg N/ha and 105 kg N/ha. The shortest plant height was recorded on control (0 kg N/ha). Increased doses of N significantly increased plant height.

Effect of N doses on yield attributes and grain yield

Nitrogen doses significantly influenced on number of tillers/m^2, number of spikes/m^2, spike length and thousand grains weight (**Table 1**). The highest number of tillers/m^2 was recorded at 90 kg/N ha and was not significantly different from 105 kg N/ha. Increasing the doses of N had increased the number of tillers/m^2. The highest number of spikes/m^2 was recorded at 90 kg N/ha and was at par with 105 kg N/ha. The lowest number of spikes/m^2 was recorded on control. The longest spike length was measured at 90 kg N/ha. However, difference was only with control. Although thousand grains weight was affected by N doses but clear trend was not observed. The highest grain yield (2.856 t/ha) was measured with 90 kg N/ha and was not significantly different from 75 kg N/ha and 105 kg N/ha (**Table 2**). Muktinath variety of barley responded up to 75 kg N/ha for grain yield production. Similarly, the straw yield was significantly affected by N doses (**Table 2**). The highest straw yield (5.647 t/ha) was recorded at 90 kg N/ha and was not significantly different with 105 kg N/ha. The agronomic nitrogen use efficiency (ANUE) was highest at lower N dose i.e. 30 kg N/ha and rest of the treatment were not significantly different (**Table 2**). Similarly, the partial factor productivity of nitrogen (PFPN) was also highest at lower N dose i.e. 30 kg N/ha. With the increasing N doses, the PFPN followed the decreasing trend. However, at 60 kg N/ha and 75 kg N/ha, the PFPN was not significantly different. There was positive correlation between number of tillers and grain yield, spike length and grain yield, and straw yield and grain yield (**Figure 2a, 2b, 2c**). The response curve on N doses with grain yield showed that the maximum grain yield was obtained with 90 kg N/ha but was not significantly different with 75 kg N/ha (**Figure 2d**).

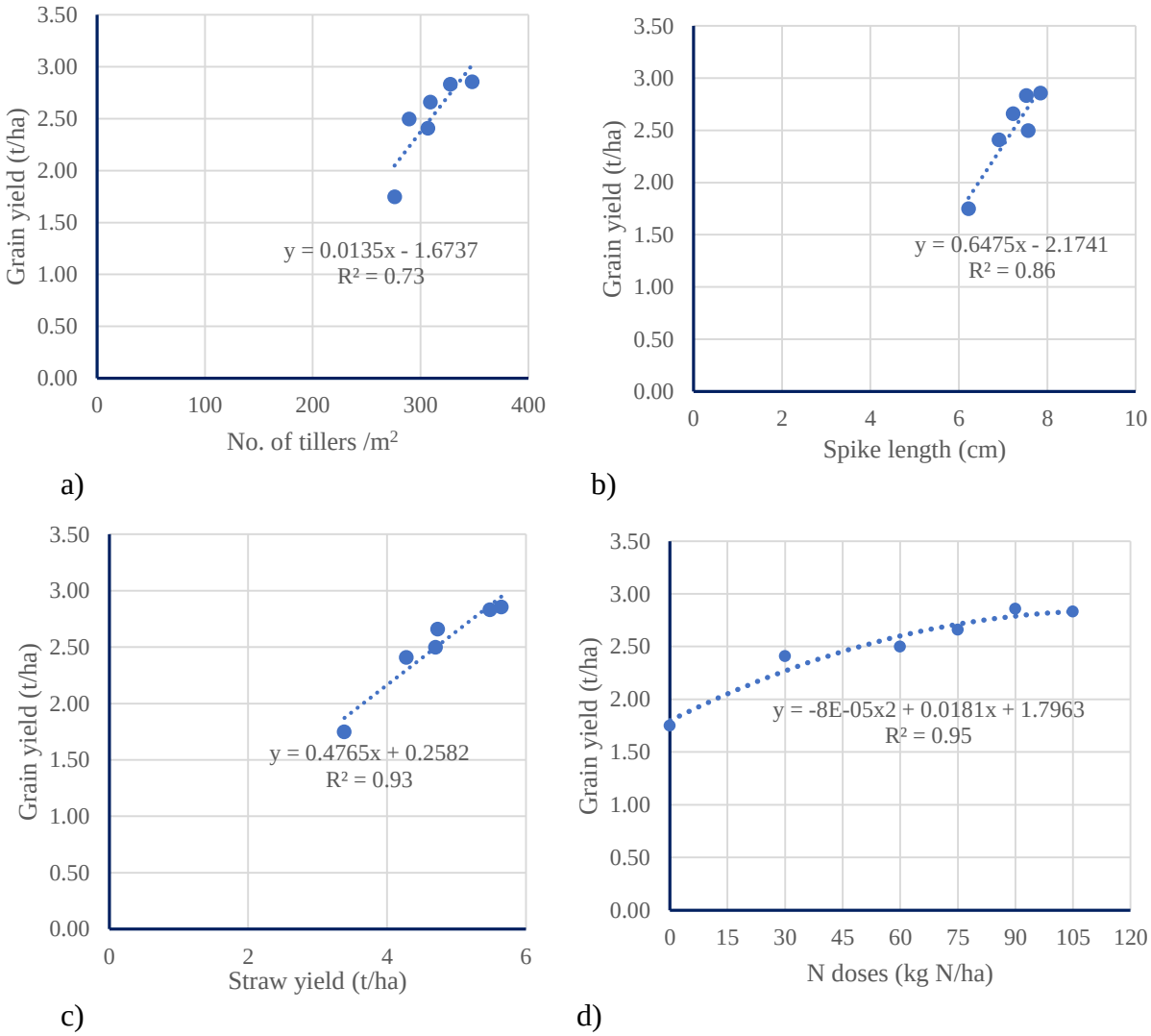

Figure 2: Correlation among growth parameters and yield attributes of barley: a) No. of tillers/m^2 and grain yield, b) spike length and grain yield, c) straw yield and grain yield, and d) N doses response on grain yield

Table 1: Effect of N doses on phenology, growth, yield attributes and grain yield of barley at HCRP, Kabre, Dolakha during 2022 and 2023

S.N.	Treatments	DTH	DTM	Ph (cm)	No. of tillers/m2	No. of Spikes/m2	SL (cm)	TGW (g)
1	0 Kg N/ha	98.0	153bc	81.9c	276.0c	271.2c	6.22b	30.7abc
2	30 Kg N/ha	96.5	154ab	92ab	306.7bc	298.3bc	6.91ab	29.7bc
3	60 Kg N/ha	97.5	152c	87.6bc	289.3c	278.0c	7.57a	28.7c
4	75 Kg N/ha	98.3	155a	88.3abc	309.2bc	290.5bc	7.23a	31.3ab
5	90 Kg N/ha	98.7	154ab	95.6a	348a	342.2a	7.85a	29.4bc
6	105 Kg N/ha	98.5	153bc	95.5a	327.7ab	318.7ab	7.53a	32.0a
	GM	97.9	153.3	90.2	309.5	299.8	7.22	30.3
	F-test	NS	*	*	*	*	*	*
	LSD	-	1.08	7.74	37.9	38.6	0.96	2.08
	CV (%)	2.7	0.6	7.1	10.2	10.7	11.1	5.3

DTH=Days to 50% heading, DTM=Days to 75% maturity, Ph=Plant height (cm), SL=Spike length (cm), TGW=Thousand grains weight (g), *=Significant difference at 5% probability level, **= Significantly different at 1% probability level, Means indicated with lower case same letter in a column are not different significantly at 5% probability level

Table 2: Effect of nitrogen doses on grain yield, straw yield and nitrogen use efficiencies of barley at HCRP, Kabre, Dolakha during 2022 and 2023

S.N.	Treatments	Grain yield (t/ha)	Stover yield (t/ha)	ANUE (Kg/Kg N)	PFPN (Kg/Kg)
1	0 Kg N/ha	1.748d	3.384d	-	-
2	30 Kg N/ha	2.407c	4.278c	21.97a	80.22a
3	60 Kg N/ha	2.497bc	4.697bc	12.49b	41.62b
4	75 Kg N/ha	2.658abc	4.731bc	12.13b	35.43bc
5	90 Kg N/ha	2.856a	5.647a	12.32b	31.74cd
6	105 Kg N/ha	2.831ab	5.483ab	10.32b	26.96d
	GM	2.499	4.703	13.85	43.1
	F-test	**	*	*	**
	LSD	0.33	0.80	5.78	7.16
	CV (%)	11.1	13.3	34.2	13.6

GM=Grand mean, LSD= Least significant difference, ANUE=Agronomic nitrogen use efficiency, PFPN=Partial factor productivity of nitrogen, *=Significant difference at 5% level, **= Significantly different at 1% level, Means indicated with lower case same letter in a column are not different significantly at 5% probability level

DISCUSSION

Nitrogen levels influenced significantly on days to maturity, plant height, no. of tillers/m^2, no. of spikes/m^2, spike length, thousand grains weight, grain yield, straw yield, agronomic nitrogen use efficiency and partial factor productivity of nitrogen in barley. Increased doses of N had significantly increased plant height. The possible reason might be that optimum nitrogen supply may have played an essential role in plant growth and development. This result is similar with the finding of Biruk and Demelash (2016) indicated that highly significant plant height differences resulted by main effect of N rate and varieties. This result is also supported by Hadi et al (2012) who reported that taller barley plants recorded on high N dose (120 kg N/ha) applied. Increasing the doses of N had increased the number of tillers/m^2. 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. The results were in agreement with that of Abdullatif et al (2010) who reported that increasing in the number of effective tillers with nitrogen fertilization. Jema and Tadesse (2020) also reported that nitrogen fertilization had significant effect on number of effective tillers of barley. Increasing N doses had significantly increased number of spikes/m^2 which might be due to increased number of effective tillers. Muktinath variety of barley responded up to 75 kg N/ha for grain yield production. Similar result was reported by Baral et al (2023) that application of 50:30:20 kg N:P_2O_5:K_2O kg/ha was optimum for Bonus variety of barley at Dolakha district condition of Nepal. This study indicated that barley responses to N level varied upon varietal characteristics and genetic attributes. The increased grain yield was the result of increased number of tillers/m^2, increased number of spikes/m^2 and spike length. In addition, there was positive correlation on number of tillers and grain yield, spike length and grain yield, and straw yield and grain yield. Nitrogen stimulates tillering, may be due to its effect on cytokine synthesis (Mangle and Kirkby 1996). Others reported that barley reacts to early N by producing more tillers per plant and by exhibiting a higher percentage survival of tillers (Hussain et al 2025, Bullman and Smith 1993). The result of this study similar with reports of Aghdam and Samadiyan (2014) indicated that effect of N on spike length was significant which means spike length became higher at higher dose of N possibly due to higher availability of nitrogen. The increase in grain yield in response with increasing rate of nitrogen could be attributed to enhanced availability of the nutrient for uptake by the plants and increased photo assimilate production that would eventually lead to improved partitioning of carbohydrate to the grains. The highest grain yield of any crop is the result of all positive relationships of the yield components. Improvement in barley yield with fertilizer application can be attributed to the

stimulating effects of nutrients on plant growth that provides ideal condition for crop as the fertilizer N supply to plants need, which ultimately increased the grain yield of crop. The current result is in agreement with Imran et al (2005) who suggested that an introduction of high yielding crop variety with balanced application of NP fertilizer can increase the grain yield of the crop.

CONCLUSION

Nitrogen response of barley varied upon soil types, fertility status and varieties. Muktinath variety of barley produced the highest grain yield (2.85 t/ha) at 90 kg N/ha and was not significantly different with 75 kg N/ha and 105 kg N/ha. The results clearly indicated that 75 kg N/ha is optimum under Dolakha condition and in areas with similar soil types and climate of Nepal.

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