



Response of multi-cut fodder barley (*Hordeum vulgare*) to varying levels and N application under semi-arid condition of Rajasthan

L R MEENA¹, J S MANN², H S JAT³, ROOP CHAND⁴ and S A KARIM⁵

Central Sheep and Wool Research Institute, Avikanagar, Rajasthan 304 501

Received: 4 September 2009; Revised accepted: 18 January 2011

ABSTRACT

An experiment was conducted during winter (*rabi*) seasons of 2005 to 2007 at Avikanagar, Rajasthan to find out the effect of barley (*Hordeum vulgare* L.) with varying levels and times of N application under semi-arid condition of Rajasthan. Application of 90 kg N/ha recorded significantly higher growth-attributing characters and dry matter accumulation over other doses of nitrogen. Application of 90 kg N/ha gave significantly higher green fodder (32.01 tonnes/ha), dry forage (8.22 tonnes/ha) and grain yield (3.57 tonnes/ha) over 30 and 60 kg N/ha, respectively. Application of 90 and 60 kg N/ha resulted an increase of 22.22% and 11.38% green fodder, 13.07 and 7.57% in dry forage and 35.23% and 15.91% grain yield, respectively over the 30 kg N/ha. Nitrogen-use efficiency showed decreasing trend and the maximum nitrogen-use efficiency was recorded with 30 kg N/ha application (848.19). Nitrogen content and uptake, crude protein content and protein yield were increased progressively with successive levels of nitrogen levels. The B:C ratio was recorded highest with 90 kg N/ha (2.40) and significantly higher than 30 and 60 kg N/ha (2.23 and 2.34). Crude protein content (7.17%) and protein yield (545.09 kg/ha) was increased with successive times of nitrogen application and was found significantly higher with three splits of nitrogen application. The maximum net returns (₹ 16 895/ha) and B:C ratio (2.43) was recorded when nitrogen were applied as 1/3 N at sowing + 1/3 N at Crown root initiation+ 1/3 N at tillering.

Key words: Barley, Economic returns, Growth attributes, Green fodder, Nitrogen content and uptake, Nitrogen levels, Protein yield, Splits application of nitrogen

Barley (*Hordeum vulgare* L.) is cultivated since ancient times (7500 BC) and mostly being used as cattle feed and also utilized for human consumption. Barley is one of the most important cereals after wheat, rice and maize and it has the widest ecological range of adaptation amongst cereals and it is widely grown in Rajasthan and other part of the country. Farmers of arid and semi-arid regions of the country prefer this crop as it requires less water, low input demand and does well even with saline soil and water. The barley produce from irrigated fertile areas is mainly used for industrial purposes, which accounts to nearly 20–25% of the total production and the remaining quantity from rainfed and less fertile area are utilized for cattle feed purposes (Sarkar *et al.* 2008). Generally, barley is grown separately for grain and fodder purposes. However, if it is harvested as green at vegetative stage, the opportunity for producing grain is eliminated. Therefore, it is necessary to develop strategy for

obtaining moderate yield of green fodder as well as grain from the same crop by adopting appropriate management practices and selecting suitable varieties. Insufficient nitrogen can reduce grain yield and quality below the acceptable level, which excess nitrogen usually produces undesirable high protein levels (Lauer and Partridge 1990).

The dual purpose type of variety that may response to use of balanced dose of nitrogen fertilizer and its times of application is considered the most limiting factor for realizing higher yields (Yadav *et al.* 2003). In Rajasthan, it is grown both as irrigated and unirrigated crop in light textured soils. These soils are deficient to low in nitrogen. As the nitrogen play a vital role in plant nutrient, its application has resulted in significant increase in yield and yield components of all the crops. The major constraints for production is poor fertility status of these soils coupled with imbalance nutrition application. The easiest way to boost the crop productivity is through balanced fertilization at most critical stages and by adopting better management practices to the undernourished crop (Roy and Singh 2006). The nitrogen management in barley becomes difficult when it is grown for green fodder as well as grain purpose. The application of

¹Senior Scientist (e mail: Irmeena63 @yahoosmail.com),
²Principal Scientist (e mail: dr_jsmann@yahoo. co.in), ³Senior Scientist (e mail: hsjat_ agron@yahoo.co), ⁴Scientist (Senior Scale) (e mail: rcbsoni @rediffmail.com), Grassland Forage Agronomy Section, ⁵Director (e mail: sakarim53@yahoo.co.in)

appropriate quantity of nitrogen at right time is one of the important agronomic techniques to increase the green fodder and grain yield of barley. Hence, an experiment was carried out to evaluate the effect of nitrogen levels and splits application of nitrogen on fodder and grain yield, quality, nitrogen uptake and B:C ratio of barley.

MATERIALS AND METHODS

A field experiment was carried out during the winter (*rabi*) seasons of 2005–07 under transfer of technology project at Avikanagar, Rajasthan. The soil was sandy loam in texture, having pH 8.4 and low in organic carbon 0.22%. The soil contained 134.3, 16.4 and 168.2 kg/ha of available nitrogen, phosphorus and potassium, respectively. The experiment was laid out in split-plot design with three levels of nitrogen (30, 60 and 90 kg/ha) as main plot treatments and three splits of nitrogen application (T_1 - $\frac{1}{2}$ at sowing + $\frac{1}{2}$ N at CRI, T_2 - $\frac{1}{2}$ at sowing + $\frac{1}{2}$ N at tillering and T_3 - $\frac{1}{3}$ N at sowing + $\frac{1}{3}$ N at CRI + $\frac{1}{3}$ N at tillering as sub-plot treatments. These treatments combinations were applied at sowing and the nitrogen was applied as per the treatments. The dual-purpose (fodder and grain) multi-cut variety 'RD 2618' barley was sown on 15 October and 20 October in 2006 and 2007, respectively apart in lines at 22.5 cm with a seed rate of 80 kg/ha. The seeds were treated with the Bavistin fungicide (2 g/kg of seed) prior to sowing. The observations pertaining to green fodder production were recorded at 45 days after sowing and thereafter the crop was left for grain and straw production. The growth attributes parameters were recorded at the time of harvesting under each treatment. Ten plants were selected randomly from each treatment and record the observation on growth parameters. Adequate plant protection measures and irrigation were given as per the requirement. The crop was harvested for grain production on 25 April 2006 and 30 April 2007, respectively. Observations on growth attributes, yield

attributes and grain yield were recorded and analyzed statistically by adopting the procedure of Gomez and Gomez (1984). The plant samples were analyzed for N content and its uptake (kg/ha) by standard method after completion of two years experimentation (AOAC 1990).

RESULTS AND DISCUSSION

Effect of nitrogen levels

The N levels had significant effects on all the growth parameters like the plant height, dry matter accumulation/plant, dry matter accumulation (g/m^2), leaf area index (LAI), and crop growth rate ($\text{g/m}^2/\text{day}$) of barley crop at 45 days after sowing (Table 1). However, effective tillers/ m^2 were not affected significantly. All the growth attributes were the maximum at 90 kg N/ha application as compared to other levels of N fertilizer (30 and 60 kg N/ha). Application of 90 kg N/ha gave significantly higher green fodder (32.01 tonnes/ha), dry matter yield (8.22 tonnes/ha) and grain yield (3.57 tonnes/ha) over 30 and 60 kg N/ha, respectively (Table 2). Green fodder, dry forage and grain yield increased significantly with increase in the dose of N up to 90 kg/ha showing an increase of 22.22 and 11.38% in green fodder yield, 13.07 and 7.57% in dry forage yield and 35.23 and 15.91% in grain yield over 30 and 60 kg N/ha, respectively. This was probably due to physiological role of N is an enhancing of dry matter accumulation might have lead to increase in growth attributes and yield attributes, thereby significantly increased in green fodder, grain yield and straw yield. Similar results were also reported by Kumawat and Jat (2005), Singh and Singh (2005) and Singh *et al.* (2009). The nitrogen-use efficiency was decreased significantly with increase in the levels of nitrogen from 30 to 90 kg N/ha. The maximum nitrogen-use efficiency (NUE) (848.19 kg green fodder yield/kg N/ha applied) with 30 kg N/ha and minimum NUE (306.16 kg green fodder equivalent/kg N applied) with 90 kg N/ha was recorded (Table 2). Nitrogen content and

Table 1 Effect of N levels and time of application on growth attributes of multi-cut barley at 45 days after sowing (average data over two years)

Treatment	Plant height (cm)	Dry matter accumulation/plant (g) at harvest	Effective tillers/ m^2	Dry matter accumulation (g/m^2) at 45 DAS	LAI at 45 DAS	CGR ($\text{g/m}^2/\text{day}$)
<i>Nitrogen level (kg/ha)</i>						
30	95.23	11.69	218.24	99.66	2.1	7.23
60	102.79	13.70	225.24	111.63	2.6	7.80
90	111.62	15.77	235.16	119.74	2.8	8.37
CD ($P=0.05$)	2.43	1.01	NS	4.28	0.94	0.51
<i>Time of N application</i>						
T_1	98.59	12.88	228.29	106.62	2.6	7.46
T_2	102.69	14.09	233.58	110.79	2.9	7.65
T_3	107.62	14.84	238.43	113.16	3.5	8.05
CD ($P=0.05$)	2.43	1.01	NS	4.28	0.94	0.51

T_1 , Half at sowing and half at crown root initiation; T_2 , half at sowing and half at tillering; T_3 , one-third each at sowing, crown root initiation and tillering; LAI, leaf area index; NS, non-significant; DAS, days after sowing; CGR, crop growth rate

Table 2 Effect of N levels and time of application on green herbage, dry forage production and nitrogen-use efficiency in multi-cut barley (average data over two years)

Treatment	Green fodder yield (tonnes/ha)	Dry forage yield (tonnes/ha)	Grain yield (tonnes/ha)	NUE (green fodder yield kg/kg nitrogen applied)
<i>Nitrogen level (kg/ha)</i>				
30	26.19	7.27	2.64	848.19
60	29.17	7.82	3.06	439.43
90	32.01	8.22	3.57	306.16
CD (P=0.05)	1.88	0.38	0.32	23.75
<i>Time N of application</i>				
T ₁	27.19	7.49	2.84	527.13
T ₂	29.17	7.78	3.05	531.15
T ₃	30.14	8.31	3.36	536.06
CD (P=0.05)	1.88	0.38	0.32	23.75

NUE, Nitrogen-use efficiency

uptake, crude protein content and protein yields were increased progressively with successive levels of nitrogen levels (Table 3). Application 90 kg N/ha fetched the maximum nitrogen content and uptake and protein content and protein yield (0.77%, 61.31 kg, 7.04 and 475.52 kg/ha respectively) over the other doses of nitrogen levels. The cost of cultivation varied according to different doses of nitrogen applied. The maximum gross returns (Rs 24 173/ha), net returns (Rs 17 076/ha) and benefit:cost ratio (2.40) were obtained with 90 kg N/ha (Table 4). This behaviour of benefit:cost ratio may be attributed due to relative cost of inputs in relation to output.

Effect of times of N application

The times of nitrogen application at different growth stages caused significant increase in all growth parameters, viz plant height, dry matter accumulation (g/plant), leaf area index, crop growth rate (g/m²/day), and yields of multi-cut barley (Table 1). The maximum plant height (107.62 cm), dry matter accumulation (14.84 g/plant), effective tillers/m² (238.43) and dry matter production/m² (113.16 g) were obtained when N applied in three equal splits (1/3 N at sowing + 1/3 N at CRI+ 1/3 N at tillering) as compared to N applied in two equal splits, i.e. 1/2 at sowing + 1/2 N at CRI and 1/2 at sowing + 1/2 N at tillering. But the difference between dry matter accumulation/plant and dry matter production/m² was found statistically at par with each other. Moreover, tillers/m² did not increase at significant level. This might be due to better use-efficiency of N when applied more than two splits. Besides leaching losses of N in light-textured soil may also be reduced. The results are in corroboration with the observations made by Patel *et al.* 2004 and Dhukia *et al.* 1998. The times of nitrogen application had also significant effects on green fodder, dry forage and straw yield of barley. Green fodder, dry forage and grain yield increased significantly with application of N in three equal splits (1/3

N at sowing + 1/3 N at CRI+ 1/3 N at tillering) as compared to two splits of nitrogen fertilizer splits, i.e. 1/2 at sowing + 1/2 N at CRI and 1/2 at sowing + 1/2 N at tillering. Application of N in three splits (1/3 N at sowing + 1/3 N at CRI+ 1/3 N at tillering) showing an increase of 10.85 and 6.81% in green fodder yield, 10.95 and 6.81% in dry forage yield and 18.31 and 10.16% in grain yield over N applied in two splits (1/2 at sowing + 1/2 N at CRI and 1/2 at sowing + 1/2 N at tillering), respectively (Table 2). Nitrogen-use efficiency of green fodder (536.06 kg N/kg N applied) was recorded non-significantly higher when nitrogen was applied in three splits as 1/3 N at sowing + 1/3 N at CRI+ 1/3 N at tillering of N. Both nitrogen content and uptake of barley crop at harvest was increased significantly with three splits as 1/3 N at sowing + 1/3 N at CRI+ 1/3 N at tillering of N application over two splits of application (Table 3). This may be attributed to greater dry matter production as a result of nitrogen application in this technique. Similar results were also reported by Ramos *et al.* (1995) and Yadav *et al.* (2003).

Table 3 Effect of N levels and time of application on nitrogen content, uptake and quality of fodder barley (average data over two years)

Treatment	Nitrogen content (%)	N uptake (kg/ha)	Crude protein content (%)	Protein yield (kg/ha)
<i>Nitrogen level (kg/ha)</i>				
30	0.62	42.02	5.46	424.07
60	0.68	51.60	6.09	453.66
90	0.77	61.31	7.04	475.52
CD (P=0.05)	0.06	6.93	0.36	40.07
<i>Time of N application</i>				
T ₁	0.63	47.85	5.31	368.08
T ₂	0.66	51.71	6.34	448.37
T ₃	0.71	55.03	7.17	545.09
CD (P=0.05)	0.06	6.93	0.36	40.07

Table 4 Effect of nitrogen levels and their mode of application on cost of cultivation, gross returns, net returns and benefit : cost ratio

Treatment	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio
<i>Nitrogen level (kg/ha)</i>				
30	6 437	20 825	14 388	2.23
60	6 767	22 627	15 860	2.34
90	7 097	24 173	17 076	2.40
CD (P=0.05)	216.14	1061.13	845.92	0.03
<i>Time of N application</i>				
T ₁	6 731	21 003	14 272	2.11
T ₂	6 839	22 593	15 754	2.30
T ₃	6 945	23 840	16 895	2.43
CD (P=0.05)	216.14	1061.13	845.92	0.03

Crude protein content (7.17%) and protein yield (545.09 kg/ha) was increased with successive times of nitrogen application and was found significantly higher with three splits of nitrogen application. However, the differences among the treatments themselves were found statistically significant in respect of times of nitrogen application. However, these parameters were the highest when nitrogen was applied in three equal splits over other times of N application. The times of nitrogen application caused significant variation in gross returns, net returns and also benefit:cost ratio. The maximum net return (₹16 895/ha) and B:C ratio (2.43) was recorded when nitrogen were applied as 1/3 N at sowing + 1/3 N at CRI+ 1/3 N at tillering and minimum were fetched with application of nitrogen in two equal splits, ie ½ at sowing + ½ N at CRI stage.

Interaction effect

The interaction effect of N levels and times of application on grain and straw yield were significant (Table 5). The highest grain yield (4.14 tonnes/ha) and straw yield (5.11 tonnes/ha) was recorded with the application of 90 kg N/ha applied in three equal splits as 1/3 N at sowing + 1/3 N at CRI+ 1/3 N at tillering over rest of the treatment combinations in case of grain yield, however, it was at par when 90 kg N/ha was applied in two equal splits either ½ at sowing + ½ N at CRI or ½ at sowing + ½ N at tillering stage in respect of straw yield.

On the basis of two years results it can be concluded that under semi-arid condition of Rajasthan, the higher green fodder, grain and straw yield of multi-cut barley can be obtained with three equal splits (1/3 N at sowing + 1/3 N at CRI+ 1/3 N at tillering) of 90 kg N/ha. The interaction effect of N levels and times of N application on grain and straw yield were found significant.

REFERENCES

A O A C.1990. *Official Methods of Analysis*, edn 12. Association

Table 5 Interaction effect of nitrogen levels and their times of application on grain and straw yields of multi-cut barley

Time of N application	Nitrogen levels (N kg/ha)		
	30	60	90
<i>Grain yield (tonnes/ha)</i>			
T ₁	2.65	3.11	3.52
T ₂	2.74	3.25	3.84
T ₃	2.84	3.28	4.14
CD (P=0.05)	0.26		
<i>Straw yield (tonnes/ha)</i>			
*T ₁	3.23	4.21	4.84
T ₂	3.80	4.41	4.94
T ₃	4.14	4.53	5.11
CD (P=0.05)	0.45		

T₁, Half at sowing and half at CRI; T₂, half at sowing and half at tillering; T₃, one third each at sowing, CRI and tillering

of Analytical Chemists. Washington D C.

Dhukia R S, Ram Sharda and Dass Bhagwan. 1998. Response of barley variety to varying level of nitrogen under semi-arid conditions. *Interventional Journal of Tropical Agriculture* **15**(1/4): 229–32.

Gomez K A and Gomez A A .1984. *Statistical Procedure for Agricultural Research*, pp 316–55. 2nd edn. John Willey and Sons inc. New York, USA.

Kumawat P D and Jat N L. 2005. Effect of organic manure and nitrogen fertilization on productivity of barley (*Hordeum vulgare*). *Indian Journal of Agronomy* **50** (3): 200–02.

Lauer J G and Partridge J R.1990. Planting date and nitrogen rate effects on spring malting barley. *Agronomy Journal* **82** (6): 1083–8.

Patel A M, Patel D R, Patel G A and Thakur D R. 2004. Optimization of sowing and fertilizer requirement of barley (*Hordeum vulgare*) under irrigated condition. *Indian Journal of Agronomy* **49**(3): 171–3.

Ramos J M, Morena I De La and Garcia L F Del. 1995. Barley response to nitrogen rate and timing in a Mediterranean environment. *Journal of Agricultural Science, Cambridge* **125**: 175–82.

Roy D K and Singh B P. 2006. Effect of level and time of nitrogen application with and without vermicompost on yield, yield attributes and quality of malt barley (*Hordeum vulgare*). *Indian Journal of Agronomy* **51**(1): 40–2.

Sarkar B, Verma R P S and Mishra B .2008. Association of important malting traits in barley (*Hordeum vulgare*). *Indian Journal of Agronomy* **51**(1): 40–2.

Singh R P, Tripathi H P and Yadav A S .2009. Effect of stage of cutting and nitrogen levels on grain and fodder yield of barley (*Hordeum vulgare*). *Indian Journal of Agricultural Sciences* **78** (10): 853–7.

Singh Ramesh K and Singh R K. 2005. Effect of time and levels of nitrogen application on malt barley (*Hordeum vulgare*). *Indian Journal of Agronomy* **50** (2): 137–9.

Yadav R K, Kumar Ashok and Lal D. 2003. Effect of cutting management and nitrogen levels on biomass production and proximate quality of barley (*Hordeum vulgare*) in saline soil. *Indian Journal of Agronomy* **48**(3): 199–02.