

Effect of Nitrogen Levels and its Scheduling on Growth, Yield and Grain Quality of Malt Barley (*Hordeum vulgare* L.) under Normal and Late Sown Conditions in North-West Rajasthan

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Abstract: The field experiment was conducted to find out the effect of nitrogen levels and its split application on growth, yield and quality of malt barley (*Hordeum vulgare* L.) under normal and late sown conditions during winter seasons of 2005-06 and 2006-07. The results showed significantly higher yield attributing characters, grain and straw yield, harvest index, husk content and net returns of malt barley under normal sown condition while, grain protein concentration was significantly higher under late sowing. Increasing nitrogen from 60 to 90 kg ha⁻¹ significantly enhanced plant height, yield attributes and yields, harvest index, grain protein concentration and net returns of malt barley. Scheduling of nitrogen at 1/3 as basal+1/3 at 1st irrigation+1/3 at 2nd irrigation substantially improved yield attributing characters and yields, harvest index, grain protein concentration and net returns while husk content was decreased. Scheduling of N in three equal splits affected the quality of malt barley grains. This treatment increased the protein content in grain, but it remained under the prescribed limit as per Indian standards in north-west Rajasthan conditions.

Key words: Nitrogen levels, growing environments, nitrogen application scheduling, malt barley.

Use of barley (*Hordeum vulgare* L.) in malt industry is most significant, where it is being used in making beer, different types of alcohol. Many crop management practices affect the yield and quality of this crop. Planting time affect the productivity and quality of malt barley particularly the grain protein and husk content (Zhang *et al.*, 2002). Nitrogen is considered as most important element in production of cereals. Barley crop responds significantly to varying nitrogen levels. However, there has been limited field research on the scheduling of N fertilizer that influences both grain yield and grain quality for malting barley. Time of application of nitrogen is known to exert considerable influence on the yield and quality of crop. The research work has revealed that application of nitrogenous fertilizers should be suitably adjusted so as to match the maximum uptake rate in relation to amount of dry matter accumulation (Sharma *et al.*, 1998). Nitrogen efficiency, especially in light soils, can be increased and losses reduced through scheduling of nitrogen application so as to match with its uptake by the growing plants. Method of N

application in malting barley may decrease the grain protein level to acceptable levels by the brewing industry. Too much splitting of N may increase the yield, but affect the grain quality of malt barley. Barley grown for malt must have low protein concentration and grain should be large (Chandola, 1990). Keeping these points in view, a field experiment was conducted to find out the effect of nitrogen levels and its scheduling on barley under different growing environments in arid sandy soils of north-west Rajasthan.

Materials and Methods

The experiment was conducted at College of Agriculture, Bikaner, during winter seasons of 2005-06 and 2006-07. The soil of the experimental field was loamy sand and soil pH was 8.28. It was low in organic carbon (0.08%), available nitrogen (112.06 kg ha⁻¹) and available phosphorus (12.05 kg ha⁻¹) and medium in potassium (199.59 kg ha⁻¹). The treatments comprized two levels of growing environments (normal and late sown) and two nitrogen levels (60 and 90 kg ha⁻¹) as main plot treatments and five levels of scheduling

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of nitrogen application [(Full basal (NS-1), 3/4 at basal+1/4 at 1st irrigation (NS-2), 2/3 at basal+1/3 at 1st irrigation (NS-3), 1/2 at basal+1/2 at 1st irrigation (NS-4) and 1/3 at basal+1/3 at 1st irrigation+1/3 at 2nd irrigation (NS-5)] as sub plot treatments and were laid out in split plot design with four replications. The nitrogen as per treatment was applied through urea after adjusting the nitrogen supplied through DAP as source of phosphorus (40 kg P₂O₅ ha⁻¹). Potassium (30 kg K₂O ha⁻¹) was supplied through MOP. The calculated quantity of urea for different treatments was applied as basal and remaining nitrogen were given at 1st and 2nd irrigation as per treatment. The malt barley variety RD-2503 was sown on 12th November (normal sown) and 2nd December (late sown) during 2005, and 20th November (normal sown) and 5th December (late sown) during 2006, maintaining 22.5 cm row to row spacing. Nitrogen content in grain at physiological maturity was estimated by modified Kjeldahl's method using Nessler's reagent. The husks were removed by treatment with sodium hypochlorite solution. The husk content was calculated from the reduction in weight by sodium hypochlorite solution. 20 g of barley grain was weighed and boiled in 80 mL hypochlorite solution and 20 mL sodium hydroxide solution. After 30 seconds cold tap water was added to agitate the sample by the action of the water stream. Decanted the water containing the husk remnants and added fresh water. Seeds were rinsed until all the husk remnants were removed. Seeds were spread out on filter paper and dried overnight at room temperature on filter paper followed by keeping for 3 hrs. at 50°C in a drying oven (Analytica-EBC, 1997). The husk content was determined as per formula given below:

$$\text{Husk content (\%)} = \frac{[\text{Sample weight (g)} - \text{Weight of dehusked grains (g)}]}{100/\text{Sample weight (g)}}$$

Results and Discussion

Effect of growing environments

Data in Table 1 revealed that there was no influence of sowing date on plant height of malt barley. The data further revealed that normal sowing significantly increased the number of effective tillers, spike length, number of grains per spike and test weight of malt barley over

late sowing on pooled basis. The possible reason may be that the reproductive phase, under normal sown conditions experienced optimum temperature conditions, while under late sown conditions, steep rise in temperature reduced the duration of reproductive phase as well as growth of grains expressed in terms of seed index and number of grains per spike. As a consequence of favorable climatic conditions, improvement in yield attributing characters was also observed by Gupta *et al.* (2001).

Significantly higher grain, straw and biological yields and harvest index of malt barley was observed under normal sown condition compared to late sown condition (Table 1). The significant increase in grain yield under normal sown conditions seemed to be on account of significant increase in yield attributes. It is also established fact that the prevalence of higher temperature shortens period from ear initiation to anthesis thus reducing supply of photosynthates relative to the rate of development, consequently less grains per ear. Further estimates revealed that over a range of 12 to 26°C, increased temperature during grain filling reduced wheat grain weight from 4 to 8% (Fischer, 1984). Barley sown on November 10 gave significantly higher grain and straw yields over early and late sowing, which was mainly attributed to improvement in yield attributes also reported by Chun *et al.* (2000).

Husk content and grain protein of malt barley was significantly increased under late sown compared to normal sown condition. This might be due to higher amounts of unutilized nutrients increasing their concentration in the plant parts. The significant increase in protein concentration under the influence of delayed planting appears to be on account of higher concentration of N in the grain. Whereas, net returns were significantly higher under normal sown condition (Table 1). The results of the experiment are in agreement with the findings of Patel *et al.* (2004).

Effect of nitrogen levels

Increasing levels of nitrogen from 60 to 90 kg ha⁻¹ significantly enhanced plant height, number of effective tillers, spike length, number of grains per spike and test weight of malt barley (Table 1). An improvement in yield components due to nitrogen might be due to

Table 1. Effect of growing environments, nitrogen levels and scheduling of nitrogen application on growth, yield attributes, yields, quality and net returns of malt barley (pooled data)

Treatment	Plant height (cm)	Effective tillers m/row	Spike length (cm)	Grains/spike	Test weight (g)	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Biological yield (kg ha ⁻¹)	Harvest index (%)	Grain protein (%)	Husk content (%)	Net returns (Rs. ha ⁻¹)
A : Growing environments												
Normal sown	71.9	59.3	5.3	31.82	43.63	2855	3360	6219	45.78	8.74	10.75	17711
Late sown	72.1	52.9	4.8	29.27	42.40	2632	3132	5764	45.59	9.04	10.96	15702
CD (P=0.05%)	NS	2.3	0.1	0.91	0.75	9	9	181	0.14	0.08	0.16	812
B : Nitrogen levels												
60 kg ha ⁻¹	70.0	52.0	4.7	28.25	42.37	2531	3036	5573	45.40	8.80	10.95	14946
90 kg ha ⁻¹	73.9	60.2	5.4	32.83	43.66	2955	3455	6410	45.98	8.97	10.75	18466
CD (P=0.05%)	2.4	2.3	0.1	0.91	0.75	9	9	181	0.14	0.08	0.16	812
C : Scheduling of nitrogen application												
NS-1	70.1	46.2	4.0	24.18	42.69	2176	2676	4852	44.76	8.31	10.95	11648
NS-2	70.7	51.7	4.6	28.16	42.81	2526	3026	5552	45.43	8.62	10.94	14722
NS-3	71.6	56.8	5.2	31.62	42.96	2825	3344	6188	45.88	8.79	10.88	17476
NS-4	73.7	60.5	5.5	33.43	43.16	3009	3509	6518	46.10	9.25	10.77	19117
NS-5	73.9	65.3	5.8	35.32	43.46	3180	3673	6847	46.26	9.48	10.71	20567
CD (P=0.05%)	NS	2.9	0.2	1.19	NS	12	12	243	0.20	0.08	0.18	1092

NS - Nitrogen scheduling.

increased supply of nitrogen and other nutrients to plants. Optimum availability of nitrogen in particular and other nutrients in general to the plants at the flower primordial initiation stage ultimately increased yield attributes of barley (Singh *et al.*, 2003).

Pooled analysis of data (Table 1) also indicate that nitrogen at 90 kg ha⁻¹ significantly increased the grain, straw and biological yields and harvest index of malt barley over 60 kg N ha⁻¹. Nitrogen application accelerated various physiological processes due to greater translocation of photosynthates from source to sink (grain) resulting in increased yield of malt barley. Secondly, increased yield attributes which ultimately increased the grain and straw yield under 90 kg N ha⁻¹ treatment. Significant improvement in yield attributes and yield due to nitrogen application up to 90 kg ha⁻¹ have also been reported by Gupta *et al.* (2001).

Application of 90 kg N ha⁻¹ significantly increased the grain protein concentration, husk content and net returns over 60 kg N ha⁻¹ (Table 1). Increasing N application from 60 to 90 kg ha⁻¹ increased protein concentration in grain, but the protein concentration at 90 kg

N ha⁻¹ remained in the prescribe limit (9.0 to 11.5%) as per the guidelines of DWR, Karnal, under Indian conditions (Verma *et al.*, 2005).

Effect of scheduling of nitrogen application

Data presented in Table 1 further revealed that nitrogen application in three equal splits viz., 1/3 at basal+1/3 at 1st irrigation+1/3 at 2nd irrigation recorded significantly higher number of effective tillers, spike length, number of grains per spike except plant height and test weight of malt barley over two splits viz. 1/2 at basal+1/2 at 1st irrigation, 2/3 at basal+1/3 at 1st irrigation, 3/4 at basal+1/4 at 1st irrigation and full basal. Full basal application of N had minimum and significantly lower number of effective tillers, spike length and number of grains per spike. Plant height and test weight of malt barley was not influenced by the different scheduling of N application. Increase in yield attributing characters of malt barley due to application of nitrogen in three splits might be due to the prevented losses of nitrogen through leaching and volatilization as compared to application in single dose and two split applications. Barley crop was benefited through adequate supply of nitrogen at different growth stages,

Table 2. Interaction effect of growing environments, nitrogen levels and scheduling of nitrogen application on grain yield (kg ha⁻¹) of malt barley (pooled data)

Scheduling of nitrogen application	Normal sown		Late sown		Mean
	60 kg N ha ⁻¹	90 kg N ha ⁻¹	60 kg N ha ⁻¹	90 kg N ha ⁻¹	
Full basal (NS-1)	1887	2151	2172	2495	2176
3/4 Basal + 1/4 at 1 st irrigation (NS-2)	2492	2630	2277	2705	2526
2/3 Basal + 1/3 at 1 st irrigation (NS-3)	2762	3244	2473	2823	2825
1/2 Basal + 1/2 at 1 st irrigation (NS-4)	2886	3549	2662	2939	3009
1/3 Basal + 1/3 at 1 st irrigation (NS-5) + 1/3 at 2 nd irrigation	2944	4001	2760	3015	3180
Mean	2594	3115	2469	2795	2743
	SEd	CD (P = 0.05)			
A-means at same level of S&N	1.23	2.45			
S&N-means at same level of A	1.31	2.67			

which may have positive influence on yield attributes (Singh and Singh, 2005). Application of nitrogen as full basal, lower availability of nitrogen resulted into nitrogen deficiency at growth and development stage and hence a weak growth was observed. Similar trend on yield attributing characters by crop was also reported by Roy and Singh (2006).

Highest grain, straw and biological yields and harvest index of malt barley was obtained under split application of nitrogen as 1/3 at basal+1/3 at 1st irrigation+1/3 at 2nd irrigation which was found significantly higher over 1/2 at basal+1/2 at 1st irrigation, 2/3 at basal+1/3 at 1st irrigation, 3/4 at basal+1/4 at 1st irrigation and full basal applications (Table 1). Further, two equal N splits viz., 1/2 at basal+1/2 at 1st irrigation was significantly superior over 2/3 at basal+1/3 at 1st irrigation, 3/4 at basal+1/4 at 1st irrigation. Full basal application of N had minimum grain and straw yield and harvest index in both the years of study. The increase in grain and straw yield might be due to continued and timely availability of nitrogen under three splits of nitrogen to malt barley. The assured availability of essential nutrient nitrogen and metabolites, which in turn increased photosynthetic efficiency and accumulation of photosynthates, synchronized to demand for growth and development of each yield component. Gupta *et al.* (2001) and Patel *et al.* (2004) also reported that split application of nitrogen increases the nitrogen use efficiency considerably by supplying nitrogen at the critical stages when the crop nitrogen requirement is more. These results are

in agreement with the experimental findings of Roy and Singh (2006) in malt barley.

Nitrogen application in three equal splits viz., 1/3 at basal+1/3 at 1st irrigation+1/3 at 2nd irrigation also recorded significantly higher grain protein concentration and net returns over two splits viz. 1/2 at basal+1/2 at 1st irrigation, 2/3 at basal+1/3 at 1st irrigation, 3/4 at basal+1/4 at 1st irrigation and full basal applications. Lowest husk content was obtained under three equal split applications of nitrogen, which was statistically at par with 1/2 at basal+1/2 at 1st irrigation and 2/3 at basal+1/3 at 1st irrigation. Full basal treatment of N had maximum husk content (Table 1). Minimum protein concentration in grain of malt barley was recorded under full basal treatment of nitrogen. In the present study, although N application in three splits had increased the protein content in grain of malt barley variety RD-2503 yet it was with in the prescribed limit (9.0 to 11.5%) as per the Indian standards (Verma *et al.*, 2005) under north-west Rajasthan conditions. The probable cause for higher protein concentration in three equal splits was due to the continuity of nutrient availability through split application which led to rational utilization of nutrients by plants, which facilitated higher uptake of nitrogen as per requirement by plants (Roy and Singh, 2006).

Interaction effect

Significant interaction effects between sowing dates, nitrogen levels and its scheduling on pooled basis indicated that significantly

higher grain yield of malt barley was recorded with 90 kg N ha⁻¹ applied in three equal splits under normal sown condition, but the effect of three splits of 90 kg N ha⁻¹ was not observed under late sown conditions compared to two equal splits of 90 kg N. Similarly, when 60 kg N ha⁻¹ was applied in three splits under both the sowing conditions, no significant effect was observed when compared with two equal splits (Table 2).

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