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RESEARCH ARTICLE

Effect of growing environments, levels and scheduling of nitrogen application on growth attribute of malt barley (*Hordeum vulgare* L.) in North-Western Rajasthan

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SUMMARY

The field experiment was conducted to find out the effect of levels and scheduling of nitrogen application on growth parameters of malt barley (*Hordeum vulgare* L.) as affected by sowing dates during winter seasons of 2005-06 and 2006-07. The results showed that significantly higher growth attributing characters viz., leaf weight, stem weight, dry matter accumulation and heat unit efficiency of malt barley at 60 DAS, anthesis, 10 days after anthesis and at physiological maturity and spike weight only at anthesis, 10 days after anthesis and at physiological maturity of malt barley was observed under normal sown condition compared to late sown condition. Further, application of increasing levels of nitrogen from 60 to 90 kg ha^{-1} significantly enhanced plant height, total number of tillers, leaf weight, stem weight, dry matter accumulation and heat unit efficiency of malt barley at 60 DAS, anthesis, 10 days after anthesis and at physiological maturity and spike weight only at anthesis, 10 days after anthesis and at physiological maturity of malt barley. Scheduling of nitrogen at 1/3 as basal + 1/3 at Ist irrigation + 1/3 at IInd irrigation brought a substantial improvement in growth attributing characters *viz.*, leaf weight, stem weight, spike weight, dry matter accumulation and heat unit efficiency at anthesis, 10 days after anthesis and at physiological maturity of malt barley.

Key Words : Plant height, Total number of tillers, Leaf weight, Stem weight, Spike weight, Dry matter accumulation, Heat unit efficiency, Nitrogen levels, Growing environments, Nitrogen scheduling, Malt barley

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Use of barley in malt industry is most significant out of its all uses where it is being used in making beer, different type of alcohol. Both barley grains and straw are highly digestible compared to wheat because they do not contain gluten. The length of phenological stages and the rates of growth, the crop within each stage are dependent on the complex interaction among genotypes, sowing dates, plant density and other management practices further more on climate and soil conditions. It is an established fact that growth and development of barley, apart from being governed by genetic factors, depends largely on a number of environmental factors of which climate and inputs, particularly the scheduling of nutrition are most important.

Nitrogen is considered as most important element in production of cereals. Barley crop has also been found to respond significantly to varying levels to nitrogen fertilizations. Time of application of nitrogen is known to exert considerable influence on the yield and quality of crop. The research work on the time of application of nitrogen fertilizers revealed that the nitrogenous fertilizers should be suitably adjusted to duration of maximum uptake rate as nitrogen is

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observed in the proportion of amount of dry matter accumulation (Sharma *et al.*, 1998).

MATERIAL 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. The treatments comprised of 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 of nitrogen application (Full basal, 3/4 at basal + 1/4 at 1st irrigation, 2/3 at basal + 1/3 at Ist irrigation, 1/2 at basal + 1/2 at Ist irrigation and 1/3 at basal + 1/3 at Ist irrigation + 1/3 at IInd irrigation) as sub plot treatments and were laid out in split plot design with four replications. Nitrogen was applied as per treatments and full dose of phosphorus (40 kg P_2O_5 ha^{-1}) and potassium (30 kg K_2O ha^{-1}) was drilled the time of sowing. 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. Barley plants selected randomly were uprooted at each stage from each plot in a one meter row length. Leaves, stems and spikes, if emerged were separated with a scissors and sun dried for two days. The sun dried plant parts were then oven dried at 70 ^{0}C to a constant weight and dry weight thus recorded for each part was averaged to record as leaf weight, stem weight and spike weight in g / meter row length, respectively. The dry weights of leaves, stems and spikes were added to record as dry matter production per meter row length. Accumulated heat units up to each phenophase were worked out by the method as described by Iwata, 1975 as under mathematically, it can be expressed as:

$$\text{Accumulated heat units or GDD (degree}-\text{day}^{-1}) = \sum_{i=1}^{n}\{(T_{max}+T_{min})/2 - Tb\}$$

where,

T_{max} is maximum temperature, T_{min} is minimum temperature of the day and T_b is the lowest temperature at which there is no growth which is also called base temperature, it is taken as 4^{o}C for barley. The accumulated heat units at 30 DAS, 60 DAS, anthesis, 10 days after anthesis (DAA) and physiological maturity stage were used to calculate heat unit efficiency (HUE) of barley.

Mathematically, it can be expressed as :

$$\text{Heat unit efficiency (kgha}^{-1}\text{degree}-\text{day}^{-1}) = \frac{\text{Biomass yield (kg ha}^{-1})}{\text{Accumulated heat units (degree}-\text{day}^{-1})}$$

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in following heads:

Effect of growing environments :

Data in Table 1 revealed that their was no influence of sowing date on plan stand, plant height and total number of

Table 1 : Effect of growing environments, nitrogen levels and scheduling of nitrogen application on plant stand, plant height, total number of tillers and leaf weight / meter row length of malt barley (pooled data)

Treatments	Plant stand at 20 DAS / meter row length	Plant height (cm) at physiological maturity	Total number of tillers / m row length		Leaf weight (g) / meter row length				
			60 DAS	Physiological maturity	30 DAS	60 DAS	Anthesis	10 Days after anthesis	Physiological maturity
Growing environments									
Normal sown	25.01	71.86	72.44	66.89	5.23	8.68	34.61	32.00	26.48
Late sown	24.77	72.13	70.52	64.67	5.18	8.42	31.97	29.56	25.53
CD (P=0.05%)	NS	NS	NS	NS	NS	0.13	0.79	0.78	0.50
Nitrogen levels									
60 kg/ha	24.80	70.04	66.29	62.45	5.18	8.42	30.20	29.70	25.25
90 kg/ha	24.99	73.95	76.67	69.11	5.24	8.69	36.37	31.86	26.76
C.D. (P=0.05%)	NS	2.36	2.38	2.33	NS	0.13	0.79	0.78	0.50
Scheduling of nitrogen application									
Full basal	24.73	70.06	69.66	63.75	5.26	8.45	32.74	29.93	25.37
3/4 Basal + 1/4 at Ist irrigation	24.85	70.70	70.63	64.85	5.24	8.51	33.10	30.41	25.72
2/3 Basal + 1/3 at Ist irrigation	24.91	71.64	71.68	65.88	5.20	8.55	33.69	30.84	25.95
1/2 Basal + 1/2 at Ist irrigation	24.92	73.69	72.38	67.04	5.18	8.61	33.96	31.23	26.33
1/3 Basal + 1/3 at Ist irrigation + 1/3 at IInd irrigation	25.06	73.88	73.06	67.38	5.16	8.63	34.15	31.48	26.67
C.D. (P=0.05%)	NS	NS	NS	NS	NS	NS	0.75	0.87	0.55

NS- Nitrogen scheduling

tillers of malt barley on pooled basis. The data (Table 3) further revealed that the normal sown malt barley produced significantly higher leaf dry matter accumulation at 60 DAS, anthesis, 10 days after anthesis (DAA) and at physiological maturity. This may due to significantly higher leaf, stem and spike weight was recorded under normal sown condition at their respective growth stages. It is further confirmed from higher heat unit efficiency at different growth stages under

Table 2 : Effect of growing environments, nitrogen levels and scheduling of nitrogen application on stem and spike weight / meter row length of malt barley at different stages (pooled mean)

Treatments	Stem weight/meter row length (g)					Spike weight/meter row length (g)		
	30 DAS	60 DAS	Anthesis	10 Days after anthesis	Physiological maturity	Anthesis	10 Days after anthesis	Physiological maturity
Growing environments								
Normal sown	1.95	19.56	47.06	48.18	44.42	106.97	138.58	170.72
Late sown	1.93	18.96	44.10	45.22	41.95	99.36	122.86	163.60
C.D. (P=0.05%)	NS	0.32	0.71	0.71	0.61	1.04	1.14	1.72
Nitrogen levels								
60 kg/ha	1.93	18.98	43.06	44.18	40.74	94.99	122.56	158.86
90 kg/ha	1.94	19.54	48.09	49.21	45.64	111.34	138.88	175.46
C.D. (P=0.05%)	NS	0.32	0.71	0.71	0.61	1.04	1.14	1.072
Scheduling of nitrogen application								
Full basal	1.96	19.04	44.51	45.63	41.97	100.83	127.55	163.27
3/4 Basal + 1/4 at Ist irrigation	1.95	19.17	45.18	46.30	42.44	102.08	129.16	165.17
2/3 Basal + 1/3 at Ist irrigation	1.93	19.28	45.65	46.77	43.23	103.39	130.78	167.49
1/2 Basal + 1/2 at Ist irrigation	1.92	19.38	46.07	47.19	43.89	104.27	132.67	169.41
1/3 Basal + 1/3 at Ist irrigation						105.25	133.44	170.46
+ 1/3 at IInd irrigation	1.92	19.44	46.49	47.61	44.41			
C.D. (P=0.05%)	NS	NS	0.89	0.89	0.81	1.07	1.74	1.79

NS- Nitrogen scheduling

Table 3 : Effect of growing environments, nitrogen levels and scheduling of nitrogen application on dry matter accumulation /meter row length and heat unit efficiency of malt barley at different stages (pooled mean)

Treatments	Dry matter accumulation / meter row length (g)					Heat Unit Efficiency (kg ha^{-1} degree-day^{-1})				
	30 DAS	60 DAS	Anthesis	10 Days after anthesis	Physiological maturity	30 DAS	60 DAS	Anthesis	10 Days after anthesis	Physiological maturity
Growing environments										
Normal sown	7.18	28.24	106.97	138.58	170.72	0.77	1.76	5.53	6.11	5.35
Late sown	7.11	27.39	99.36	122.86	163.60	0.96	1.87	5.27	5.52	5.19
C.D. (P=0.05%)	NS	0.36	1.04	1.14	1.72	0.009	0.02	0.05	0.05	0.05
Nitrogen levels										
60 kg/ha	7.10	27.39	94.99	122.56	158.86	0.86	1.79	4.97	5.46	5.01
90 kg/ha	7.18	28.23	111.34	138.88	175.46	0.87	1.85	5.82	6.18	5.53
C.D. (P=0.05%)	NS	0.36	1.04	1.14	1.072	NS	0.02	0.05	0.05	0.05
Scheduling of nitrogen application										
Full basal	7.22	27.50	100.83	127.55	163.27	0.87	1.80	5.28	5.68	5.14
3/4 Basal + 1/4 at Ist rrigation	7.18	27.68	102.08	129.16	165.17	0.87	1.81	5.34	5.75	5.21
2/3 Basal + 1/3 at Ist rrigation	7.14	27.83	103.39	130.78	167.49	0.86	1.82	5.41	5.82	5.28
1/2 Basal + 1/2 at Ist rrigation	7.10	27.99	104.27	132.67	169.41	0.86	1.83	5.46	5.91	5.34
1/3 Basal + 1/3 at Ist rrigation	7.08	28.07	105.25	133.44	170.46	0.85	1.83	5.51	5.94	5.37
+ 1/3 at IInd irrigation										
C.D. (P=0.05%)	0.09	NS	1.07	1.74	1.79	NS	NS	0.06	0.08	0.06

NS- Nitrogen scheduling

normal sown condition (Tables 1, 2 and 3). Data revealed that significantly higher leaf and stem weight was recorded under normal sown condition at 60 DAS, anthesis, 10 days after anthesis and at physiological maturity, similarly, spike weight was also significantly higher at anthesis, 10 days after anthesis and at physiological maturity and consequently increased. The dry matter accumulation significantly higher their respective stages. This may due to significantly higher heat unit efficiency of barley under normal sown conditions in Table 3 (Gupta *et al.*, 2001). The data in Table 1 and 2 further revealed that application of 90 kg N ha^{-1} recorded significantly higher leaf and stem weight at was recorded. Under normal sown conditions, the vegetative phase experienced optimum temperature conditions while under late sown conditions, steep rise in temperature at this stage reduced the duration of vegetative phase as well as growth stages. As a consequence of favorable climatic conditions, improvement in growth attributing characters was also observed by Gupta *et al.* (2001).

Effect of nitrogen levels :

Data in Table 1 revealed that their was no influence of higher nitrogen levels on plan stand, plant height and total number of tillers of malt barley on pooled basis. The data (Table 3) further revealed that the 90 kg N ha^{-1} barley produced significantly higher dry matter accumulation at 60 DAS, anthesis, 10 days after anthesis and at physiological maturity, there was no significant effect on dry matter accumulation of nitrogen levels at 30 DAS. Significantly higher leaf, stem and spike weight recorded under 90 kg N ha^{-1} at 60 DAS, anthesis and respective growth stages except 30 DAS (Table 1 and 2). The magnitude of increase in plant height, total number of tillers, leaf weight, stem weight, spike weight, dry matter accumulation and heat unit efficiency at physiological maturity was 5.58, 10.66, 5.98, 12.03, 10.97, 10.45 and 10.38 per cent under 90 kg N ha^{-1} as compared to 60 N ha^{-1}on pooled basis, respectively. An improvement in growth components due to nitrogen might 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 tillering stage might have ultimately increased growth attributes of barley (Singh and Singh 2005).

Effect of scheduling of nitrogen application :

Table 1 further, revealed that their was no influence of scheduling of nitrogen application on plant stand, plant height and total number of tillers of barley. The data (Table 3) further, revealed that the nitrogen applied in three equal splits, malt barley produced significantly higher dry matter accumulation at 30 DAS, anthesis, 10 DAS anthesis (DAA) and physiological maturity, and their was no significant effect on dry matter accumulation of scheduling of nitrogen application at 60 DAS over 3/4 at basal + 1/4 at I^{st} irrigation and full basal. This may due to significantly higher leaf, stem and spike weight was recorded nitrogen application in three equal splits at their respective growth stages except 60 DAS (Table 2). It is further confirmed higher heat unit efficiency was recorded at different growth stages under three N equal splits (Table 3). Leaching and volatilization losses of nitrogen particularly under loamy sand soil result in low availability of nitrogen in basal application which might be unable to fulfill the supply of N at critical growth stage of plants. Hence, the marked improvement in growth parameters, due to split application of N could be ascribed to rational utilization of N at its critical growth stages which play a potential role in modifying plant environment *vis-à-vis* better growth and development of the crop. Similar findings were also reported by Singh and Singh (2005) at Varanasi in barley.

Interaction effect :

Interaction effect of growing environments and nitrogen levels was significant on spike weight at anthesis, dry matter accumulation and heat unit efficiency at physiological maturity of barley (Table 4). The maximum and significantly higher spike weight (27.71g), dry matter accumulation (179.90 g) and heat unit efficiency (5.64 kg ha^{-1} degree-day^{-1}) were recorded in normal sown with the application of 90 kg N ha^{-1} but no significant effect of growing environments was observed on dry matter accumulation with on 60 kg N ha^{-1} pooled basis.

Conclusion :

Keeping in view the objectives framed for undertaking the study and the results obtained after experimental period, under mentioned conclusion may be drawn. Application of nitrogen @ 90 kg N ha^{-1} in three splits as 1/3 at basal + 1/3 at

Table 4 : Interaction effect of growing environments and nitrogen levels on spike weight at anthesis, dry matter accumulation and heat unit efficiency at physiological maturity of malt barley (pooled mean)

	Spike weight (g) at anthesis			At physiological maturity					
				Dry matter accumulation (g)			Heat unit efficiency (kg ha^{-1} degree-day^{-1})		
SXN	N_1	N_2	Mean	N_1	N_2	Mean	N_1	N_2	Mean
S_1	94.30	91.44	92.87	161.54	179.90	170.72	5.06	5.64	5.35
S_2	105.34	100.78	103.06	156.17	171.02	163.60	4.95	5.42	5.19
Mean	99.82	96.11	97.97	158.86	175.46	167.16	5.01	5.53	5.27
S.E.±	0.97			1.16			0.04		
C.D.5%	2.04			2.44			0.08		

I[st] irrigation + 1/3 at II[nd] irrigation with normal sown proved to be the best practice for different growth characters of malt barley.

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