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Review/Overview

Effect of nitrogen on yield and quality of barley (*Hordeum vulgare*) genotypes

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 2011–12 at Hisar, to study the effect of nitrogen levels on yield and nitrogen-use efficiency of barley (*Hordeum vulgare* L.*)* genotypes. Grain yield (4.50 t/ha) and straw yield (5.99 t/ha) showed significant increase up to 90 kg N/ha. Genotype 'DWR 91' being equally efficient in productivity with 'DWRUB 52' and 'BH 885' was significantly superior to 'DWRUB 64' and 'DWR 73'. The highest protein content (11.18%), husk content (11.97%) and hectoliter weight (64.71 kg/hl) were obtained with 120 kg N/ha, which was statistically at par with 90 kg N/ha and significantly higher than control, 30 and 60 kg N/ha. Significantly higher malt recovery (88.90%) was recorded with control (0 kg N/ha).

***Key words* :** Barley, Genotypes, Nitrogen levels, Nitrogen-use efficiency, Quality

Barley is the world's fourth most important cereal crop after wheat, rice and maize. It is grown throughout the temperate and tropical region of the world. It is usually used as food for human beings and feed for animals and poultry. It is also a valuable input for industries for extracting malt. In the world, it has 48.6 million ha and 134.2 million tonnes production in 2011–12 (FAOSTAT, 2013). In India, it is grown on 649.7 thousand hectare area, which is largely confined to Uttar Pradesh, Punjab and Haryana, having 1,608 thousand tonnes production and 2,480 kg/ha productivity in 2011–12 (AICWBIP, 2012). Sharma *et al.* (2001) reported that increasing dose of nitrogen results in increasing absorption of nitrogen by the barley plants and consequently higher protein content in grain, which is an undesirable feature from point of view of malting quality. The consistent increase of domestic demand of malting barley has lead to the development of cultivars with superior malting quality. Kaur and Singh (2011) reported varietal and quality variation in barley. Since nitrogen is deficient in most of the soil, there is need to study the graded dose of nitrogenous fertilizer being variability of new genotypes to respond this nutrient. Keeping the above in consideration, the present study was taken to find out the optimum dose of nitrogen to get good quality of barley for higher malt and grain yield.

The field experiment was carried out at Research farm of CCS Haryana Agricultural University during the winter (*rabi*) season of 2011–12. The soil was sandy loam, with pH 8.3, low in available nitrogen (133 kg/ha), medium in available phosphorus (16 kg/ha) and high in available potash (328 kg/ha). The experiment was laid out in split-plot design with 3 replications keeping 5 nitrogen levels (0, 30, 60, 90 and 120 kg/ha) in main plots and 5 genotypes ('DWR 91', 'DWRUB 64', 'DWRUB 52', 'DWR 71' and 'BH 885') in sub-plots. Nitrogen was applied in 2 equal splits–sowing and first irrigation (45 days after sowing) stage as per treatment; however, phosphorus was applied @ 30 kg/ha in the form of single superphosphate as a basal dose. The crop was sown on 16 December 2011 using a seed rate of 100 kg/ha with a row-to-row spacing of 18 cm and was harvested on 20 April 2012. Two irrigations were given to the crop. Average plant height of 5 tagged plants in the plot was recorded. Dry matter of the above-ground parts was recorded from 1 m row length. The yield attributes (effective tillers/m row length, grains/ear and 1,000-grain weight) were recorded at harvesting. The grain and straw yield of net plot were converted into t/ha. Representative samples were tested for various grain and malt quality characteristics. Nitrogen content in the grain was determined by Nessler's Reagent Method as described by Jackson (1973). The percentage of protein in grain was calculated by multiplying N content (%) of grain with 6.25. Hectoliter weight was measured by using the test weight apparatus designed by the Directorate of

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Wheat Research, Karnal and results are expressed as (kg/hl). Husk content was determined as per Cook (1962). Malting of barley grains were carried out as per the method suggested by Singh and Sosulski (1985).

The various efficiencies were calculated by using the following formulae:

Agronomic N efficiency (kg yield increase per kg N applied) = $(Y_t - Y_0) / N_a$

Physiological N efficiency (kg yield increase/kg increase in N uptake) = $(Y_t - Y_0) / (U_t - U_0)$

Partial factor productivity (kg harvest product/kg N applied) = Y_t / N_a

Apparent recovery efficiency (kg increase in uptake/kg N applied) = $(U_t - U_0) / N_a$

where, Y_t = Grain yield in the test treatment (kg/ha); Y_o = Grain yield in the control plot (kg/ha);

U_t = Total N uptake in the test treatment (kg/ha); U_o = Total N uptake in the control plot (kg/ha);

N_a= N applied to the test treatment (kg/ha)

Application of 120 kg N/ha resulted in significant higher grain and straw yield than control (0 kg N/ha), 30 and 60 kg N/ha, but at par with 90 kg N/ha. Increased grain and straw yield owing to nitrogen application could be ascribed to improved biomass production and yield attributes, viz. effective tillers, spike length, grains/spike and 1,000-grain weight. Application of 30, 60, 90 and 120 kg N/ha lead to 23.5, 41.5, 53.6 and 56.7% increase in grain yield, respectively, over the control. Positive effect of nitrogen on grain yield was reported by Kaur and Singh (2011). There were significant variations in growth and yield attributes, grain and straw yield among barley genotypes. Genotype 'DWR 91' produced significantly taller plants and more dry matter than the other genotypes. Highest grain yield was obtained with 'DWR 91', which was at par with 'DWRUB 52' and 'BH 885' but significantly higher than 'DWRUB 64' and 'DWR 73' genotypes. 'DWR 91' gave 8.35 and 7.00% higher yield than 'DWR 73' and 'DWRUB 64' respectively. Genotypic variation in yield and yield attributes was reported by Sharma *et al.* (2007).

The maximum protein content (11.18%) was obtained with 120 kg N/ha, which was significantly higher than the control (0 kg N/ha), 30 and 60 kg N/ha, but was on a par with 90 kg N/ha. Significant increase in grain nitrogen content with the increase in nitrogen could be attributed to more nitrogen uptake by the plant and more translocation of nitrogen to grain. Nitrogen being the precursor of protein increased the grain protein content accordingly. The husk content and hectoliter weight were also higher at 120 kg N/ha. The husk content increased significantly up to 90 kg N/ha, whereas hectoliter weight increased significantly up to 60 kg N/ha. The malt recovery decreased with each increment of nitrogen dose. The higher malt recovery was obtained with the control (0 kg N/ha), which was significantly higher than 30, 60, 90 and 120 kg N/ha. The higher nitrogen levels produced higher protein content in grain, which is undesirable for malt recovery, as the malt extract is inversely related to grain protein content (Verma *et al.*, 2003). Malt recovery decreased with the increase in nitrogen levels, but the malt yield was maximum at 120 kg N/ha, which was owing to higher grain yield at 120 kg N/ha than lower nitrogen levels. Genotype 'BH 885' recorded

Table 1. Effect of nitrogen levels on growth, yield attributes and yield of barley genotypes at harvest

Treatment	Height(cm)	Dry matter (g)	Effective tillers (no.)	Spike length(cm)	Grains/ spike(no.)	1,000-grain weight(g)	Grain yield (t/ha)	Straw yield (t/ha)
Nitrogen (kg/ha)								
0	76.0	370.8	71.9	6.7	22.8	46.9	2.93	4.25
30	87.0	456.8	78.9	8.1	25.3	48.4	3.62	4.90
60	93.7	486.1	87.4	8.8	26.5	49.6	4.14	5.60
90	97.5	501.4	92.0	9.2	27.5	50.6	4.50	5.99
120	99.8	508.5	94.1	9.3	28.1	50.9	4.59	6.10
SEm±	1.0	2.3	1.4	0.1	0.5	0.7	0.05	0.06
CD (P=0.05)	3.3	7.5	4.4	0.3	1.5	2.1	0.18	0.19
Genotypes								
'DWR 91'	94.7	509.6	84.1	9.2	21.8	63.5	4.12	5.68
'DWRUB 64'	92.7	474.1	80.4	8.2	39.9	43.1	3.85	5.42
'DWRUB 52'	89.3	471.2	88.2	8.2	23.8	44.9	4.00	5.29
'DWR 73'	90.1	436.4	85.2	8.1	22.3	44.6	3.80	5.27
'BH 885'	87.2	432.5	86.4	8.5	21.9	49.9	4.00	5.19
SEm±	0.6	2.8	1.6	0.1	0.3	0.4	0.07	0.09
CD (P=0.05)	1.8	8.1	4.6	0.41	0.7	1.3	0.20	0.26

significantly higher protein content than the other genotypes; and 'DWRUB 64' and 'DWRUB 52' being at par with each other in respect to protein content in grains. Genotype, 'DWRUB 52' recorded significantly higher hectoliter weight than the other genotypes, viz. 'DWR 91', 'DWRUB 64', 'DWR 73' and 'BH 88'. 'DWRUB 64', 'DWR 73' and 'BH 885' were found at par in relation to hectoliter weight. The husk content could not be influenced significantly by the genotypes. Genotype 'DWR 91' gave higher malt recovery of 87.20%, which was significantly higher than 'BH 885' (84.72%) but at par with 'DWRUB 64' (86.43%), 'DWRUB 52' (86.32%) and 'DWR 73' (86.32%). Higher malt yield was also recorded with 'DWR 91' as compared to the rest of genotypes which was resulted owing to higher malt recovery and more grain yield.

Nitrogen application had a significant influence on nitrogen uptake of barley. With the successive increase in N levels from 0 to 90 kg N/ha, the uptake of nitrogen in grain increased significantly. Application of 90 kg N/ha registered 108.5, 49.8 and 16.8% higher uptake of nitrogen in grain and 126.0, 51.0 and 16.3% in straw, respec-

Table 2. Effect on nitrogen on grain quality of barley genotypes

Treatment	Protein (%)	Hectoliter weight (kg/hl)	Husk content (%)	Malt recovery (%)	Malt yield (t/ha)
Nitrogen (kg/ha)					
0	7.99	61.33	10.36	88.90	2.60
30	8.99	62.80	10.85	87.29	3.16
60	10.03	63.66	11.42	85.81	3.56
90	10.84	64.07	11.73	84.86	3.82
120	11.18	64.71	11.97	84.09	3.86
SEm±	0.20	0.31	0.08	0.31	-
CD (P=0.05)	0.65	1.03	0.25	1.03	-
Genotypes					
'DWR 91'	9.18	63.97	11.05	87.20	3.59
'DWRUB 64'	9.42	62.20	11.39	86.43	3.33
'DWRUB 52'	9.62	64.70	11.21	86.32	3.45
'DWR 73'	10.08	62.85	11.66	86.32	3.28
'BH 885'	10.70	62.84	11.03	84.72	3.39
SEm±	0.16	0.25	0.17	0.50	-
CD (P=0.05)	0.46	0.73	N.S.	1.43	-

Table 3. Effect of nitrogen levels on nitrogen uptake and nitrogen-use efficiency of barley genotypes

Treatment	N uptake (kg/ha)		Nitrogen-use efficiencies			PNUE	Net returns	Benefit:
	Grain	Straw	PFP	ANUE	ARE (%)		($\times 10^3$₹/ha)	cost ratio
Nitrogen (kg/ha)								
0	37.5	12.3	-	-	-	-	10.80	1.43
30	52.2	18.4	120.7	23.4	69.7	33.0	17.36	1.65
60	66.9	23.9	69.2	20.3	68.4	29.6	23.30	1.86
90	78.2	27.8	50.1	17.5	62.6	27.9	27.02	1.98
120	81.2	30.2	38.3	13.9	51.4	26.9	26.67	1.99
SEm±	1.1	0.9	1.0	0.4	0.8	0.9	-	-
CD (P=0.05)	3.7	3.0	3.6	1.4	2.8	3.0	-	-
Genotype								
'DWR 91'	62.0	23.8	72.0	19.0	67.9	27.6	23.29	1.86
'DWRUB 64'	59.1	22.9	67.3	17.0	56.2	31.6	20.46	1.76
'DWRUB 52'	61.9	19.9	71.4	20.0	64.2	30.7	21.52	1.80
'DWR 73'	61.9	21.9	66.9	18.9	56.3	33.7	19.55	1.72
'BH 885'	69.9	21.6	70.3	19.0	71.4	26.4	21.38	1.79
SEm±	1.4	0.7	1.5	0.6	0.9	0.9	-	-
CD (P=0.05)	4.0	2.1	N.S.	1.8	2.7	2.6	-	-

PFP, Partial factor productivity (kg harvest product/kg N applied); ANUE, Agronomic N-use efficiency (kg yield increase/kg N applied); ARE (%), Apparent recovery efficiency (kg increase in N uptake/kg N applied × 100); PNUE, Physiological N-use efficiency (kg yield increase/kg increase in uptake) tively, over control, 30 and 60 kg N/ha. Genotype 'BH 885' recorded significantly higher nitrogen uptake (69.9 kg/ha) in grain than rest of the genotypes, whereas maximum nitrogen uptake in straw was registered in 'DWR 91'. Nitrogen-use efficiency parameters, viz. partial factor productivity (PFP), agronomic N-use efficiency (ANUE), apparent recovery efficiency (ARE) and physiological N-use efficiency (PNUE), decreased with the successive increase in nitrogen levels from 30 to 120 kg N/ha. The lowest PFP was obtained with 120 kg N/ha, indicating negative relationship of PFP with nitrogen. Meena *et al.* (2011) also reported the decrease in nitrogen-use efficiency with increase in nitrogen levels. Genotype 'DWRUB 52' recorded significantly higher ANUE than 'DWRUB 64'. With respect to ARE, 'BH 885' recorded 5.1, 27.0, 11.2 and 26.8% increase over 'DWR 91', 'DWRUB 64', 'DWRUB 52' and 'DWR 73' respectively. The PNUE of 'DWR 73' was significantly higher than 'DWR 91', 'DWRUB 52' and 'BH 885'. The PFP remained unaffected due to nitrogen levels. The highest benefit: cost ratio was observed with 120 kg N/ha. Among genotypes 'DWR 91' produced maximum benefit: cost ratio being 5.6, 3.3, 8.1 and 3.9% higher than 'DWRUB 64', 'DWRUB 52', 'DWR 73' and 'BH 885' respectively.

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