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YIELD AND QUALITY OF MALT BARLEY (*Hordeum distichum* L.) AS INFLUENCED BY SEED RATE, ROW SPACING AND NITROGEN LEVELS

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ABSTRACT

A field experiment was conducted during *rabi* season 2014-15 at Agronomy Research Farm, CCSHAU, Hisar (India) to assess the effect of seed rate, row spacing and nitrogen on yield and quality of malt barley. The experiment comprised of two seed rates (87.5 and 100 kg ha^{-1}) and three spacings (22, 20 and 18 cm) in main plots and four nitrogen levels (60, 75, 90 and 105 kg N ha^{-1}) in sub-plots, laid out in a split plot design. The application of 100 kg seed ha^{-1} significantly improved grain, protein and malt yield over 87.5 kg seed ha^{-1}. However, the quality parameters like bold grain, hectoliter weight, starch content, protein content, husk content and malt recovery were at par under both the seed rates. Row spacing of 18 cm gave significantly higher grain and malt yield as compared to 22 cm but was at par with 20 cm spacing. The grain, protein and malt yield increased significantly up to 90 kg N ha^{-1}. It appears that 100 kg ha^{-1} seed rate, 18 or 20 cm row spacing and 90 kg N ha^{-1} are optimum for most yield and quality parameters for two rowed barley under Haryana conditions.

Key words: Malt recovery, nitrogen, protein, row spacing, seed rate, yield

INTRODUCTION

The two-rowed barley (*Hordeum distichum* L.) can be grown in a wide range of environment as compared to other cereals and has been described as a cosmopolitan crop (Hingonia *et al.*, 2016). It has immense potential as quality cereal especially with respect to nutritional and medicinal value. Malt is the second largest use of barley; and malting barley is grown as a cash crop in many developed and developing countries including India. It is a preferred cereal for malting because its glumes and hull are firmly cemented to the kernel and remain attached to the grain after threshing (Singh *et al*., 2012). The malting barley has non-shattering spikes, plump kernels and higher bushel weight. It usually has lower protein content (Johnston and Helm, 2009) but shows more uniform germination, needs shorter steeping and has less protein in the extract which makes the beer cloudy. The use of two-rowed barley for malting and brewing industry has picked up recently with increased consumption of beer and other malt-based products in many countries (Gupta *et al*., 2010).

Different management practices influence the productivity and quality parameters of barley, which have direct bearing on its malt quality. The agronomic practices for malt-grade barley are altogether different from its grain crop. Amongst these, seed rate, row spacing and nitrogen levels greatly affect the yield and quality of grain and malt. Nitrogen is the most important factor for realizing maximum crop yield potential as it is the main constituent of amino acids that are precursors to protein (Kakraliya *et al*., 2017a,b). The yield of malt barley is significantly influenced by the application of nitrogen (Paramjit *et al.*, 2001). However, high protein content in grain is undesirable as malt extract is inversely related to grain protein content (Verma *et al*., 2003). The optimum use of nitrogen is pre-requisite for the production of malt barley. The work done on these aspects in two-rowed barley is meager. Hence, the present study was aimed to assess the effect of seed rate, row spacing and nitrogen levels on the quality parameters of malt barley.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* 2014-2015 at Research Farm, Department of Agronomy, CCSHAU, Hisar, Haryana (India). The location is situated at 29°10' N latitude and 75° 46' E longitude at an elevation of 215.2 m amsl. The soil of the site was sandy loam, slightly alkaline (pH 8.3), low in organic carbon (0.32%) and available nitrogen (135 kg N ha^{-1}), medium in available phosphorus (17 kg P ha^{-1}) and high in available potassium (334 kg K ha^{-1}). During crop growth, the mean weekly maximum and minimum temperature ranged from 13.8 to 32.4ºC and 4.0 to 17.6ºC, respectively, with rainfall of 225.8 mm and total pan evaporation of 298.9 mm. The experiment consisted of two seed rates (87.5 and 100 kg ha^{-1}) and three spacings (22, 20 and 18 cm) in main plots and four nitrogen levels (60, 75, 90 and 105 kg N ha^{-1}) in sub-plots. The 24 treatment combinations were tested in a split plot design with three replications. The sowing of two-rowed malt barley cv. 'BH-885' was done on 28 Nov., 2014 by pora method at 5-6 cm depth as per treatments. The recommended full dose of P and K and half dose of N, as per treatments, were applied at sowing time and the rest N dose was top dressed at 1st irrigation (45 DAS). Other practices followed were as per the package of practices of CCSHAU, Hisar (Anonymous, 2014).

The proportion of bold and thin grains was determined by using German Sortimate, in which 100 g barley grains sample was passed through sieves of different sizes *viz*., 2.8, 2.5 and 2.2 mm. Bold grains remained above the sieve size of 2.5 mm while thin grains passed through it. The proportion of bold to thin grains was calculated in percentage. The hectoliter weight (kg hL^{-1}) was measured with a hectoliter weight equipment (The test weight instrument developed by Indian Institute of Wheat and Barley Research Karnal, India). The husk content was determined as per Cook (1962). Barley grains, weighing $\geq$25 g, were immersed in 50% H_2SO_4 in a 250 mL beaker for 3 h at room temperature with occasional stirring. The acid was then drained off and grains washed freely with water over a sieve to remove digested husk. Dehusked grains were transferred to 250 mL beaker containing 200 mL 2% calcium carbonate (to neutralize the leftover acid) and kept as such for 15 min. Alkali was drained off and grains again washed freely with water to remove excessive alkali. Dehusked grains were spread thinly over a filter paper for air drying and then weighed. The moisture content was estimated after the samples were fried in an air oven at 130^{0}C for 1 h. The husk content was determined by using following formula:

$$\text{Husk content (\%)} = \frac{W1-W2}{W1} \times 100$$

Where, W_1 = Dry weight of husked barley and W_2 = Dry weight of dehusked barley

The protein and starch contents were analyzed using automatic whole grain analyzer infratech-1241 (FOSS Analytical AB, Sweden). The instrument measures the light transmitted through grain in the range of 850 to 1050 nm. The instrument used five sub-samples of whole grain. The value of constituent was displayed directly as per the software provided in the equipment.

Malting process of barley grains was carried out as per Singh and Sorsulski (1985). Properly cleaned, pre-weighed samples of barley grains were steeped in water at 15^{0}C in an incubator for 60 h. Water was changed after every 10 h and a rest of 1 h was given after 24 h during steeping. The steeped samples, taken in a muslin cloth, were placed in a wooden box with wire-mesh bottom for germination in an incubator at 15^{0}C and relative humidity of >90%. The samples were allowed to germinate for 5 days. Then green malt was kilned in an oven at 45^{0}C for 4 h. Roots from kilned malt were removed and weight of malt and roots recorded separately.

$$\text{Malt recovery (\%)} = \frac{Malt\ weight}{Sample + weight} \times 100$$

Then the malt yield in t ha^{-1} was obtained by using the following formula:

$$\text{Malt yield (t ha}^{-1}\text{)} = \frac{\text{Malt recovery (\%)} \times \text{Grain yield (t ha}^{-1}\text{)}}{100}$$

The experimental data was analyzed by using analysis of variance technique. The significance of treatments was computed by ‘F’ test, and to judge the significant difference between means of two treatments, critical differences were worked out as per Gomez and Gomez (1983).

RESULTS AND DISCUSSION

Effect of seed rate

All the quality parameters, except per cent thin grain, did not differ significantly in both 87.5 and 100 kg ha^{-1} seed rates (Table 1). The probable reason for above observation may be that these parameters are more genetic in nature and are not much influenced by management practices. These findings corroborated with those of EI-Shatnawi *et al*. (2003). However, per cent thin grain significantly decreased with increase in seed rate. This may be due to the fact that under higher seed rate lesser lateral tillers are produced which may have significantly affected bold and uniform grain formation in main tillers. Wade and Froment (2003) attributed increased kernel uniformity with increase in barley seeding rates to the decreased tillering at higher seeding rates.

Maximum protein yield (363.6 kg ha^{-1}) was recorded at seed rate of 100 kg ha^{-1} which was significantly higher by 5.6% than the protein yield found at seed rate of 87.5 kg ha^{-1} (344.3 kg). The malt yield of barley increased significantly with increase in seed rate. At 100 kg ha^{-1} seed rate significantly higher (7.94%) malt yield (2994 kg) was obtained than at 87.5 kg ha^{-1} seed rate. The higher protein and malt yield under higher seed rate, in spite of non-significant increase in their contents, may be attributed to higher grain yield obtained with higher seed rate.

Table 1: Effect of seed rate, row spacing and nitrogen levels on the quality parameters and grain, protein and malt yields of two-rowed barley

Treatments	Bold grain (%)	Thin grain (%)	Hectoliter weight (kg hL^{-1})	Husk content (%)	Starch content (%)	Protein content (%)	Malt recovery (%)	Yields (kg ha^{-1})		
								Grain	Protein	Malt
Seed rate (kg ha^{-1})										
87.5	94.47	1.043^{a}	64.55	11.09	61.73	10.70	86.29	3212^{b}	344.3^{b}	2769^{b}
100.0	95.48	0.812^{b}	64.58	10.95	62.18	10.56	87.11	3440^{a}	363.6^{a}	2994^{a}
SEm±	0.65	0.059	0.24	0.11	0.22	0.09	0.26	23	5.0	22
$CD_{0.05}$	Ns	0.215	ns	ns	Ns	ns	ns	72	15.8	70
Row spacing (cm)										
22	95.59	0.826	64.78	11.11	61.95	10.70	86.10	3209^{b}	343.8	2761^{b}
20	95.12	0.976	64.84	10.83	62.06	10.44	87.10	3352^{a}	350.9	2917^{a}
18	94.23	0.980	64.07	11.13	61.86	10.73	86.89	3416^{a}	367.2	2966^{a}
SEm±	0.79	0.073	0.30	0.04	0.27	0.12	0.32	28	6.2	27
$CD_{0.05}$	Ns	ns	ns	ns	Ns	ns	ns	89	ns	86
Nitrogen levels (kg ha^{-1})										
60	95.43	0.919	64.53	10.61^{b}	63.52^{a}	10.10^{b}	88.61^{a}	3028^{c}	305.5^{c}	2684^{c}
75	95.31	0.955	64.55	10.97^{ab}	62.18^{b}	10.54^{ab}	87.18^{b}	3274^{b}	345.1^{b}	2855^{b}
90	94.49	0.927	64.31	11.15^{ab}	61.74^{b}	10.82^{a}	85.82^{c}	3498^{a}	378.5^{a}	3003^{a}
105	94.69	0.908	64.85	11.36^{a}	60.38^{c}	11.03^{a}	85.18^{c}	3502^{a}	386.8^{a}	2983^{a}
SEm±	0.54	0.086	0.21	0.19	0.27	0.17	0.38	40	9.1	35
$CD_{0.05}$	Ns	ns	ns	0.54	0.80	0.53	1.10	126	27.4	101

Effect of row spacing

The boldness and thinness of barley grains were insignificantly affected by row spacing (Table 1). Likewise, hectoliter weight, starch content, husk content, protein content and malt recovery remained unaffected by changing row spacing. These characters are more of genetic nature and thus not much influenced by the management practices. The observations are in agreement with Minkey *et al*. (1999).

The protein yield did not differ significantly among various row spacing. However, highest malt yield was found in 18 cm row spacing, which was at par with 20 cm row spacing but significantly higher than 22 cm row spacing. The possible reason for this trend appears that the grain yield was higher at narrow row spacing. These findings corroborated the results obtained by Sultana *et al*. (2012).

Effect of nitrogen levels

The nitrogen levels did not significantly affect bold grain, thin grain and hectoliter weight (Table 1). However, highest protein and husk contents were noticed in 105 kg N ha^{-1} treatment and were at par with 90 and 75 kg N ha^{-1} but significantly higher than 60 kg N ha^{-1}. The results are in line with O'Donovan *et al*. (2011), Valkama *et al*. (2013) and Nega *et al.* (2015). Protein and husk contents were positively and highly correlated with nitrogen levels with determination factors as 0.971 and 0.974, respectively (Fig. 1).

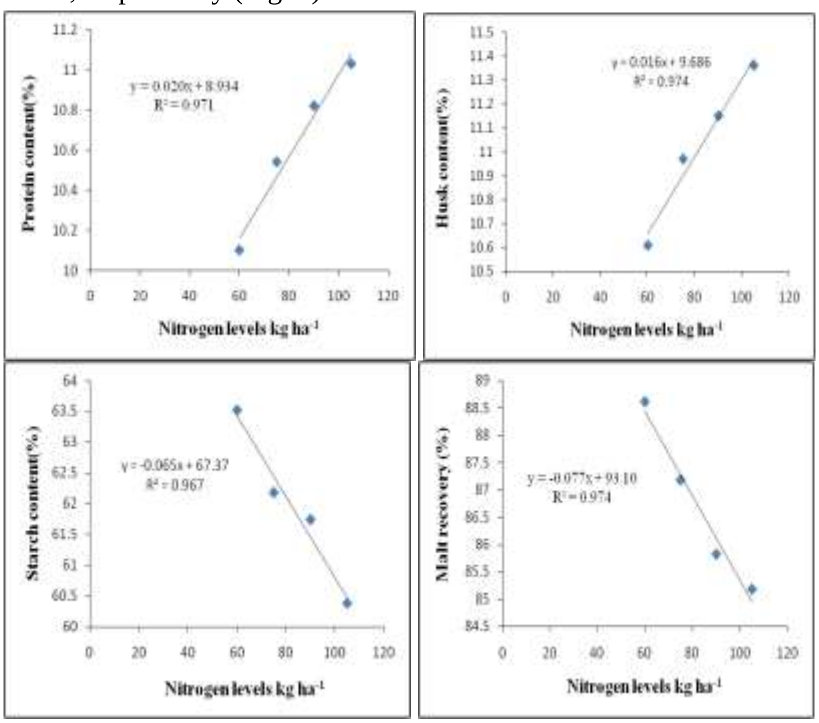

Fig. 1: Relationship of quality parameters with nitrogen levels

Starch content and malt recovery decreased significantly with increase in N levels upto 105 kg N ha^{-1}. The highest values of these parameters were found in 60 kg N ha^{-1} treatment, followed by 75, 90 and 105 kg N ha^{-1}. The results are in unison with Edney *et al*. (2012) and Singh *et al*. (2013). Starch and malt content were negatively but highly correlated with N levels having determination factors of 0.967 and 0.974, respectively (Fig. 1). The high malt extract is normally associated with low protein content in grain (Singh *et al*., 2013) and this relation has truly been noticed in present study with determination factor R^2 = 0.992 (Fig. 2). Malt extract is a key quality indicator as it reflects the beer yield that can be produced from a given quantity of malt. Verma and Singh (1989) and Roy and Singh (2006) reported strong negative correlation between malt extract and protein content. The protein yield in barley varied significantly among various N levels (Table 1). Highest protein yield of 386.8 kg ha^{-1} was found in 105 kg N ha^{-1} which was at par with 90 kg N ha^{-1} (378.5 kg) treatment but significantly higher than 75 kg N ha^{-1} (12.1%) and 60 kg N ha^{-1} (26.6%). The increase in protein yield was 8.4, 13.4 and 16.8% with 75, 90 and

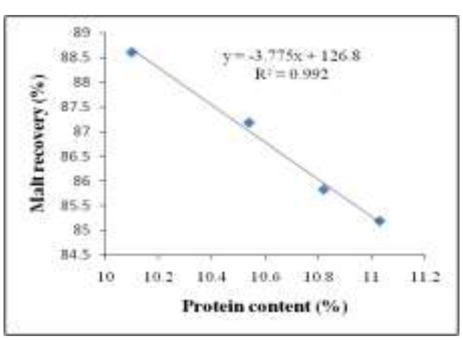

Fig. 2: Relationship of protein content with malt recovery

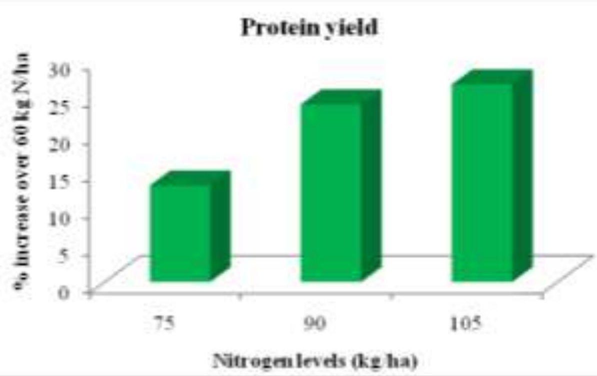

Fig. 3: Effect of nitrogen levels on per cent increase in protein yield

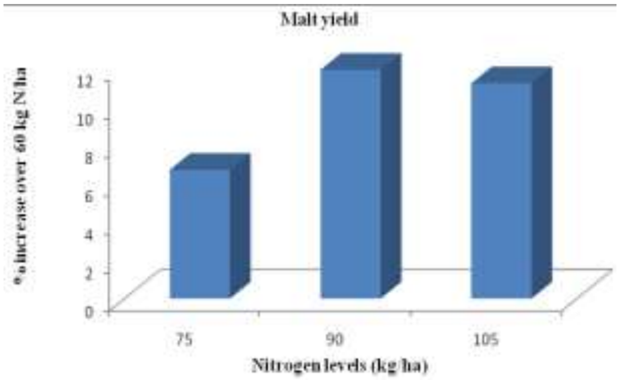

Fig. 4: Effect of nitrogen levels on per cent increase in malt yield

105 kg N ha^{-1} over 60 kg N ha^{-1}, respectively (Fig. 3).

Different levels of N caused significant variations in malt yield and it increased with increase in N level up to 90 kg N ha^{-1} (3003 kg) and thereafter, it decreased slightly at 105 kg N ha^{-1} (2983 kg). However, both these nitrogen levels had significantly higher malt yield than 75 kg N ha^{-1} (2855 kg) or 60 kg N ha^{-1}(2684 kg). The malt yield was 8.4, 13.4 and 16.8% higher than 60 kg N ha^{-1} with 75, 90 and 105 kg N ha^{-1}, respectively (Fig. 4). The increase in malt may be attributed to higher grain yield.

It may be concluded that the application of 100 kg seed ha^{-1} for two-rowed barley was optimum in terms of grain, protein and malt yields. Among row spacing, 18 and 20 cm were at par and significantly better than 22 cm in terms of grain and malt yield. Application of 90 kg N ha^{-1} was optimum with respect to quality parameters as well as grain, protein and malt yield of two rowed barley.

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