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Research Article

Performance of barley varieties for malting quality parameters in north western plains of India

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Abstract

Four barley cultivars were used to study the effect of cultivar and growing location on the grain and malt quality parameters. The results showed that both cultivar and growing location affect the quality parameters and two rowed cultivars have better grain and malt quality traits as compared to six rowed types. In two rowed type barley DWRUB-52 was found better and in six rowed type BH 902 was superior. It has also been observed that well irrigated and cooler regions like Karnal and Pantnagar are also suited to get better malt quality traits.

Keywords: Barley (*Hordeum vulgare* L.), malting quality, protein, hot water extract, diastatic power

1. Introduction

With the growing demand of malting quality barley in India, development of varieties and agrotechnologies is also keeping pace with it. In India barley is mainly grown in the states of Rajasthan, Uttar Pradesh, Punjab and Haryana besides the minor quantities at other places. The malting quality barley should have bold grains with lower protein content and the malt prepared from it should have higher hot water extract value. All these quality parameters are affected by the genotype as well as the growing conditions/environment (Wang *et al.*, 2003; Haslemore *et al.*, 1982; Bleidere, 2008). Two rowed barleys generally have more bold grains and lesser yield as compared to six rowed type (The barley inflorescence is an indeterminate spike that produces three single-flowered spikelets in a distichous manner at each rachis internode that develop into one central and two lateral spikelets. Based upon lateral spikelet/floret size and fertility barley is classified into two different row-types; i.e., two-rowed and six-rowed barley. In two-rowed barley, the central spikelet is fertile and produces grain, and the two lateral spikelets remain sterile. In six-rowed barley, all three spikelets are fertile and develop into grains (Koppolu *et al.*, 2013 and references therein). Two indigenously developed 2-rowed malt barley varieties namely DWRUB 52 and RD 2668 were released in 2007 by CVRC for timely sown conditions of North Western Plain Zones (NWPZ). The variety K 551 released in 1997 is 6-rowed variety, but is being used by industry occasionally for malt purposes. One of the recently released 6-rowed cultivar BH 902, though developed for feed purposes, has been found to possess good percentage of bold grains. NWPZ is one of the major supplier of malt purpose barley being grown under high input conditions. Since barley is being grown under different locations in north western plains of India, it is essential to find out the effect of growing locations on malting quality for future varietal improvement programmes and for the benefit of the malt industry. Therefore, this study was conducted to generate information on the relative values of malting quality parameters in 2-rowed and 6-rowed varieties grown over different locations in north western plain zones of India.

2. Materials and methods

The experiment was conducted during the years 2010-11 and 2011-12 at eight locations i.e. Karnal (29.68° N, 76.98° E), Hisar (29.17° N, 75.72° E), Bawal (28.08° N, 76.58° E), Ludhiana (30.91° N, 75.85° E), Bhatinda (30.2039° N, 74.9426° E), Durgapura (26.92° N, 75.82° E), Mathura (27.5° N, 77.68° E) and Pantnagar (29.05° N, 79.5167° E) located in NWPZ of India. Four cultivars of barley, two each from 2-rowed (DWRUB 52 and RD 2668) and 6-rowed (K 551 and BH 902)were grown in the timely sown conditions (i.e. mid of November) in three replications. The grains were harvested at full maturity and a composite sample was prepared from three replications for analysis at Indian Institute of Wheat &

Barley Research, Karnal. The grains were initially analysed for test weight (kg/hectolitre weight), thousand grain weight (TGW), bold and thin grain percentage, husk percentage and crude protein content (dry weight basis) as per the European Brewery Convention (EBC) approved procedures (Analytica-EBC, 1997). Hundred grams grains (>2.5 mm size) were then subjected to malting in Joe White (Australia) micro malting system in the cycle of steeping, germination and kilning for the total duration of 120 hours. The malt was cleaned of sticking roots and then subjected to the analysis of friability percentage, filtration rate and hot water extract (Analytica-EBC, 1997). Diastatic power (DP) of the malt was estimated using Institute of Brewing (IOB) method. Since the pooled samples were obtained from all the locations, year was used as replication to analyse the effect of cultivar and location using the software CropStat 7.2.

3. Results and discussion

3.1 Grain quality

3.1.1 Hectolitre weight: The hectolitre weight was significantly affected by genotype and location and there was uniform effect of growing location on all the four varieties (Table 1). The hectolitre weight was highest in DWRUB 52 (65.5 kg/hl) followed by RD 2668 (62.7 kg/hl), K 551(60.5 kg/hl) and BH 902 (60.4 kg/hl). Since the varieties DWRUB 52 and RD 2668 were specifically released for malt purpose, the hectolitre weight is higher in these two varieties as compared to non-malt purpose varieties. Verma *et al.* (2008) had shown that hectolitre weight is one of the best correlated parameter for malt quality. The effect of location had significant effect on hectolitre weight, but no clear cut differentiation could be made in relation to the locations studied.

Table 1. Effect of variety and location on grain physical parameters

Variety	Location								Mean
	Karnal	*Hisar*	*Bawal*	*Ludhiana*	*Bhatinda*	*Durgapura*	*Pantnagar*	*Mathura*	
Hectolitre weight									
DWRUB52	67.2	64.4	67.7	65.9	65.7	66.8	64.0	61.9	**65.5**
RD2668	63.5	62.5	65.2	62.5	61.5	63.3	64.8	58.6	**62.7**
K551	63.5	58.2	60.9	57.3	61.3	61.8	62.7	58.7	**60.5**
BH902	62.7	59.2	61.6	57.6	62.7	59.5	60.9	58.8	**60.4**
Mean	64.2	61.1	63.8	60.8	62.8	62.9	63.1	59.5	
TCW (g)									
DWRUB52	50.3	46.1	47.9	47.9	45.2	43.9	47.4	46.6	**46.9**
RD2668	43.0	44.4	45.8	47.6	46.6	38.6	43.4	42.2	**43.9**
K551	46.4	42.5	41.7	44.8	43.3	39.0	42.6	45.0	**43.1**
BH902	46.5	44.5	45.9	45.4	43.5	39.9	43.2	43.7	**44.1**
Mean	46.5	44.4	45.3	46.4	44.6	40.3	44.1	44.4	
Bold (%)									
DWRUB52	91.6	82.3	91.8	93.0	73.4	66.5	92.4	83.8	**84.3**
RD2668	71.0	65.8	77.6	74.0	66.9	56.4	69.7	62.6	**68.0**
K551	83.3	60.1	78.6	69.4	66.7	53.8	74.3	77.3	**70.4**
BH902	91.1	90.6	89.4	82.9	80.8	63.0	89.8	85.4	**84.1**
Mean	84.3	74.7	84.3	79.8	72.0	59.9	81.5	77.3	
Thin (%)									
DWRUB52	1.3	1.5	1.0	1.5	4.3	11.0	0.9	1.8	**2.9**
RD2668	7.2	2.5	2.8	4.5	5.0	20.9	3.8	4.8	**6.4**
K551	3.2	8.6	7.6	9.9	7.1	22.0	6.2	5.2	**8.7**
BH902	2.4	2.1	3.8	5.2	3.5	16.5	3.2	3.2	**5.0**
Mean	3.5	3.7	3.8	5.3	5.0	17.6	3.5	3.7	

LSD (5%)	Hectolitre weight	TCW (g)	Bold (%)	Thin (%)
Variety (V)	1.4	1.8	7.9	2.9
Location (L)	1.9	2.5	11.1	4.0
V× L	NS	NS	NS	NS

3.1.2 Thousand grain weight: Thousand grain weight was highest in variety DWRUB 52 over the locations (46.9 g), while there was no significant difference in thousand grain weight among rest of the three varieties (Table 1). Among the locations, lowest values were obtained at Durgapura (40.3 g), while rest of the locations were under the same statistical group. However, highest values (> 46 g) were obtained at Karnal and Ludhiana. Thousand grain weight (g) should be >45 g for 2-rowed barley and > 42 g for 6-rowed barley (Anonymous, 2012).

3.1.3 Grain size: Grain size is an important descriptive trait based on the physiology of the grain. The final grain size is determined by several environmental factors as well as biochemical components within the grain itself (Coventry *et al.*, 2003). The bold grain percentage should be >90% for 2-rowed barley and >80% for 6-rowed barley (Anonymous, 2012). Highest mean bold grain percentage was obtained in DWRUB 52 and BH 902, while varieties RD 2668 and K 551 had lower values (Table 1). Among the locations highest bold grain percentage was obtained at Karnal and Bawal. The varieties RD 2668 and K 551 could not touch the > 90% figure at any of the locations tested. Thin grain percentage was lowest in DWRUB 52 (2.9%) and highest in K 551 (8.7%). There was no significant difference in thin grain percentage across the locations except at Durgapura, where the percentage was high (17.6%). Thin grain percentage should be <3% (Anonymous, 2012). The possible reason for higher thin grain percentage at Durgapura could be the mode of irrigation (sprinkler irrigation) (personal communication), however this needs to be confirmed through further experimentation.

3.1.4 Husk content: Lowest mean value of husk content was obtained in RD 2668 (10.3%), followed by DWRUB 52 (11.1%) and on higher side in K 551 (12.4%) and BH 902 (12.2%). Husk content in malt barley varieties should be < 11.0% (Anonymous, 2012). There was no effect of location on husk content showing that only genotype affected this trait (Table 2).

3.1.5 Protein content: Desirable protein content range for 2-rowed barley is 9.0-11.0% and for 6-rowed barley is 9.0-11.5% (Anonymous, 2012). Barley used for malt should have a grain protein concentration (GPC) below 11.5%, as higher protein content will deteriorate malting produce and final beer quality. However, it is often difficult to keep it below this upper limit, since the GPC is influenced, to a large extent, by both genotype and environment (Bathgate, 1987). In general, high availability of nitrogen and stress situation caused by drought or heat in combination with drought may increase GPC (Coles *et al.*, 1991, Savin & Nicolas, 1996and Weston *et al.*, 1993). Lowest mean protein content was obtained in BH 902 (10.6%), followed by DWRUB 52 (11.0%). The content was on higher side in RD 2668 (11.7%) and K 551 (12.2%) (Table 2). Among the locations, lowest protein content was registered at Bawal (9.2%) and highest at Durgapura (14.6%). Singh *et al.* (2005) studied the malting quality

Table 2. Effect of variety and location on husk and protein content of grain

Variety	Location								Mean
	Karnal	*Hisar*	*Bawal*	*Ludhiana*	*Bhatinda*	*Durgapura*	*Pantnagar*	*Mathura*	
					Husk (%)				
DWRUB52	11.4	12.2	10.2	11.3	10.5	10.8	10.1	13.0	**11.2**
RD2668	10.3	10.7	11.0	10.2	10.1	10.0	9.7	10.6	**10.3**
K551	11.0	14.0	12.6	12.6	12.5	12.3	12.5	11.9	**12.4**
BH902	11.7	12.7	11.3	11.4	11.5	12.7	12.3	14.3	**12.2**
Mean	11.1	12.4	11.2	11.4	11.2	11.4	11.2	12.5	
					Protein (%)				
DWRUB52	10.2	12.3	9.1	11.0	12.0	14.8	9.2	10.1	**11.0**
RD2668	12.0	11.6	9.4	11.1	12.2	15.9	10.7	11.2	**11.7**
K551	12.6	14.4	10.0	12.1	13.4	14.3	11.2	10.0	**12.2**
BH902	10.5	10.8	8.5	10.5	12.4	13.6	9.3	9.3	**10.6**
Mean	11.3	12.2	9.2	11.1	12.5	14.6	10.1	10.1	
					LSD (5%)				
				Husk			Protein		
Variety (V)				0.8			0.6		
Location (L)				NS			0.8		
V× L				NS			NS		

of eight genotypes in Kanpur (Uttar Pradesh) and found that protein content was inversely correlated with starch, insoluble carbohydrates and predicted extract value.

3.2 Malt quality

3.2.1 Malt Friability: Friability is a measure of the breakdown of malt endosperm cell wall components. Malt friability should be >60% (Anonymous, 2012). The variety DWRUB 52 had the highest mean friability of 72.1% (Table 3), but it was statistically at par with RD 2668 (68.3%). Rest of the two varieties also had friability percentage of >60%, but it was statistically lower in BH 902 as compared to both the 2-rowed cultivars. The mean value of friability was 60% or more at all the 8 locations tested. Highest friability value was obtained at Karnal (75.2%) and lowest at Hisar and Ludhiana (60.1%). When barley endosperm is properly modified during malting, the resulting malt is soft and friable. Factors that interfere with endosperm modification, such as poor germination, large kernels and high protein, are expected to reduce malt friability (Edney andMather, 2004).

3.2.2 Wort filtration rate: The mean filtration rate was statistically at par in three varieties (DWRUB 52, RD 2668 & K 551) and lowest value was obtained in BH 902 (Table 3). Among the locations highest value for filtration rate was obtained at Bhatinda (246.3 ml/hr) and lowest at Durgapura (145.0 ml/hr). Haslemore *et al.* (1982) have reported that the wort filtration rates is of limited use for selection purposes but gives a clear indication of the influence of environment on malting quality.

Table 3. Effect of variety and location on malt quality parameters

Variety	Location								Mean
	Karnal	*Hisar*	*Bawal*	*Ludhiana*	*Bhatinda*	*Durgapura*	*Pantnagar*	*Mathura*	
	Friability (%)								
DWRUB52	89.2	68.0	73.6	64.7	75.4	64.8	71.0	70.2	**72.1**
RD2668	73.4	62.4	71.5	71.2	68.8	57.6	72.6	69.0	**68.3**
K551	64.9	57.5	67.1	53.8	65.2	66.3	64.6	67.3	**63.3**
BH902	73.2	52.6	68.1	50.7	62.7	53.2	66.1	56.4	**60.4**
Mean	75.2	60.1	70.1	60.1	68.0	60.4	68.5	65.7	
	Filtration rate (ml/hr)								
DWRUB52	232.5	162.5	187.5	155.0	247.5	157.5	135.0	247.5	**190.6**
RD2668	240.0	190.0	187.5	235.0	262.5	100.0	232.5	162.5	**201.3**
K551	246.3	178.8	197.5	157.5	262.5	200.0	178.8	177.5	**199.8**
BH902	205.0	177.5	130.0	182.5	212.5	122.5	155.0	186.3	**171.4**
Mean	230.9	177.2	175.6	182.5	246.3	145.0	175.3	193.4	
	Hot water extract								
DWRUB52	81.1	80.2	80.7	80.2	80.0	78.5	82.5	79.2	**80.3**
RD2668	81.3	79.8	80.6	81.0	80.8	78.1	81.8	80.7	**80.5**
K551	78.9	76.1	80.3	79.9	77.8	78.9	80.0	78.8	**78.8**
BH902	80.5	79.1	77.8	77.2	79.9	79.4	79.1	79.0	**79.0**
Mean	80.5	78.8	79.8	79.5	79.6	78.7	80.9	79.4	
	Diastatic power								
DWRUB52	98.8	95.9	88.3	92.1	94.9	103.4	90.8	88.3	94.0
RD2668	103.1	91.1	99.1	116.1	108.1	103.1	98.8	92.8	101.5
K551	101.7	97.6	98.2	101.1	103.9	117.4	103.8	93.8	102.2
BH902	113.6	109.7	93.4	97.9	96.9	100.2	95.5	97.5	100.6
Mean	104.3	98.6	94.7	101.8	100.9	106.0	97.2	93.1	

LSD (5%)	Friability	Filtration rate	Hot water extract	Diastatic power
Variety (V)	5.7	25.0	1.4	6.1
Location (L)	8.1	35.4	1.9	8.6
V× L	16.2	70.7	3.9	17.2

3.2.3 Hot water extract: The mean values of hot water extract were statistically at par in DWRUB 52 and RD 2668 and similarly, between K 551 and BH 902 (Table 3). The mean values were also desirable as these are minimum 80% for 2-rowed varieties and minimum 78% for 6-rowed varieties. Among the locations, highest HWE was obtained at Pantnagar (80.9%) followed by Karnal (80.5%). Verma *et al.* (2008) studied the correlation between hot water extract and several grain and malt parameters in 131 genotypes and the multiple regression analysis indicated that hectolitre weight, TGW, hull content and malt friability can be used to predict HWE, the ultimately important trait with malting and brewing industry, in early generations of a breeding programme or for initial screening of germplasm accessions.

3.2.4 Diastatic power: Diastatic power, the total activity of starch-degrading enzymes in barley malt, is considered to be an important quality characteristic for malting and brewing (Hayter and Allison, 1995). Diastatic power, like other quality attributes in barley, has been reported to be determined by a complex interaction of genetic and environmental factors (Arends *et al.*, 1995). The desirable range for diastatic power is 90-110°L for 2-rowed cultivars and 90-120°L for 6-rowed ones. The mean values of DP were in optimum range for all the four varieties tested. Mean DP value was however significantly lower in DWRUB 52 as compared to three other varieties (Table 3). Mean values of DP for locations were also in the desirable range with highest value at Durgapura (106.0°L) and lowest value at Mathura (93.1°L).

The development of improved varieties for quality purposes always requires identification of important traits affecting quality in a particular growing environment. Since nowhere in India, barley gets equivalent grain filling period with mild temperatures like Europe and other countries which grow better malting quality barley (Verma *et al.*, 2005), there is a need to study barley malting quality parameters under Indian environments. Verma and Nagrajan (1996) reported that malting barley traits are not independent and are also influenced by environmental conditions in India. Kant *et al.* (2012) reported positive effect of relatively longer grain filling duration in hills on malt quality traits. This can be one of the possible reasons for better grain quality parameters in Pantnagar and Karnal owing to slightly better temperature profile during crop maturation. Verma and Sarkar (2010) while analysing the malt quality of Indian varieties reported that all 2-row barleys were good in quality; however, there are number of 6-row genotypes with equally good quality. In this study also both 2-rowed cultivars were found superior to 6-rowed across the locations, however the newly released 6-row cultivar BH 902 has been found to be better than traditionally popular K 551 with respect to malt quality.

Based upon the parameters studied, it is inferred that between 2-rowed types DWRUB 52 is the better choice and between 6-rowed types BH 902 is superior performer. It has also been observed that well irrigated and cooler regions like Karnal and Pantnagar are also suited to malt purpose barley quality as evident from the better performance for most of the parameters. Among the relatively drier regions, Bawal location was found better. Further work on including more locations in these regions to study genotype and environmental interaction are required to find out clear cut climatic requirements for superior malt quality.

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