Malt Quality Evaluation of Exotic Barley Germplasm Grown in Northern Hills: A Non-Traditional Malt Area

Lakshmi Kant[1]*, RPS Verma[2], HS Gupta[3], PK Agarwal[1] and JC Bhatt[1]
[1]*Vivekananda Parvatiya Krishi Anusandhan Sansthan, Almora-263601, Uttarakhand*
[2]*Directorate of wheat Reaserch, Karnal-132001, Haryana*
[3]*Indian Agricultural Reaserch Institute, New Delhi-110012*

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Barley (*Hordeum vulgare* L.) cultivation in recent past has got boost in India due to its industrial use in malting and brewing. The areas like northern hills having relatively cooler temperatures during grain development phase with longer duration are considered suitable for malt barley production. However, it is believed that malt quality gets adversely affected by the occurrence of rains during maturity of the crop in the hills. Thirty germplasm cultivated at Hawalbagh, Almora, Uttarakhand were analyzed for malt traits. Though these were not bred for malt barley but the malt quality was found highly desirable for a number of malt traits suggesting that hills can be promising areas for malt barley cultivation.

Key Words: Barley, Germplasm, Hills, *Hordeum*, Malt

Introduction

Barley (*Hordeum vulgare* L.) is one of the important cereal crops of northern hills of India comprising the states of Himachal Pradesh, Jammu and Kashmir and Uttarakhand, particularly in marginal and fragile lands as well as in higher hills. It is the staple food crop in the tribal areas of hills where it is also used in preparation of the local beverages in addition to food and cattle feed. Barley is predominantly grown under rainfed conditions in northern hills and farmers use very low inputs (Verma *et al.,* 2005, Kant, 2006). During past few years the winters have become warmer in hills and drought is becoming a frequent phenomenon. Therefore, most of the farmers now prefer to grow barley over other crops as it supposed to be drought tolerant (Verma *et al.,* 2005). Although, this gives some yield even under drought like conditions but, that's not very profitable in absence of good market. However, if malt quality barley can be grown in hills and procured for use in malting and brewing industry the cultivation of barley will become a profitable preposition.

During recent years barley cultivation in India has got a boost due to its use as industrial raw material for malting and brewing. The minimum quality standards of barley grain and malt have been finalized (Table 1) as desirable limits to classify any barley variety as malt type in India (Verma *et al.,* 2005). As such, malt quality depends on combination of a number of grain and malt traits and not on any single trait because of differential requirements of the brewing and non-brewing malt by these industries. Many of these traits are though genetic in nature but the environmental effects are also significant. The areas of Haryana, northern Rajasthan, western UP and southern Punjab with sandy soils and shorter vegetative phase with grain development under relatively lower temperature, have been identified suitable for malt barley cultivation (Verma and Nagarajan, 1996). The released cultivars if grown under optimum management conditions in these areas produce very good quality grain. However, in India, barley doesn't get equivalent grain filling period with mild temperatures like Europe and other countries which grow better malting quality barley. In northern plains hardly 30 to 35 days after anthesis are available for grain development and then there is sudden rise in temperature causing the forced maturity (Verma *et al.,* 2005). However, in Northern hills the available period for grain development ranges from 40 to 50 days and temperature are not so high during maturity and the crop matures naturally. Therefore, apart from the traditional areas of malt barley, northern hills can also be a potential area for production of good quality malt barley owing to these highly suitable climatic conditions. There is a general understanding and belief that the malt barley do not perform well under hills condition as the crop normally experience rainfall during maturity which affects the malt quality adversely (Kant, 2006).

**Author for Correspondence: E-mail:* lkant_vpkas@yahoo.com

Table 1. Pedigree of the germplasm tested for malt quality

Sl. No.	Accessions	Pedigree / Cross
Two-rowed barley		
1.	VB 0701	Roho//Alger/Ceres362-1-1/3/Kantara/4/Bowman
2.	VB0705	Mo.B1337/WI2291//Moroc9-75
3.	VB 0708	PRTL/BICHY2000//MSEL
4.	VB 0709	SICH84.80/MSEL//INCI
5.	VB 0710	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs
6.	VB 0711	Viringa'S'//Hml-02/ArabiAbiad*2
7.	VB 0712	WI2291/Roho//WI2269/3/WI2291/Bgs//Hml-02
8.	VB 0713	WI2291/Roho//WI2269/3/WI2291/Bgs//Hml-02
9.	VB 0714	Alpha/Durra//ICB-101912
10.	VB 0718	EC-532636
11.	VLB 111	LAMOLINA 94/PETUNIA 1
12.	VLB 113	L.P /OXBOW/MSEL
Six-rowed barley		
13.	VB 0702*	15th HBSN-16
14.	VB 0703*	MJA/BRB2//QUINA/3/PETUNIA 2
15.	VB 0704	Akrash//WI2291/WI2269/3/WI2291/WI2269//WI2291/Bgs
16.	VB 0706	Lignee640/Lignee527//Lignee527/Rhn
17.	VB 0707	CHUAN 1/3/SLLO/ROBUST//QUINA/4/CEN-/2*CALI92
18.	VB 0715	TOCTE/3/MJA/BRB2//QUINA/4/CIRU
19.	VB 0716	WI2291/Roho//WI2269/3/Arta
20.	VB 0721	BOLDO/MJA//CABUYA/3/CIRU
21.	VLB 94	DL237/VLB 58
22.	VLB 102	TOCTE/TUBO//SHYRI
23.	VLB 104	P.STO/3/LNRIAN/UWA80//LIGNEE640/4/BLLU/5/PETUNIA 1
24.	VLB 107	ISBONO4-27 (BF 89IM-592)
25.	VLB 108	LINAZA-BAR/JAZMIN/5/CEN-B/3/LBIRAN/UNA8271//GLORIA- BAR/ COME-B/4/SEN
26.	VLB 109	CABUYA/3/CLN-B/80.5138//GLORIA-BAR/COPAL/4/CIRU
27.	VLB 110	GOB91DH/ALELI/3/ARUPO/K8755//MORA
28.	VLB 1(C)	NP 109/HBL 62
29.	VLB 56 (C)	Morocco/ VLB 1
30.	VLB 85(C)	HBL 348/VLB 49

* Hull-less barley

Materials and Methods

The present study was undertaken with a view to examine whether the malt quality traits really get adversely affected by the climatic conditions of northern hills. One hundred and seventy six exotic barley germplasm were selected during *rabi* 2005-06 from different International nurseries *viz.,* IBON06-LRA-C, 15th HBSN, IBON-MRA, 13th EMBSN, IBON-06-LRA-M, 28th IBYT, IBYT-06-LRA-C and 33rd IBON during field day at NBPGR, New Delhi as well as DWR, Karnal. These were evaluated during *rabi* 2006-07 at VPKAS, experimental farm, Hawalbagh for agronomic suitability and disease resistance. Grain samples of 30 barley germplasm were selected for malt quality analysis. These including 27 exotic germplasm and three prevalent checks, chosen for grain yield, were grown in station trial, state varietal trial and coordinated IVT during 2007-08 season at experimental farm, Hawalbagh of *Vivekananda Parvatiya Krishi Anusandhan Sansthan* (Vivekananda Institute of Hill Agriculture), Almora, India (29º 36'N and 79º 40' E and 1250 m amsl) under rainfed conditions. All the recommended package of practices was followed. The temperature and rainfall during the period is given in Fig. 1. None of these germplasm has been bred for malt quality. The malt quality analysis was done at quality laboratory, Directorate of Wheat Research, Karnal, India during 2009. The observations on following malt traits were recorded.

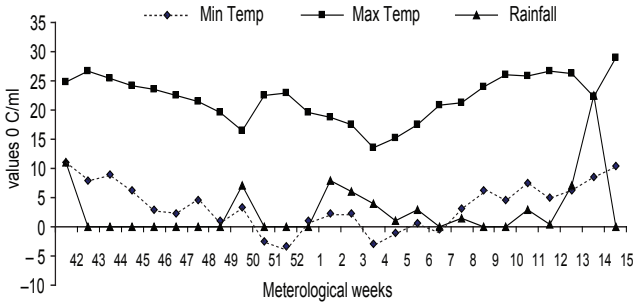

Fig. 1. Meterological data during the period at Hawalbagh

1. ***Malt yield (MY) %:*** The malt yield with acceptable range of malt friability should be taken into consideration.
2. ***Hot water extract (HWE %):*** is one of the most important malting quality traits for the industry and is measured in per cent on fine grind dry weight basis as per the EBC-Analytica IV, 2003 after mashing the grounded malt in mashing bath. It is the extract of soluble components from the malt. It should be around 80% as per standard.
3. ***Malt friability (Fb %):*** The physical quality of malt is measured by malt friability and homogeneity. The friability meter is a device whose role is to physically disintegrate the grain of malt and to separate its friable constituents from the hard constituents. More a malt is friable, better will it be disintegrated. The whole grain percentage permits to examine the homogeneity of the share (*http://www.e-malt.com/specifications/en_friability.htm*). It was measured as per EBC-Analytical, 2003. The acceptable limit is 60% in India and 80% at international level.
4. ***Malt homogeneity (Hg%):*** measured as per cent homogeneous malt using sample retained in malt friability meter mesh during friability analysis and passing this fraction on Sortimat for sieve analysis, as per EBC-Analytica IV, 2003. The non-homogenous fraction is that, which is retained on the 2.2 mm sieve and rest was considered as homogeneous malt (Verma *et al.,* 2008).
5. ***Diastatic power (DP):*** measured in degree linter value (^{O}L) as the total enzymatic activity of the amylases in malt samples as per Institute of Brewing (IOB) Method. Its desirable limit is 90-100^{0}L.
6. ***Sachharification time (min):*** The total time of transformation of the starch into sugar at the time of the brewing is measured. The time is verified by the disappearance of blue coloration of the iodine in presence of starch. A good malt saccharifies in less than 10 minutes (correct enzymic action), a longer duration is caused by a bad disintegration of the starch (*http://www.e-malt.com*). More than 5 S times is undesirable.
7. ***Wort filtration rate (F rate):*** The rate of wort filtration on the standard Whatman No. 1 filter papers, measured as amount of wort (ml/hr) passes through filter paper in one hour duration, as per EBC-Analytica, 2003.
8. ***Wort Colour:*** Wort colour was measured using EBC Analytica, 2003. The value between 2.0 to 2.5 is desirable.
9. ***Grain filling period:*** has been calculated by deducting the days to 50% heading form days to 75% maturity.

Results and Discussion

Though there are various malt parameters important in barley but the hot water extract (HWE) is the trait which is paramount (Wright, 2000) and the price of malt is mainly dependent on its HWE values, apart from few other traits like *diastatic* power, friability and homogeneity *etc*. The malting quality is the optimum combination of several grain and malt traits. Since the main purpose of this study was to find out the effect of environmental conditions on malt quality, therefore, the observations were recorded only on malt traits. For comparison the germplasm were grouped into two-rowed and six-rowed. Generally the six-rowed barley is considered to have higher enzyme content, more protein, less starch and a thicker husk than two-rowed barley. The higher level of *diastatic* enzymes makes six-rowed barley desirable for conversion of adjunct starches during mashing (*http://www.maltcompany.com/malt.htm*). The brewing industry does not prefer the malt with very high *diastatic* power and this kind of malt is preferred for malt based energy drinks and confectionaries.

Among the two-rowed strains VB 0710 has number of malt quality traits *viz.,* HWE (80.2), Hg (99.5), Fb (93.1), DP (105) and F rate (285) (Table 2). It has a grain filling duration of 42 days almost one week longer than the plains. The other strain VB 0709 has HWE (81.0), Fb (97.3), Hg (99.3), F rate (265) and grain filling duration 53 days but it has high DP (122). Out of 12, three more strains VB 0701, VB 0705 and VB 0708 have more than 80% HWE. The average HWE of this

set of germplasm was 78.64 and average DP was 105. All the strains showed very high Fb% as well as Hg%. The high wort filtration rate is desirable for the brewing industry. Seven strains VB 0709, VB 0710, VB 0712, VB 0714, VB 0718, VLB 111 and VLB 113 showed F rate more than 250 ml/h (Table 2).

Out of 18 six-rowed strains VB 0706 has HWE (79.0), Fb (81.5), Hg (98.1), DP (105), F rate (265) and 44 grain filling days whereas, VB 0715 has HWE (78.5), Fb (96.0), Hg (99.8), DP (105), F rate (310) and 46 grain

Table 2. Malt quality traits of two-rowed barley grown at Hawalbagh, Almora

Accessions	MY (%)	HWE (%)	Fb (%)	Hg (%)	D.P. (^{O}L)	S.Time	F.Rate (ml/hr)	WC (EBC)	Heading (days)	Maturity (days)	GF (days)
VB 0701	88.2	**83.2**	**90.6**	**99.0**	**83**	5	105	2.5	130	173	43
VB 0705	90.7	**80.2**	**83.3**	**95.5**	**125**	5	150	2.5	110	163	53
VB 0708	88.6	**85.2**	**95.9**	**99.1**	**105**	5	170	3.0	117	165	48
VB 0709	83.9	**81.0**	**97.3**	**99.3**	**122**	5	**265**	2.5	113	166	53
VB 0710	84.7	**80.2**	**93.1**	**99.5**	**105**	5	**285**	2.5	128	170	42
VB 0711	85.3	77.0	**83.1**	**97.6**	**105**	5	235	2.5	137	174	37
VB 0712	86.2	78.0	88.5	**97.8**	**100**	5	290	2.5	124	169	45
VB 0713	84.3	75.0	**70.7**	**91.8**	**125**	5	230	2.5	133	170	37
VB 0714	84.4	78.7	**97.1**	**99.8**	**111**	5	**310**	2.0	136	170	34
VB 0718	83.2	71.0	**84.2**	**97.9**	**105**	5	**255**	2.5	133	171	38
VLB111	86.8	75.0	96.4	99.8	80	5	300	2.5	126	166	40
VLB113	86.6	79.0	95.1	99.8	95	5	**310**	2.5	124	167	43
Mean	86.1	78.6	89.6	98.1	105.2	5	242.1	2.5	126	169	42.8
Range	83.2-90.7	71.0-85.2	70.7-97.3	91.8-99.8	80-125	-	105-310	2-3	110-137	163-174	34-53
STDEV	2.2	3.8	8.0	2.4	14.6	0.00	67.5	0.2	8.8	3.0	6.2
Desirable limit		>80%	>60%	>90%	80-120 °L	≤ 5.0	>250	2.0-2.5			

Note: Bold one indicate the desirable values

Table 3. Malt quality traits of six-rowed barley grown at Hawalbagh, Almora

Accessions	MY (%)	HWE (%)	Fb (%)	Hg (%)	D.P. (^{O}L)	S.Time	F.Rate (ml/hr)	WC (EBC)	Heading days	Maturity days	GF (days)
VB 0702	77.7	**83.5**	**78.4**	**98.1**	**91**	5	120	2.5	130	170	40
VB 0703	82.7	**85.5**	**79.1**	**98.7**	71	5	110	2.5	124	166	42
VB 0704	88.2	**80.7**	**67.9**	**86.7**	83	5	175	2.5	139	175	36
VB 0706	87.3	**79.0**	**81.5**	**98.1**	**105**	5	**265**	2.5	125	169	44
VB 0707	88.6	**81.0**	**74.0**	**93.6**	**105**	5	220	3.0	122	163	41
VB 0715	81.9	**78.5**	**96.0**	**99.8**	**105**	5	**310**	2.5	122	168	46
VB 0716	87.4	78.3	**86.3**	**99.3**	87	5	**275**	2.5	134	172	38
VB 0721	79.8	75.5	**94.7**	**99.5**	**119**	5	**260**	3.0	136	176	40
VLB 56	85.3	73.8	**82.3**	**97.3**	**111**	5	80	3.0	149	195	46
VLB 102	75.8	73.3	72.1	**94.4**	91	5	165	3.0	151	194	43
VLB 85	77.6	76.5	68.2	**92.5**	74	5	85	2.5	127	171	44
VLB104	83.4	**78.7**	**94.1**	**99.1**	74	5	145	2.5	148	195	47
VLB107	84.9	**78.0**	**68.8**	**93.9**	77	5	**275**	3.0	150	196	46
VLB108	81.1	**79.0**	**96.2**	**99.8**	67	5	150	2.5	152	192	40
VLB1	82.1	71.8	**74.5**	**95.9**	**91**	5	**275**	2.5	141	184	43
VLB109	89.3	77.0	**88.9**	**99.4**	**95**	5	330	2.5	127	171	44
VLB110	83.0	73.5	**90.0**	**99.3**	**95**	5	300	2.0	126	167	41
VLB94	85.3	75.0	**91.8**	**98.5**	77	5	320	2.5	152	195	43
Mean	83.4	77.7	82.5	**96.9**	89.9	5.0	214.4	2.6	136	179	42.4
Range	75.8-89.3	71.8-85.5	67.9-96.2	86.7-99.8	67-119		80-320	2-3	121-152	163-196	36-47
STDEV	4.00	3.60	10.10	3.5	15.0	0.00	85.5	0.27	11.5	12.2	2.9
Desirable limit		78%	>60%	>90%	90-130 °L	≤ 5.0	>250	2.0-2.5			

Note: Bold one indicate the desirable values

filling days. Malt Fb and Hg showed very high values for all the accessions. In addition, eight more strains had high HWE (> 78%) and two more strains have F rate > 250 (Table 3). The average grain filling period in both the groups is more than 42 days ranging from 34-53 days (Table 2 & 3). The mean maximum temperature ranged from 13.5 to 28.9 ^{O}C and minimum temperature from -2.9 to 10.4^{o}C. From mid march to mid april around 33 mm rainfall was received (Fig. 1).

The encouraging results from the present study are suggestive that northern hills can be a promising area for malt barley production. The climatic conditions are more congenial for its production and high malt quality can be obtained in hills as compared to plains. The cultivation of malt barley in the hills will not only provide good quality malt barley leading to establishment of new malting and brewing units to utilize the locally produced malt barley, but will also provide premium prices to the farmers. More employment can be generated and migration of rural youth can also be checked.

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