Identification of Resistance Sources to Barley Yellow Rust (*Puccinia striiformis* f. sp. *hordei*) in India

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One hundred and twenty seven genotypes of barley from the various centres of the All India Coordinated Wheat & Barley Improvement Project (AICW&BIP) were evaluated by artificial inoculation in the field for two consecutive years (2009-10 and 2010-11) to identify new sources of resistance to yellow rust (*Puccinia striiformis* f. sp. *hordei*). The same set of genotypes was also evaluated against five individual races, 24, 57, G, Q and M at the seedling stage during 2009-11 in the greenhouse under controlled conditions. Based on both seedling and adult plant evaluation 10 genotypes (BHS392, DWR88, JB187, JB206, PL844, RD2786, RD2787, RD2803, RD2804 and VLB119) were found resistant across the five races of yellow rust in India. These new sources of resistance to multiple races of yellow rust would be useful in resistance breeding programme in India.

Key Words: Barley, *Puccinia striiformis* f. sp. *hordei*, Resistance, Yellow rust races

Introduction

Barley (*Hordeum vulgare* L.) is a globally important crop adapted in the marginal and stress-affected environments. Therefore it is of high importance to resource poor farmers in many developing countries. Barley is an important cereal in India and is used for variety of purposes including animal feed, human food and in industry for malting and brewing. It suffers from many diseases and amongst them the yellow rust (*Puccinia striiformis* f.sp. *hordei*) is of major importance in the main barley growing area of the north-western plains in India. The incidence of yellow rust may create havoc in susceptible varieties and results in heavy yield losses.

In conventional plant breeding, new varieties are generated from a primary adapted pool of elite germplasm. In the past decades, intensive breeding of crop varieties has further narrowed the gene pool, especially in barley. Due to limited genetic variation among modern varieties, efficient use of the genetic variation available in wild relatives of modern cultivars is therefore necessary for continued improvement. In India, barley resistance breeding has been based on sources available in landraces of indigenous or exotic origin. Yellow rust races, 24, 57, G, Q and M are more prominent in barley (Bhardwaj and Gangwar, 2012). There are very few reports on sources of resistance to yellow rust in India (Sarkar *et al*., 2003; Singh *et al*., 2004; Verma *et al*., 2008). Several varieties under cultivation have become susceptible to yellow rust because of breakdown of resistance by new virulent pathotypes. Therefore, there is a need to screen barley germplasm from diverse sources for yellow rust resistance under artificial epiphytotic conditions under different environments.

Materials and Methods

Adult Plant Resistance Test

Under the All India Co-ordinated Wheat & Barley Improvement Project (AICW&BIP), a total of 127 barley genotypes supplied by barley breeders from various centres were evaluated at seven locations (Almora, Dhaulakuan, Bajaura, Durgapura, Hisar, Ludhiana and Karnal) during 2009-10 and 2010-11 crop seasons for screening for resistance to yellow rust under artificial epiphytotic conditions (Table 1).

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Table 1. Number of barley genotypes tested for adult plant resistance

Centre	Code	Genotypes tested
Ludhiana	PL	14
Bajaura	HBL	3
Rewa	JB	6
Faizabad	NDB	10
Kanpur	K	5
Varanasi	HUB	8
Almora	VLB	6
Hisar	BH	11
Pantnagar	UPB	7
Karnal	DWR/ DWRUB	11
Shimla	BHS	5
Durgapura	RD	23

Each genotype was grown in 1 m length consisting of 10-12 plants with 30 cm distance between rows. After every 20 lines, one line of infector (mixture of susceptible genotypes- Bilara2, RD31, RS6, Jyoti and RD2035) was sown. The susceptible mixture was also grown on all four sides of test lines.

The yellow rust inoculum was received as mixtures of the most common races (24, 57, G, Q and M) from the Regional Station, Directorate of Wheat Research (DWR), Flowerdale, Shimla, and multiplied in polyhouses on susceptible genotypes at the respective centres. In the main field, susceptible infector rows were artificially injected with uredospores suspension just before early tillering stage of the crop. In addition, 3-4 sprays of water containing uredospores were also given between 45-55 days after sowing from tillering to flag leaf stage in the main field for developing rust epidemics. The rust spore sprays @5g/ litre of water were given in the evening hours. The crop was grown following the recommended agronomic practices. The data on yellow rust were recorded by combining severity (per cent leaf area covered by rust) and response (infection type). Plants were scored when the disease showed the maximum development on the infector rows. The scoring for yellow rust was done using the modified Cobb's scale (Peterson *et al*., 1948). The host response in the field was scored using 'R' to indicate resistance; 'MR' to indicate moderate resistance; 'MS' to indicate moderately susceptible and 'S' to indicate full susceptibility.

The disease severity and host response data were combined into a single value called the coefficient of infection (CI). The CI is calculated by multiplying the severity times a constant for host response: where immune=0.0, R=0.2, MR=0.4, MS=0.8, and S=1.0. The average coefficient of infection (ACI) was calculated. The genotypes showing ACI up to 1.00 for rusts at all the centres were considered highly resistant (HR). If the rust reaction at any one centre was more than zero and other centres recorded zero, the entry was subjected to reconfirmation during the second year of multi-locational screening. The lines observed as resistant were repeated for screening in subsequent years to eliminate any chance of escape.

Seedling Resistance Test

The seedling resistance test on selected resistant genotypes from field evaluation during 2008-09, was conducted at the Regional Station, DWR, Flowerdale, Shimla, using individual pathotypes (24, 57, G, Q and M) during 2009-10 and 2010-11 under controlled conditions. Eight to ten seeds per entry were sown in a row thus accommodating 10 rows in a tray. Seven to eight days old seedlings were inoculated with uredospores in talcum powder @1:500 with a spatula and placed in a moist chamber for 48 hours. Subsequently, they were placed in the glasshouse having temperatures 15-20ºC. The observations were recorded on reaction type of these seedlings against each pathotype on 14-15 day of the inoculation (Nayar *et al*., 1997).

Results and Discussion

Adult Plant Resistance

A total of 127 genotypes showing yellow rust resistance during 2008-09 and 2009-10 cropping seasons were again screened during 2010-11 in the Elite Barley Disease Screening Nursery (EBDSN) to confirm the resistance. Twenty seven genotypes (BH936, BH941, BHS387, BHS392, DWR84, DWR85, DWR87, DWR88, DWRUB73, HBL704, HBL706, HBL707, JB187, JB206, NDB1490, PL843, PL852, RD2786, RD2787, RD2798, RD2803, RD2804, UPB1008, VLB118, VLB119, VLB121, VLB122) were confirmed as resistant in adult plant stage across the locations consecutively for the next two years.

Seedling Resistance

During 2009-10, all the 127 genotypes were screened against individual races of yellow rust for seeding resistance at the Regional Station, Flowerdale, Shimla. Out of these, 31 genotypes exhibited resistance to all

Table 2. Field response of barley genotypes to stripe rust at different locations during 2009-11

Genotype	2009-2010								2010-2011							
	Almora	Bajaura	Dhaulakuan	Durgapura	Hisar	Karnal	Ludhiana	ACI	Almora	Bajaura	Dhaulakuan	Durgapura	Hisar	Karnal	Ludhiana	ACI
BH936	0	0	0	10S	0	0	0	1.4	0	0	5S	5MS	0	0	0	1.5
BH941	0	0	0	10S	0	0	0	1.4	0	0	10S	5MS	0	0	0	2.3
BHS387	0	0	0	10MS	0	0	0	1.1	0	0	20S	15MS	0	0	5MS	6.0
BHS392	0	0	5S	10S	0	0	0	2.1	0	0	0	10MS	0	0	0	1.3
DWR84	TS	0	0	10S	0	0	0	1.6	0	0	0	15S	0	0	TS	2.7
DWR85	5S	0	10S	10S	0	0	0	3.6	0	0	0	10S	0	0	5MS	2.3
DWR87	0	0	0	20S	0	0	0	2.9	0	0	10S	15S	0	0	TS	4.3
DWR88	0	0	0	0	0	0	0	0	5S	0	10S	0	0	0	0	2.5
DWRUB73	10S	0	10S	5S	0	0	0	3.6	0	10S	0	15S	0	5MS	5MS	3.8
HBL704	0	0	0	5MR	0	0	0	0.3	0	0	0	TMR	0	0	0	0.1
HBL706	0	0	0	5MR	0	0	0	0.3	0	0	0	10MR	0	0	0	0.7
HBL707	0	0	5S	5MR	0	0	0	1.0	0	0	0	5MR	TS	0	0	0.5
JB187	0	0	0	0	20S	0	0	2.9	0	0	20S	0	0	0	0	3.3
JB206	0	0	0	0	0	20S	0	2.9	0	5S	0	0	0	0	TS	0.2
NDB1490	0	0	0	0	10MS	0	0	1.1	0	0	5S	0	NG	0	0	1.0
PL843	0	0	10S	0	0	0	0	1.4	0	0	0	0	0	0	0	0.0
PL852	0	0	0	5MS	0	0	0	0.6	0	5S	5S	10S	0	0	0	2.5
RD2786	0	0	0	0	0	0	0	0	0	0	10S	0	0	0	0	1.7
RD2787	0	0	5S	0	0	0	0	0.7	0	0	20S	0	0	0	0	3.3
RD2798	0	0	0	10MS	0	0	0	1.1	0	0	40S	5MR	0	0	0	7.0
RD2803	0	0	0	0	0	0	0	0	0	0	10S	0	0	0	0	1.7
RD2804	0	0	0	0	10S	0	0	1.4	0	0	20S	0	0	0	0	3.3
UPB1008	0	0	0	5S	0	0	0	0.7	0	0	10S	10MS	0	0	0	3.0
VLB118	0	0	0	10S	0	TS	0	1.6	0	0	0	15MS	0	0	0	2.0
VLB119	0	0	0	10S	0	0	0	1.4	0	0	5S	20MS	0	0	0	3.5
VLB121	0	0	0	10S	10S	0	0	2.9	0	0	10S	20S	0	0	0	5.0
VLB122	0	0	0	10S	0	0	0	1.4		0	10S	15MS	0	0	0	3.7

S = Susceptible; MS = Moderately Susceptible; TS = Traces to Susceptible; MR = Moderately Resistant; TMR = Traces to Moderately Resistant

Table 3. Confirmation of seedling resistance by selected genotypes having adult plant resistance

Genotype	2009-2010					2010-2011				
	G (4S0)	M (1S0)	Q (5S0)	24 (0S0-1)	57 (0S0)	G (4S0)	M (1S0)	Q (5S0)	24 (0S0-1)	57 (0S0)
BHS392	R	MR	R	R	R	R	R	R	R	R
DWR88	R	R	R	R	R	R	R	R	R	R
JB187	R	R	R	R	R	R	R	R	R	R
JB206	R	R	R	R	R	R	R	R	R	R
PL844	R	R	R	R	R	R	R	R	R	R
RD2786	R	R	R	R	R	R	R	R	R	R
RD2787	R	R	R	R	R	R	R	R	R	R
RD2803	R	R	R	R	R	R	R	R	R	R
RD2804	R	R	R	R	R	R	R	R	R	R
VLB119	R	R	R	R	R	R	R	R	R	R

G, M, Q, 24, 57 = Yellow rust races

Table 4. List of identified resistant sources to stripe rust of barley

Genotype	Centre	Parentage	Origin
BHS392	IARI, Shimla	ZIGZIG/PETUNIA2// PETUNIA2	Exotic
DWR88	DWR, Karnal	DWR28/DL472	Indigenous
JB187	JNKV, Rewa	RD2508/RD2035	Indigenous
JB206	JNKV, Rewa	K560/RD2503	Indigenous
PL844	PAU, Ludhiana	TOCTE/3/CHAMICO/ TOCTE//CONGONA/4/ LIGNEE527/ GERBEL/3/BOY-B*2/ SURB//C112225.2D (30th INYT-904)	Exotic
RD2786	ARS, RAU, Durgapura	RD2634/NDB1020// K425	Indigenous
RD2787	ARS, RAU, Durgapura	RD2035/NDB1245	Indigenous
RD2803	ARS, RAU, Durgapura	P490/K560//RD2552	Indigenous
RD2804	ARS, RAU, Durgapura	RD387/BH602//RD2552	Indigenous
VLB119	VPKAS, Almora	16th HBSN-9632	Exotic

the five races and these were retested during 2010-11 for individual races under the EBDSN (Table 3). Out of the 127 genotypes tested, 10 (BHS392, DWR88, JB187, JB206, PL844, RD2786, RD2787, RD2803, RD2804, and VLB119) showed the both seedling and adult plant resistance for two years across all five races of yellow rust (Table 4).

Yellow rust in barley causes severe production lossess in northern hills, and adjoining plains. Being a crop of low input grown by marginal farmers and the disease being of multicyclic nature, chemical control is not a viable option. Therefore, resistance breeding seems to be a preferable option for the Indian barley programme. The identified sources from this study can be used as resistance donor in resistance breeding programme to minimize the losses due to yellow rust.

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