New Sources of Resistance to Yellow Rust (*Puccinia striiformis* f. sp. *hordei*) in Barely

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In order to identify new diverse sources of resistance to yellow rust (*Puccinia striiformis* f. sp. *hordei*) in barley germplasm a total of 607 accessions of indigenous and exotic origin were evaluated during four years (1999-2003) under artificial inoculation in the field with mix inocula of races 24, 57, G and M. The resistant accessions identified in the field screening for at least three years were further evaluated for seedling resistance test (SRT) with seven races (24, 57, G, G-1, M, Q and a new biotype). Based on the field screening, 47 accessions were found resistant for more than two years. Seventeen highly resistant accessions were used for SRT and ten were found resistant to all the seven pathotypes. Interestingly, all these seventeen resistant accessions are of exotic origin and expected to add to the diversity of resistance to the yellow rust in the national programme.

Key Words: Barley, Germplasm, *Puccinia striiformis* f. sp. *hordei*, Resistance, Yellow Rust

Barley is an important cereal crop grown in India and used for a variety of purposes including animal feed, human food and in industry for malting and brewing. It suffers from many diseases and amongst them the stripe rust and leaf blights (net blotch and leaf spot) are of major importance in the main barley growing area of the North-western plains in India, where better management is provided to the crop and the crop growth is luxuriant. The incidence of yellow rust (*Puccinia striiformis* f. sp. *hordei*) may create havoc in susceptible varieties and result in heavy yield losses (Suryanarayana, 1979). Several races of yellow rust have been reported on wheat and barley, however, race 24, 57, G and M are more prominent (Prasada *et al.*, 1967; Jain, 1978). Race 24 is only the one reported on barley in the Nilgiri Hills in South India but is also reported in Lahual and Spiti, Himachal Pradesh. Recently some more new biotypes, like M, G-1 Q etc. have been added to the list of barley pathotypes (Anonymous, 2002). The numbers of varieties under cultivation is very few and several of them have become susceptible to yellow rust because of either breakdown of resistance or by evolution of new virulent pathotypes. There are very few reports on sources of resistance to yellow rust in India (Gulati *et al.*, 1988; Upadhyay and Prakash, 1977; Mathur and Siradhana, 1990) and inheritance of the disease (Luthra, 1966; Luthra, 1988; Luthra and Chopra, 1990). Some of these identified genes have also been isolated in Fongtein barley background (Luthra, *et al.* 1991). But the numbers of diverse resistance genes are very few in present cultivars. Therefore, there is a need to screen barley germplasm from diverse sources against yellow rust under artificial epiphytotic condition for identifying new sources for utilization in the breeding programme.

Materials and Methods

A total of 607 barley genotypes consisting of indigenous and exotic germplasm accessions received from International Centre for Agricultural Research in Dryland Areas, Syria (ICARDA), and International Maize, Wheat and Barley Improvement Centre, Mexico (CIMMYT) were evaluated at DWR, Karnal, during 1999 to 2003 in four crop seasons for their resistance to yellow rust. The materials were grown in one row of 2.5 m length at 30 cm distance between rows. After every 20 lines one line of susceptible check (Bilara-2) was sown with the test materials. Also susceptible infector lines (mixture of susceptible cultivars) were sown bordering the test materials block from all sides. The susceptible infector rows were artificially inoculated repeatedly with mix inocula of four most common races (24, 57, G and M) of yellow rust in between 45-55 days after sowing. The inocula were mixed with water and syringe inoculated on alternate day in the evening and also sprayed over the infector line. At the later stages the test material was also directly sprayed with inocula collected from the injector rows. The crop was grown as per recommended agronomic practices. Data on yellow rust were recorded by combining severity (percent leaf area covered by rust) and response (infection type) according to the method developed by Loegering (1959). The categorization was made as F/R = Free/Resistant type, MR = Moderately Resistant, S = Susceptible HS = Highly Susceptible. The lines observed as resistant were repeated for screening in subsequent years, thereby having observation on such

lines for two to four years in continuation to eliminate any chance of escape and also to observe the stability of resistance.

Results and Discussion

Barley germplasm were subjected to artificial screening under heavy infection of yellow rust, with the advantage of suitable environment at Karnal, where lot of natural dew formation helps in rapid spread of yellow rust till the mid of March. Based on the four consecutive years' evaluation barley genotypes were classified into various categories (Table 1).

It was observed that 15 entries, BCU 424, BCU 455, BCU 492, BCU 519, BCU 532, BCU 543, BCU 544, BCU 546, BCU548, BCU 550, BCU 551, BCU 554, BCU 729, BCU 775, BCU 841 (Table 1) were consistently showing resistance for four years to yellow rust at audit plant stage under artificial epiphytotic condition and there were additional 13 lines, which were showing resistance to yellow rust for three years. Seventeen lines, which were giving immune and highly resistant type reaction out of these 28 lines (13+15) were screened for seedling resistant test (SRT) against seven races of yellow rust individually at DWR Regional Station, Flowerdale, Shimal under controlled inoculation conditions. The parentage and other details of these entries are given in Table 2.

Ten lines namely BCU 131, BCU 424, BCU 455, BCU 544, BCU546, BCU 550, BCU 551, BCU 554, BCU 729 and BCU 775 (Table 3) were showing complete resistance against all the races (24, 57, G, M, Q, G-1, and N.B.). Among the rest seven entries, five showed resistance against all the known races except against the new biotype and remaining two were susceptible

Table 1. Reaction of barley genotypes to yellow rust (*Puccinia striiformis* f. sp. *hordei*)

Reaction type	Years of evaluation	Total entries	Genotypes (BCU Nos.)*
Resistant	Four	15	424,455,492, 519, 532, 543, 544, 546, 548, 550, 551, 554, 729, 775, 841,
	Three	13	131, 134, 549, 571, 766, 1009, 1022, 1023, 1025, 1026, 1069, 1070, 1085
	Two	19	135, 387, 516, 530, 531, 575, 576, 628, 632, 641, 642, 644, 702, 730, 809, 812, 1065, 1088, 1091
	Total	47	
Moderately resistant		138	
Moderately susceptible	133		
Highly susceptible		289	
Total accession		607	

*BCU = Barley Coordinating Unit Number given to each barley accession maintained as active collection at DWR, Karnal.

Table 2. Parentage of accessions showing resistance at APR and SRT

Accession	Name/Parentage	Source	Origin	Botanical Name
BCU 131	HBL-113 (Selection from Zyphzee)	PALAMPUR, H.P., INDIA	Exotic	*H. distichon*
BCU 424	GLORIA "S"/COME "S"/LIGNE640/3/SUPER PRECOZ	CIMMYT EMBSN(91091)-19	Exotic	*H. distichon*
BCU 455	SUPER PRECOZ/5/HJA A33/ID601810/1102.2/STEUDELLT/3/EGYPT20/4/PYE "S"/6/ABN	CIMMYT EMBSN(91092)-50	Exotic	*H. vulgare*
BCU 492	GLORIA "S"/COME "S"//ORGEFICHEDRETT3270/ROW906.73	CIMMYT 19th IBON(91-92)-32	Exotic	*H. vulgare*
BCU 519	CAMPILLO LIBERNA/DAPHENE//SEN "S"	CIMMYT 19th IBON(91-92)-59	Exotic	*H. vulgare*
BCU 532	4259/CI5831/S.A1/3/, EMIET/4/GABRONE515/TEQ//G; PROA "S"	CIMMYT 19th IBON(91-92)-73	Exotic	*H. vulgare*
BCU 543	80.5056/NOHA "S"//GLORIA "S"/COME "S"	CIMMYT 19th IBON(91-92)-84	Exotic	*H. vulgare*
BCU 544	SUDAN/4/ASE/3/M/RO/3/SMAI/5/GLORIA "S"/IAR-H485	CIMMYT 19th IBON(91-92)-85	Exotic	*H. vulgare*
BCU 546	BARBEROUSSE/RUMOROSA/GLORIA "S"/COME "S"	CIMMYT 19th IBON(91-92)-87	Exotic	*H. vulgare*
BCU 548	BARBEROUSSE/P.STO "S"//GLORIA "S"/COPAL "S"	CIMMYT 19th IBON(91-92)-89	Exotic	*H. vulgare*
BCU 550	MJA "S"	CIMMYT 19th IBON(91-92)-91	Exotic	*H. vulgare*
BCU 551	GLORIA "S"/COME "S"	CIMMYT 19th IBON(91-92)-92	Exotic	*H. vulgare*
BCU 554	GLORIA "S"/COPAL "S"//TERAN/78/3/SHYRI	CIMMYT 19th IBON(91-92)-95	Exotic	*H. distichon*
BCU 571	M10080	CIMMYT 19th IBON(91-92)-89	Exotic	*H. vulgare*
BCU 729	LIGNEE 527/3/HARBING/AVT//ATHS	ICARDA IInd IWFBON-131	Exotic	*H. vulgare*
BCU 775	UC566/5/M64-76/BON/JO/YORK/3/MS/GALT//AS46/4/HJ34-80 ASTRIX	ICARDA BCH (91-92)-31	Exotic	*H. vulgare*
BCU 841	AS46/PRO/BAL. 16/API/4/11012/TERN//H252/3/ NOPAL "S"/5/ASSALA	ICARDABON-LRA(91-92)-42	Exotic	*H. vulgare*

to race G as well. The variation in adult plant reaction and seedling resistance test may be due to fact that new biotype was not used during field screening. The results indicated that there are several new exotic resistance sources in barley germplasm. Entries showing resistance against all races of yellow rust are selections from international trail/nurseries from ICARDA/CIMMYT except BCU 131 (HBL 113), which is a released variety in the NH Zone, but it is also a selection from exotic germplasm Zyphzee.

Out of the total 607 accessions tested, most of them fall into the categories of moderately susceptible (22%) to highly susceptible types (47%), making a total 69% in the susceptible category. Around 22.7% entries were observed as moderately resistant types. Only 47 accessions (8%) showed resistance against yellow rust a different years of screening.

Similar studies on identifying resistant sources for yellow rust in barley were undertaken by Upadhyay and Prakash (1977); Gulati *et al.* (1985, 1988); Luthra (1988); Luthra and Chopra (1990). However, most of them are either not available in national collection or have been utilized earlier.

Data were also recorded on a number of other characters (Table 4) which indicate that apart from resistance these lines are also having diversity for maturity duration, plant height and 1000-grain weight, three important traits of interest in barley breeding. All genotypes were of six row type except BCU 131, BCU 424 and BCU 554. This will provide the opportunity to choose the diverse material of choice from these resistant sources.

Table 4. Yield and related triats of resistance sources of barley germplasm

Genotypes	Row type (2/6R)	Heading days	Plant height (cm)	1000 grain weight (gm)
BCU 131	2	100	103	28.5
BCU 424	2	102	100	25.6
BCU 455	6	83	106	31.2
BCU 492	6	97	110	37.0
BCU 519	6	97	166	39.0
BCU 532	6	103	100	32.4
BCU 543	6	95	104	29.5
BCU 544	6	102	105	33.0
BCU 546	6	99	90	35.4
BCU 548	6	103	85	28.6
BCU 550	6	103	87	33.7
BCU 551	6	95	75	33.6
BCU 554	2	93	85	32.5
BCU 571	6	82	92	35.1
BCU 729	6	83	82	33.3
BCU 775	6	103	84	31.2
BCU 841	6	102	81	32.5

Since the national programme on barley has taken up the work on malt barley improvement for optimally managed condition of the NWP Zone the importance of resistance to the stripe rust has further increased in Punjab, Haryana, Western UP and Northern Rajasthan where weather conditions are congenial for the disease development and spread. The disease may affect the crop yield as well as grain quality, the two important aspect for malting.

These lines which showed resistance both at SRT and adult plant reaction (APR) may be utilized as donor parents in the hybridization programme for incorporation

Table 3. Seedling reaction (SRT) of new barley lines to individual races of yellow rust (Puccinia striiformis f. sp. hordei)

S.No.	Genotypes	Reaction* to yellow rust races**						
		24	57	G	M	Q	G-1	N.B.
1.	BCU 131	;	;	;	;	;	;	;
2.	BCU 424	0;	0;	0;	0;	0;	0;	0;
3.	BCU 455	0;	0;	0;	0;	0;	0;	0;
4.	BCU 492	0;	0;	2+	0;	0;	0;	2+,3
5.	BCU 519	0;	0;	3+	0;	0;	0;	2+,3
6.	BCU 532	0;	0;	0;	0;	0;	0;	2+,3
7.	BCU 543	0;	0;	0;	0;	0;	0;	2+,3
8.	BCU 544	0;	0;	0;	0;	0;	0;	0;
9.	BCU 546	0;	0;	0;	0;	0;	0;	0;
10.	BCU 548	0;	0;	0;	0;	0;	0;	3
11.	BCU 550	0;	0;	0;	0;	0;	0;	;
12.	BCU 551	0;	0;	0;	0;	0;	0;	2
13.	BCU 554	0;	;	0;	0;	0;	0;	;
14.	BCU 571	0;	;	0;	0;	;	0;	3+
15.	BCU 729	0;	0;	0;	0;	0;	0;	0;
16.	BCU 775	0;	0;	0;	;	;	0;	;
17.	BCU 841	0;	0;	3-	;	;	0;	;

of resistance to yellow rust in high yielding barley variety of the country.

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