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EVALUATION OF CANDIDATE LINES AGAINST WHEAT RUSTS IN PAKISTAN

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ABSTRACT: Twenty nine promising candidate bread wheat lines of National Uniform Wheat Yield Trial, 2004-05 were evaluated against stripe and leaf rust at multilocations in different agro-ecological zones of the country presenting hot spots for leaf and yellow rust along with artificial inoculation with prevalent pathotypes. These candidate lines were undergoing mandatory testing to develop varieties for irrigated and rainfed areas of Pakistan. Out of these 29 candidate lines, 9 were common to NUWYT 2003-04 and 2004-05. Three candidate lines namely, V-00125, 99B2278, 99B4012 from seeding date were found resistant to both leaf and yellow rusts and showed desirable Relative Resistance Index (RRI) during 2003-04 and 2004-05. In addition, two of these lines, 7-03 and RWM-9313 from seeding date were also found resistant to yellow and leaf rust, respectively. Out of remaining 20 candidate lines, 8 (4 from seeding date, 4 from rainfed) showed desirable RRI for both rusts in 2004-05. These lines will remain in NUWYT 2005-06 for further evaluation.

Key Words: Wheat; NUWYT; Candidate Lines; Leaf Rust; Yellow Rusts; Pakistan.

INTRODUCTION

The rusts of wheat have historically been one of the major biotic production constraints both in Asia and the rest of the world (Singh and Rajaram, 1991). Yellow (or stripe) and brown (or leaf) rusts caused by *Puccinia striiformis* westend and *P. triticinia*, respectively are important diseases of wheat world wide. This is mainly due to the pathogen's ability to mutate and multiply rapidly and to use their air borne dispersal mechanism from one field to another and even long distances (Singh et al., 2005). In 1973, leaf rust intensity ranged from 40-50% with 100% infection on susceptible varieties (Hassan et al., 1973). A severe leaf rust epidemic in 1978 resulted in an estimated national loss of US$86 million on account of 10% loss in yield in Pakistan (Hussain et al., 1980). Similarly, stripe rust continue to pose a major threat to wheat production over a large area. Severe epidemics have been recorded since the early 1800s in India (Joshi, 1976) that may result loss upto 70% (McIntosh et al., 1995). Ahmad et al. (1991) reported an estimated US$8 million revenue loss in just three districts of Balochistan province in Pakistan. Several epidemics of stripe rust on wheat crop have been reported in the past and this disease continues to be a major threat to future wheat production.

Due to air borne nature of the disease use of chemicals is neither economical nor feasible on large scale. However, in advance countries wheat management strategies like resistant varieties and foliar application are utilized (Roelf et al., 1992). In Asia, after the appearance of virulence capable of attacking major wheat varieties Inqilab 91 (*Yr27*) and PBW 343 (resistance is based on *Yr 3/Yr 9* combination) in Pakistan and India (Singh et al., 2004). It was imperative to identify wheat varieties/genotypes possessing resistance against *Yr27* virulence for the deployment and future use.

The most rational approach is to breed resistant varieties to combat rust diseases of wheat. Growing resistant cultivars has no cost to farmers and also economical and environmentally safe measure to reduce crop losses by rust diseases (Singh, 2000). The national breeders develop candidate wheat lines in the light of above recommen-

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dations and these lines are evaluated/ screened against rust to identify the resistance sources at different hot spots by creating artificial rust epidemic under NUWYT for two consecutive years. On the basis of results of these trials, the candidate wheat lines that perform better in yield and showing desirable reactions against prevailing rust virulence are selected. Recommendations are made for their release from Technical Sub Committee (TSC).

MATERIALS AND METHODS

The NUWYT nursery comprises 29 promising bread wheat candidate lines and grouped into two categories viz., seeding date and rainfed (Table 1). It was planted at seven locations for screening against wheat rusts, in Sindh, Punjab, NWFP and NARC, Islamabad. These locations represent areas comprising different agro ecological zones and "hot spots" conducive for development of rusts. Methodology on planting, rust inoculations, rust observation and calculation of relative resistance index (RRI) were according to NUWYT report 1996-97 (Hussain, 1997). Artificial rust inoculations with the inoculums of known virulence of leaf rust were carried out in February 2004 to early March 2004 at CDRI, Karachi; WRI, Sakrand; RARI, Bahawalpur; AARI, Faisalabad; NARC, Islamabad; CCRI, Pirsabak and NIFA, Peshawar. Similarly stripe rust inoculations were arranged in February and March 2004 at NARC, Islamabad; AARI, Faisalabad; CCRI, Pirsabak and NIFA, Peshawar. Stripe rust pathotypes possessed virulence to host genes *Yr1, Yr2, Yr6, Yr7, Yr8, Yr9, Yr27* and *YrA* whereas leaf rust pathotypes possessed virulence for host genes *Lr1, Lr2a, Lr2c, Lr3, Lr10, Lr13, Lr15, Lr17, Lr20, Lr23, Lr24, Lr26, Lr27+31* and *Lr29* (Ahmad et al., 2000).

The nurseries were regularly monitored for rust development and final observations were recorded after full establishment of rust and at physiological maturity of international susceptible check/ spreader Morocco. At all locations, observations on response of stripe and leaf rusts were recorded according to Loegering (1959) and severity was recorded as per cent of rust infection on the plants according to the modified Cobb's scale (Peterson et al., 1948).

Coefficient of infection (CI) was calculated by multiplying the response value with the intensity of infection in percent. Average Coefficient of Infection (ACI) was derived from the sum of CI values of each entry divided by the number of locations. The highest ACI of a candidate line is set at 100 and all other lines are adjusted accordingly. This gives the Country Average Relative Percentage Attack (CARPA). The '0' to '9' scale previously designated as Resistance Index (RI) has been re-designated as RRI (Relative Resistance Index). From CARPA, RRI is calculated on a 0 to 9 scale, where 0 denote most susceptible and 9 highly resistant (Akhtar et al., 2001).

RESULTS AND DISCUSSION

Observations were made at the maximum development of stripe rust on the test material in the nurseries planted at NARC, Islamabad; CCRI, Pirsabak and NIFA, Tarnab where the infection on susceptible check Morocco was developed up to 90S.

Leaf rust observations were recorded at Zadoks stages 77-85 (Zadoks et al., 1974). The data of RRI and terminal reaction of each entry for both leaf and yellow rust for 7 locations viz., CDRI, Karachi; WRI, Sakrand; RARI, Bahawalpur; WRI, Faisalabad; CCRI, Pirsabak; NIFA, Peshawar and NARC, Islamabad was recorded (Table 2 and 3) .

Out of 29 candidate lines included in NUWYT 2004-2005, 9 were common to NUWYT 2003-2004 and 2004-2005. Out of remaining 20 candidate lines, 8 (4 from rainfed, 4 from seeding date) showed acceptable or desirable RRI for both stripe and leaf rusts (Table 4). These lines will remain in NUWYT for one more year to meet the criteria for release of variety by VEC.

Three candidate lines common in NUWYT for two years were found resistant to both rusts (Table 5). These included 3 lines from seeding date category (V-00125, 99B2278, and 99B4012). One line 7-03 from seeding date common in NUWYT both years

Table 1. List of lines/entries included in National Uniform Wheat Yielding Trial 2004-05

Line/Var	Parcentage/Pedigree	Source
NUWYT (Seeding date)		
V-00125	BULBUL//F3.71/TRM/3/CROW PB 26508 -9A-0A-0A-1A-0A	AARI, Faisalabad
V-01078	CHIL/2*STAR /4/BOW/CROW//BUC/PVN/ 3/CMSS9Y00645-100Y-200M-17Y-10M-0Y	AARI, Faisalabad
V-00055	PB81//F3.71/TRM/3/BULBUL//F3.71/TRM PB26720-9A—0A-4A-0A	AARI, Faisalabad
V-02192	SHL 88/V87094/MH97 PBP 88647-20A-3A -45A-15A-0A	AARI, Faisalabad
V-01180	PB96/87094/MH97	AARI, Faisalabad
DN-47	CHIL/2*STAR CM 112793-0TOPY-7M-020Y -010M-2Y-0M-0KBY-0M	ARI, D.I.Khan
Diamond	CHIL/2* STAR CM112793-0TOPY-8M-020Y- 010M-3Y-010M-010Y.	WRI, Sakrand
99B2278	PND 88//BB'S'/TOB66 BR 2900-1B-1B-5B -2B-0B	RARI, Bahawalpur
99B4012	PTS/3/TOB/LEN//BB/HD8325//ON/5/G. V/ALD'S'//HPO'S' BR 3385-3B-1B-0B	RARI, Bahawalpur
V-002493	PND 88//BB'S'/TOB66 BR 2900-1B-1B-3B- 2B-0B	RARI, Bahawalpur
V-9021	LU-31 x ROHTAS-90	UAF, Faisalabad
RWM-9313	VEE#5'S'/SARA//SOGHAT90	NIA, Tando Jam
7-03	CHAM4/URES//BOW'S' ICW 91-0012	NIA, Tando Jam
PR-84	KAUZ/STAR CMBW90Y3058-74M-015Y-015M -1Y-0B	CCRI, Pirsabak
PR-86	IAS63/ALD'S' GLEN/3/SNB'S'/PIMA//C306. FR6809-0K-1F-0K-0F	CCRI, Pirsabak
KT-7	STAR//KAUZ/STAR	BARS, Kohat
TW0135	CHANAB/HD 2204.JUOVS	AZRI, Bhakkar
CT-00062	VORONA/KAUZ//KAUZ-CMBW90M3785- 0TOPY-47M-010Y-010M-010Y-6M-15Y-0Y.	NIFA, Peshawar
Morocco		
NUWYT (Rainfed)		
V-00055	PB81//F3.71/TRM/3/BULBUL//F3.71/TRM PB26720-9A—0A-4A-0A	AARI, Faisalabad
DN-44	JUP/ALD'S'//KLT'S'/3/VEE'S'/6/BEZ//TOB/ 8156/4/ON//3/6*TH/KF//6*LEE/KF/S ICW91 -0321-2AP-0TS-1AP-2AP-0L_0AP	ARI, D.I.Khan
V-002467	91B2061/FSD BR3252-3B-3B-5B-4B-0B	RARI, Bahawalpur
PR-83	MUNIA/CHTO//AMSEL CMSS93 B00729S- 23Y-010M-010Y-010M-7Y-1M-0Y	CCRI, Pirsabak
PR-87	ATTILA/3/HUT/CAR//CHEN/CHTO 14/ ATTILA CMBW 90M 4860-0TOPY-16M-1Y- 010M-010Y-6M	CCRI, Pirsabak
V00BT004	PAK81/INQ.91 BIOTECH 0R0-0R1-2R2-0R3K	AARI, Faisalabad
SN-128	PASTOR/OPATA CM110624-7M-020Y-010M- 010SY-010M-0M-0SY	ARS, Sarai Naurang
NRL-2017	AMSEL/TUI CM107503-12Y-020Y-010M-3Y- 010M-1Y-0M-0AP	NIFA, Peshawar
V-5	KAUZ/2*BOW//KAUZ CRG 905-13Y-010M-0Y	ARI, Sariab, Quetta
NR-234	FRET 2 CGSS96Y00146T-099B-099Y-099B- 14Y-0B-0ID	NARC, Islamabad
NR-241	CROC-1/AESQUARROSA(213)//PGO/3/UP 2338 CMSS 96Y00047S-040Y-020M-040Y -020Y-032M-0ID-18ID-0ID	NARC, Islamabad
Morocco		

Table 2. Response of candidate lines to yellow rust along with Terminal Reaction Average (TR) Coefficient Infection (ACI), Country Average Relative Percent Attack (CARPA),Relative Resistance Index (RRI) during 2004-05

NUWYT Lines	CCRI Yr	NIFA Yr	NARC Yr	T.R Yr	ACI	CARPA	RRI
Seeding date							
V-00125	40MSS	40RMR	10S	10S	19.33	38.66	6
V-01078	20MSS	TR	40S	40S	19.4	38.8	6
V-00055	70MSS	40MSS	5S	5S	34.66	69.32	3
V-02192	20MRMS	TR	40S	40S	17.4	34.8	6
V-01180	60MSS	60MSS	10S	10S	39.33	78.66	2
DN-47	20MS	TMR	40S	40S	18.76	37.52	6
Diamond	40S	5RMR	50MSS	40S	28.83	57.76	4
99B2278	40MSS	20MSS	10MRMS	40MSS	20	40	5
99B4012	40MSS	10RMR	50MRMS	40MSS	23	46	5
V-002493	20MSS	40MSS	30S	30S	28	56	4
V-9021	40MSS	20MSS	60S	60S	38	76	2
RWM-9313	70MSS	40MSS	10MSS	70MSS	36	72	3
7-03	40MSS	TR	20MRMS	40MSS	16.06	32.12	6
PR-84	60MS	TR	30MSS	30MSS	25.06	50.12	5
PR-86	40MRMS	40MSS	40S	40S	33.33	66.66	3
KT-7	20MRMS	30MRMS	30S	30S	20	40	5
TW0135	70MSS	30MSS	60S	60S	50	100	0
CT-00062	60MSS	20MS	20S	20S	30	60	4
Morocco	80S	60S	80S	80S			
Rainfed							
V-00055	20MSS	40MSS	40S	40S	31.33	92.15	1
DN-44	TR	TR	0	TR	0.13	0.38	9
V-002467	10MSS	10RMR	20MRMS	10MSS	8	23.53	7
PR-83	TR	TR	0	TR	0.13	0.38	9
PR-87	10MSS	10MSS	30S	30S	16	47.06	5
V00BT004	40MSS	40MSS	30S	30S	34	100	0
SN-128	TR	30MSS	0	30MSS	9.05	26.68	7
NRL-2017	40MSS	20MSS	10S	10S	21.33	62.74	3
V-5	20MSS	5MS	10S	10S	10.66	31,35	6
NR-234	40MSS	10MRMS	10S	10S	17.33	50.97	4

Final disease rating includes two components: disease severity based on modified cobb's scale (Peterson et al., 1948) and host response.
TR= Trace Resistant, TMR= Traces Moderately Resistant
RMR= Resistant 15 Moderately Resistant
MR-MS= Moderately Resistant to Moderately Susceptible
MS= Moderately Susceptible: MSS= Moderately Susceptible to Susceptible
TMS= Traces Moderately Susceptible
S=Susceptible

was found resistant to yellow rust only (Table 6). One candidate line RWM 9313 from seeding date common in NUWYT for both years was found resistant to leaf rust only (Table 6). These lines have fulfilled two year testing requirement under NUWYT, therefore, these can be recommended for approval by VEC and release in the areas where stripe and leaf rust are the major problem.

V-00125 gave response up to 10% susceptibility for yellow rust and 5% severity for leaf rust it means that it has more than one gene for yellow and leaf rust for protection against both rusts. It is product of cross between Bulbul, Crow and TRM. Bulbul was the variety released in Pakistan in 1980 (Skoovmand et al., 1997), which is used as female for high yielding while the resistance is required from TRM and Crow. Crow

Table 3. Response of candidate lines to leaf rust along with Terminal Reaction Average Coefficient Infection (ACI), Country Average Relative Percent Attack (CARPA), Relative Resistance Index (RRI) during 2004-05

NUWYT Line/Variety	AARI Lr	RARI Lr	CDRI Lr	WRI Lr	T.R Lr	ACI	CARPA	RRI
Seeding Date								
V-00125	TMRMS	5MRMS	TMS	5MSS	5MSS	2.22	12.87	8
V-01078	5MRMS	20MRMS	0	TMS	20MRMS	3.95	22.9	7
V-00055	0	0	0	0	0	0	0	9
V-02192	10MRMS	10MRMS	10MSS	0	10MSS	5.25	30.43	6
V-01180	10MRMS	20MRMS	30MSS	TMS	30MSS	11.4	66.38	3
DN-47	20MRMS	50MRMS	30MSS	0	30MSS	17.2	100	0
Diamond	5MR	5MRMS	10MSS	TMS	10MSS	3.7	21.45	7
99B2278	5MR	0	TMS	0	TMS	0.7	4.06	9
99B4012	5MR	0	5MSS	0	5MSS	1.62	9.39	8
V-002493	TMR	0	40S	0	40S	10.1	58.55	4
V-9021	TMR	TMR	10MSS	TMS	10MSS	2.65	15.36	8
RWM-9313	5MRMS	0	10MSS	0	10MSS	3	17.39	7
7-03	TMRMS	50MRMS	20MSS	0	20MSS	12.1	70.43	3
PR-84	5MR	0	5MSS	0	5MSS	1.62	9.39	8
PR-86	TMR	0	TMS	0	TMS	0.3	1.74	9
KT-7	10MRMS	0	30MSS	TMS	30MSS	8.45	48.98	5
TW0135	30MRMS	20MRMS	20MSS	0	20MSS	12	69.57	3
CT-00062	10MRMS	20MRMS	20MSS	0	20MSS	9	52.17	4
Morocco	40S	40S	20MSS	5MSS	40S			
Rainfed								
V-00055	0	60R	20MSS	TMS	20MSS	7.7	60.39	4
DN-44	0	70R	TMS	0	TMS	3.9	30.59	6
V-002467	0	0	5MSS	TMS	5MSS	1.32	10.35	8
PR-83	5MR	TMR	TMS	0	TMS	0.8	6.27	8
PR-87	0	TMR	5MSS	0	5MSS	1.22	9.57	8
V00BT004	20MRMS	50MRMS	10MSS	0	10MSS	12.7	100	0
SN-128	10MRMS	0	30MSS	0	30MSS	8.25	64.71	3
NRL-2017	10MRMS	10MRMS	5MSS	TMS	5MSS	4.32	33.86	6
V-5	5MR	20MRMS	30MSS	0	30MSS	10.2	80.39	2
NR-234	0	0	30MSS	5MSS	30MSS	7.87	61.73	3
NR-241	20MS	30MRMS	TMS	0	20MS	8.7	68.23	3
Morocco	40S	50S	20MSS	5MSS	50S			

Final disease rating includes two components: disease severity based on modified cobb's scale (Peterson et.al., 1948) and host response.
TR= Trace Resistant, TMR= Traces Moderately Resistant
RMR= Resistant, 15 Moderately Resistant
MR-MS= Moderately Resistant to Moderately Susceptible
MS= Moderately Susceptible: MSS= Moderately Susceptible to Susceptible
TMS= Traces Moderately Susceptible
S=Susceptible

was released in 1980 in Mexico as slow ruster. Crow posses *Lr34*, which is genetically, linked with Yr18 (Singh, 1992a). Both yellow and leaf rust resistance genes *Lr34* and *Yr18* are adult plant resistance genes. The line V-00125 may have the adult plant resistance as depicted by the response for both rusts in the field. Resistance gene *Lr34* was also genetically associated with leaf tip necrosis (LTN) (Singh, 1992b). As *Lr34* having widespread effectiveness as source of resistance under field conditions and interactive effects (German and Kolmer, 1992) have been selected by sev-

Table 4. Candidate lines with desirable & acceptable relative resistance index (RRI) against yellow rust during 2004-05

Candidate line	Yellow Rust	Leaf Rust
NUWYT (Seeding date)		
V-01078	6	7
V-02192	6	6
PR-84	5	8
KT-7	5	5
NUWYT (Rainfed)		
DN-44	9	6
V-002467	7	8
PR-83	9	8
PR-87	5	8

Table 5. Candidate lines found resistant to both rusts during 2003-04 and 2004-05

Lines	RRI			
	2003-04		2004-05	
	Lr	Yr	Lr	Yr
V-00125	8	6	8	6
99B2278	9	5	9	5
99B4012	8	8	8	5

eral wheat breeders in the world. Second responsible parent for resistance was Torim F 73 (TRM) was released in Mexico and the parents were Bluebird and Inia66 (Skoovmand et al., 1997). It possesses *Lr1*, *Lr13, Lr17* and *Lr34* genes for leaf rust resistance. *Lr34* are responsible for the durable rust resistance (Roelf, 1988) whereas *Lr13* was also considered to confer durable adult plant resistance (Singh et al., 2001).

In 99B2278 parents are Punjnad-88, Bluebird and Tob-66. Punjnad-88 was used as female while Bluebird and Tob-66 as resistance parents. Bluebird was released in 1969 while Tobari-66 in 1966 in Mexico and is used in many crosses of CIMMYT as a resistant source. Tobari- 66 parents are Tezanos Pintos Precoz (TZZP) and Sanoora 64A. TZZP is the Argentinean semi dwarf based variety. Tobari-66 possess *Lr1, Lr13* and an unidentified gene while Sonora 64A only *Lr1* (Singh and Rajaram, 1991). Rust response in field by 94B2278 suggested that it may have the adult resistance gene *Lr13* along with unidentified resistance genes showing adult plant resistance like its parents.

Table 6. Candidate lines seeding dates found resistant to yellow rust and leaf rust during 2003-04 and 2004-05

Lines	RRI			
	2003-04		2004-05	
	Lr	Yr	Lr	Yr
Yellow Rust				
7-03	6	6	3	6
Leaf Rust				
7-03	6	0	7	3

Semi dwarf varieties Piamontes inita (PTS) in Argentina, Lenana (LEN) in Kenya while other rest of the Tobari- 66 (Tob-66), Bluebird (BB) and Hopo (HPO) in Mexico are the parents of 99B4012. All were high yielding at the time of their release (Skoovmand et al., 1997). It gave 40% moderately susceptible to susceptible response in fields at tested locations in heavy artificial epidemic. It means this line may have adult plant resistance to combat virulence of yellow and leaf rust prevailing in the environment.

One line 7-03 from seeding date common in NUWYT both years was found resistant to yellow rust only (Table 6). According to the parentage the resistance is coming from BOW'S. Unknown genes for yellow rust resistance are response for such response as given by the wheat line 7-03 in the field. Both years it was susceptible for leaf rust that may be due to the presence of resistance gene *Lr26* which is already present in one of its parent named Ures. Virulence for *Lr26* was observed in 2004-05 wheat growing season in Pakistan (unpublished data)

Regarding response by the wheat line RWM-9313 in two consecutive tested years data showed that it has more than one gene for leaf rust resistance. Soghat variety was used as resistant source in its parentage. *Lr13* was postulated in variety Soghat in combination with *Lr1* and *Lr10*. *Lr13* is predominant resistance gene and was postulated in nine Pakistani wheats including three commercial varieties Zardana, Faisalabad-83 and Soghat-90 (Mirza et al., 2000). The gene may have Adult Plant Resistance (APR) ability and by using in combination it gives desirable resistant reac-

tion.

The concept of the durable resistance or slow rusting is increasing in the world. More than 50 *Lr* genes, 40 *Yr* genes and 50 *Sr* genes have been mapped and catalogued. All of them are race-specific with exception *Lr34, Lr46, Yr18, Yr29, Yr30* and *Sr2*.

Cultivation of resistant wheat varieties would contribute greatly to the increasing productivity and stability of the wheat production in Pakistan. The substantial progress has been made by the national breeders in breeding for rust resistance. However, because of ever-evolving the virulence in the pathogen, rust diseases continue to impose real threat to wheat production. There is need for continuous monitoring of the diversity of the pathogen in addition to active efforts to maintain resistance level and improve its durability. The development of resistant varieties requires a continuous search for resistance and an active breeding programme to exploit genetic variability in rich gene pool of bread wheat germplasm, but also to better manage the deployment of resistance sources.

During the study period no virulence was observed on resistance genes *Lr9, Lr19, Lr28, Lr36* and *Lr37* for leaf rust as well as for yellow rust genes for resistance *Yr5, Yr10, Yr15, Yr26 ,YrSP* and *YrCV* (Unpublished). Hence these genes can be recommended as a resistance source for incorporation in adopted cultivars.

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