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LEAF AND STRIPE RUST RESISTANCE AMONG ETHIOPIAN GROWN WHEAT VARIETIES AND LINES

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ABSTRACT: Ethiopian grown wheat varieties and lines were studied to identify germplasm sources possessing resistance to leaf rust caused by *Puccinia triticina* and stripe rust (*P. striiformis*). Sixty-four lines were included of which 38 were bread wheat (*Triticum aestivum*, 2n=6x=42, AABBDD) and 26 durum wheat (*T. turgidum*, 2n=6x=42, AABBDD). Controlled glasshouse studies were conducted by inoculating seedling plants using pathotypes of five *P. triticina* (UVPrt2, UVPrt3, UVPrt5, UVPrt9 and UVPrt13) and two *P. striiformis* (6E16A and 6E22A). The result indicated that 20 varieties and lines harbor resistance to the leaf rust and 26 to the stripe rust pathotypes showing infection types $< 2^+$. Twelve bread wheat varieties and lines (Et-13 A2, HAR 1407 [Tusie], HAR 1775 [Tura], HAR 1920, HAR 2192, HAR 2534, HAR 2536, HAR 2561, HAR 2563 and three durum lines (DZ-114–08, AL-138, AL-69) had resistance reactions to both pathogen pathotypes. These varieties and lines, therefore, may be utilized in leaf and stripe rust resistance breeding programs.

Key words/phrases: Leaf rust, resistance, stripe rust, *Triticum aestivum*, *Triticum turgidum*

INTRODUCTION

The wheat stripe (yellow) rust caused by *Puccinia striiformis* West. f. sp. *tritici* and leaf rust (*P. triticina* Eriks.) are major constraints to increased yield globally (Knott, 1989; Das *et al.*, 1992). Yield losses due to rusts are variable because of differences in weather conditions, cultivar susceptibility and availability of inoculum. However, grain losses have been significant and estimated to reach 30–70% or even greater on susceptible varieties (Knott, 1989; Murray *et al.*, 1994). High moisture and warm weather favor leaf rust development while stripe rust is important under cool and moist environmental conditions (Knott, 1989). To reduce losses cultural control methods, application of chemicals and use of resistant cultivars are employed by wheat growers. The use of resistant cultivars is the best strategy (Raupp *et al.*, 2001).

Until presently 51 leaf rust (*Lr*) and 30 stripe rust (*Yr*) genes have been reported worldwide that confer seedling and/or adult plant resistance (McIntosh *et al.*, 1998; 2003). Selection for new sources of rust resistance remains important as earlier developed lines with single race-specific genes have mostly become ineffective due to the development of new and virulent pathotypes. Subsequently wheat rust researchers are constantly selecting new lines possessing additional and/or new resistance genes to complement the yield potential of cultivars (Sayre *et al.*, 1998).

Resistance can be sought in seedlings and/or adult plants. Seedling resistance genes are recognised in primary leaves and normally confer resistance at all stages of plant growth (Sawhney *et al.*, 1992). However, adult-plant resistance (APR) genes are not effective in seedlings and are the common sources of durable resistance. A combination of both seedling and adult-plant resistance is reported to occur in the presence of certain genes such as *Lr34* (Dyck and Samborski, 1982) and *Lr37* (Bariana and McIntosh, 1993). The genes for resistance can be demonstrated based upon the concepts of the gene-for-gene (Flor, 1942) and interorganismal genetics of host-pathogen association (Loegering, 1978; 1985).

Ethiopia and South Africa are situated in the same epidemiological zone of wheat rusts. It is

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reported that within the same zone there is relatively free movement of the rust spores and the virulence of a rust population will tend to be similar. However, virulence shifts may occur from area to area within a zone if the predominant cultivars in different areas carry different genes for resistance (Knott, 1989). In Ethiopia the wheat rusts obstruct stable wheat production and productivity (Dagnachew Yirgou, 1967; Eshetu Bekele, 1985; Ayele Badebo *et al*., 1990). Yield losses due to wheat rusts may vary according to climatic conditions and cropping systems. However, it is not well quantified in economic terms. Farmers in Ethiopia still require improved rust resistant wheat varieties and lines to reduce yield losses. It is important to identify sources of resistance and exploit them in a resistance breeding programs. Selection for resistance among Ethiopian grown varieties and lines would be feasible as the country is believed to be the centre of diversity of durum wheat (*Triticum turgidum* L., AABB, 2n=4x=28) (Vavilov, 1951; Harlan, 1969; 1992; Zohary, 1970). The present study has aimed at identifying germplasm sources possessing resistance to leaf rust and stripe rust among Ethiopian grown bread wheat (*T. aestivum* L., AABBDD, 2n=6x=42) and durum wheat. The information may help wheat rust researchers to introgress resistance genes to susceptible wheat cultivars and for subsequent gene deployment.

MATERIALS AND METHODS

Plant materials

A total of 64 bread wheat and durum wheat varieties and lines were included in the experiments. The list and detailed description of lines is presented in Table 1. Supplemental lines were included for comparative assessment. Ethiopian grown bread wheat and durum wheat seeds were kindly made available by Dr. Tadesse Dessalegn, from Adet Agricultural Research Centre of the Amhara Regional State, Ethiopia.

Table 1. Ethiopian-grown bread and durum wheat varieties and lines used in the study.

No.	Variety/line	Year released/ Registered	Cross/selection
Bread wheat (2n=6x=42, AABBDD)			
1.	Et-13 A2	1981	UQ105 Sel. x ENKOY
2.	HAR 1709 (MITIKE)	1993	BOW28/RBC
3.	K 6290-Bulk	1977	(AF.MAYO x GEM) x Romany
4.	K 6295-4A	1980	Romany x GB -Gamenya
5.	Enkoy	1974	[HEBRAND sel./(WIS 245/ SUP51)]//[FR-FN/Y)^2.A)
6.	Romany B.C.	1974	NA[(a)]
7.	Kanga	1993	MENCO/ (WIS245 x SUP51)/(FR-FN/Y)^2.A
8.	Mamba	1973	(AF.MY48/WIS245 x UP51)x(FR-FN/Y)^2.A
9.	Dereselign	1974	CI8154/2*FR
10.	Israel	Pre-1949	NA
11.	Bonde	Pre-1949	NA
12.	Salmayo	1966	NA
13.	Lakech	1970	PJ62/GB55 (118156)
14.	Pavon 76	1982	VCM//CNO/7C/3/KAL/BB (PAVON)
15.	Dashen	1984	KVZ/BUHO//KAL/BB (VEERY 5)
16.	Batu	1984	GLL/CUC//KVZ/SX (SUNBIRD)
17.	Gara	1984	AU//KAL/BB/3/WOP (BOBWHITE)
18.	HAR 407	1987	KVZ/BUHO// KAL/BB (VEERY 15)
19.	HAR 416	1987	AU//KAL/BB/3/WOP (BOBWHITE 28)
20.	HAR 1685 (KUBSA)	1994	ND/VG9144//KAL/BB/3/YACO /4/VEERY #5 (ATTILA)
21.	HAR 710 (WABE)	1994	MRL/BUC
22.	HAR 604 (GALAMA)	1995	4777*2//FLN/GB/3/PVN
23.	HAR 1522 (ABOLA)	1997	BOW/BUC
24.	HAR 1407 (TUSIE)	1997	COOK/VEE//DOVE/SERI
25.	HAR 1595 (MAGAL)	1997	F3.71/TRM//BUC/3/LIRA
26.	HAR 1706	Advanced line	Bow 'S'
27.	HAR 1775 (TURA)	1999	AROYR Sel.60/1989

NA=not available

Table 1. (Contd).

No.	Variety/line	Year released/ registered	Cross/selection
28.	HAR 1863	Advanced line	BOW/URE
29.	HAR 1868 (SHINA)	1999	GOV9/AZ//MUS/3/R37/GHL21//KAL/BB/4/ANI
30.	HAR 1901	Advanced line	BUC /FLK //MYNA/VUL
31.	HAR 1920	2000	MON / VEE//SARA
32.	HAR 2192	2002	CM75113-B-5M-1Y-O5M-3Y-2B-OY (MILAN)
33.	HAR 2501	2000	CHIL/PRL
34.	HAR 2508	2003	BJY/COC//PRL/BOW
35.	HAR 2534	2003	ND/VG9144//KAL/BB/3YACO/4/CHIL
36.	HAR 2536	2000	PRL/VEE6/MYNA/VUL (PRINIA)
37.	HAR 2561	Candidate	CM90722-22Y-OM-OY-3M-OY-4M-1M-OY (PRINIA)
38.	HAR 2563	Candidate	CHUM18//JUP/BJY
Durum wheat (2n=4x=28, AABB)			
39.	E-26	NA	Landrace
40.	DZ-114-08	1966	Landrace
41.	AL-138	NA	Landrace
42.	AL-69	NA	Landrace
43.	CADU #17	NA	Landrace
44.	BAHIRSEDED	NA	Landrace
45.	BOOHAI	1982	COO/CII
46.	BOOHAI "S"	1982	CD 3862-1BS-1BS-1GDZ-1GDZ
47.	FOKA	1983	Cocorit 71/Candeal II
48.	KILINTO	1994	ILLUMILO/INRAT69//BOOHAI/3/HorA/4/CIT 71/JORO
49.	Ld-357	1979	Ld-357/CI8155
50.	QUAMY	1997	FG/CR/FG/DOM/6/HUI
51.	TOB – 66	1997	REICHNBACHII/LD357//DUCK/YEL
52.	FETAN (TOP-2)	NA	NA
53.	DZ-393–4 (BICHENA)	1995	Illumilo/Cocori 71
54.	DZ-2023	NA	Dz04–1169/Dz04–129/Yemen Cit /PLCS/3/Tugaroy B.B/4//5/Chen /PCHI//HUI/ TUB :3
55.	DZ-1691	NA	Boohai//Cit 71/Candeal II
56.	DZ-2085 (ASSASA)	1997	CHO/TARU//YAU/3/Fg/4/Fg/ kr/5/Fg/Dom /6/HUI
57.	DZ-1050	2000	Boohai/ULNV
58.	DZ-1052	NA	Boohai/4/Mexi //Chap/21563/3/Fg
59.	Gerardo	1976	VZ466/61-B0xLDsXGII
60.	Cocorit 71	1976	RAE/4/ TC60// TW63/3/3/AA
61.	DZ-575	NA	Boohai/GDO Dz 466/61–130K Gll
62.	DZ-1640 (ROBE)	1999	Hora/Cit //JOO/GS/3/Some/4/Hora/Raspinegro//CM/ 9908/3/Rahum
63.	DZ-966	NA	NA
64.	DZ-1928–2	NA	NA

NA=not available

Growing conditions

Resistance was studied through two independent tests by growing seedling plants in controlled rust free glasshouse cubicles at the University of the Free State, South Africa. Studies were conducted from September through December 2002 and April to August 2003. From each variety and line 10–15 seeds were sown in a 10 cm diameter plastic pots filled with steam-sterilized soil. For leaf rust studies, the glasshouse day and night temperature was maintained at 20 ± 5°C and 14 ± 5°C, respectively with a day light regime of 14 h. The stripe rust studies were carried out by maintaining the glasshouse temperature at 17 ± 2°C with 16 h light and 8 h night regimes. The daylight was supplemented with 120 $\mu molm^{-2}s^{-1}$ photosynthetically active radiation that was emitted from cool white fluorescent tubes arranged directly above plants. Seedling of 2 to 3 cm long were fertilized with a solution that contained 12.5%N, 8.3%P, 4.2%K and 0.5%Zn (Omnia Fertilizer Limited) at a rate of 10 g/l and a solution of 50 ml was applied per pot.

Rust pathotypes, inoculum preparation and incubation

Single pathotype of UVPrt2, UVPrt3, UVPrt5, UVPrt9 and UVPrt13 of *P. triticina* and 6E16A and

6E22A of *P. striiformis* were used for inoculating seedling plants. The Department of Plant Sciences, the University of the Free State (South Africa) supplied the pathotypes. Based on the infection types on South African differential sets, the avirulence/virulence pattern of the pathotypes with respect to array of named resistance genes is presented in Table 2.

Fresh and sufficient inoculum was prepared using susceptible selective hosts (Table 2). At emergence seedlings of the selective hosts were treated with a solution of maleic hydrazide (MH) to retard plant development and encourage sporulation. A MH solution was prepared at a rate of 0.3 g/l and 50 ml/pot basally applied. Two days after applying MH, seedlings were fertilized with a solution as described above. Week old seedlings were infected by spraying with urediniospores of both pathotypes. Fresh inoculum of stripe rust was used from growth chambers for inoculating the selective hosts. While urediniospores of leaf rust pathotypes kept under ultra low temperature (-156 °C) in gelatin capsules were used after heat shock in warm water at 47°C for 6 min. For inoculations urediospores were suspended in light mineral oil (Soltrol 70). The upper surfaces of primary leaves were uniformly inoculated with a pressurized sprayer by putting pots in an inoculation booth that was automatically rotating to allow uniform spraying. The booth was thoroughly cleaned after spraying and different pathotypes were handled separately to prevent contamination. Inoculated seedlings were allowed to dry for about 2 h before they were incubated. Leaf rust inoculated sets were incubated for 16 h at 20 to 24°C by placing in a moist chamber (96% RH) while the stripe rust set was incubated for 48 h at 6°C. Seedlings were taken from the moist chambers and allowed to dry slowly for another 2 h and moved to glasshouse cubicle until sufficient spores were harvested for inoculating test plants.

Week old seedlings of test lines and varieties were infected by spraying with a single pathotype of leaf rust and stripe rust urediospores. For inoculation, fresh spores were harvested from susceptible hosts and a solution was prepared at standard spore concentration of 40×10^4 urediospores/ml oil. The concentration was established by mixing about 1.5 mg of urediospores per ml of the mineral oil followed by counting the number of spores under a counting chamber and light microscope. Before each inoculation suspensions were adjusted to the appropriate density. Growing conditions as well as pre- and post-inoculation procedures were followed as described above.

Table 2. Avirulence/virulence combinations of South African pathotypes of *Puccinia triticina* (UVPrt2, UVPrt3 UVPrt5 UVPrt9 and UVPrt13) and *Puccinia striiformis* (6E16A and 6E22A) and susceptible hosts used for increasing the pathotypes.

Pathotype	Avirulence/Virulence genes	Susceptible host
UVPrt2	*Lr1, Lr2a, Lr2b, Lr3ka, Lr11, Lr15, Lr17, Lr20, Lr24, Lr26, Lr30/Lr2c, Lr3a, Lr3bg, Lr10, Lr14a, Lr16*	Zaragoza
UVPrt3	*Lr3a, Lr3bg, Lr3ka, Lr10, Lr11, Lr14a, Lr16, Lr17, Lr20, Lr26, Lr30/Lr1, Lr2a, Lr2b, Lr2c, Lr15, Lr24*	Agent
UVPrt5	*Lr1, Lr2a, Lr3bg, Lr10, Lr11, Lr14a, Lr15, Lr17, Lr24, Lr26/Lr2b, Lr2c, Lr3a, Lr3ka, Lr16, Lr20, Lr30*	Thew
UVPrt9	*Lr2a, Lr2b, Lr3bg, Lr15, Lr16, Lr17, Lr26, Lr30/Lr1, Lr2a, Lr2b, Lr2c, Lr10, Lr14a, Lr15, Lr17, Lr24*	Karee
UVPrt13	*Lr3a, Lr3bg, Lr3ka, Lr11, Lr16, Lr20, Lr30/Lr1, Lr2a, Lr2b, Lr2c, Lr10, Lr14a, Lr15, Lr17, Lr24, Lr26*	Gamtoos
6E16A	*Yr1, Yr3a, Yr4, Yr4a, Yr4b, Yr5, Yr9, Yr10, Yr15, Yr24, Yr25, Yr26, Yr27/Yr2, Yr6, Yr7, Yr8, Yr11, Yr14, Yr17, Yr18, Yr19*	Morocco
6E22A	*Yr1, Yr3a, Yr4, Yr4a, Yr4b, Yr5, Yr9, Yr10, Yr15, Yr24, Yr25, Yr26/Yr2, Yr6, Yr7, Yr8, Yr11, Yr14, Yr17, Yr18, Yr19, Yr27*	Morocco

Infection type assessment

Infection types (ITs) were scored from primary seedling leaves of 14, and 14 to 16 days after inoculation, respectively of leaf rust and stripe rust inoculated varieties and lines. The Stakman *et al.* (1962) scale as modified by Roelfs (1988) was used as a guide and the ITs were decided on 0 to 4 scale (Table 3). IT readings of 3 (medium-size uredia with/without chlorosis) and 4 (large uredia without chlorosis or necrosis) were regarded to show a compatible reaction. Other readings, *i.e.*, 0 (immune), ; (flake), 1 (small uredia with necrosis), 2 (small to medium uredia with chlorosis or necrosis) were incompatible. Pustules that were accompanied by chlorosis or necrosis were indicated by "C" and "N"; respectively (Table 3). The variations above the established pustule sizes were indicated by a plus or minus sign (McIntosh *et al.*, 1995).

Table 3. Seedling infection types[a] of 38 bread wheat and 26 durum wheat grown in Ethiopia when tested to pathotypes of *Puccinia triticina* and *Puccinia striiformis*

No.	Line	Pathogen and pathotype						
		P. triticina					*P. striiformis*	
		UVPrt2	UVPr3	UVPrt5	UVPrt9	UVPrt13	6E16A	6E22A
Bread wheat								
1	Et-13 A2	1N	1	1	1N	1N	1N	1N
2	HAR 1709	2C	3C	2C	3	3	3	2C
3	K 6290-BULK	1N	3C	2C	2C	1N	3C	3
4	K 6295-4A	2C	1N	3C	3	3	2C	2
5	ENKOY	3	3C	3C	3	3	;C	1N
6	KANGA	2C	3	3	1C	2C	2C	2C
7	ROMANY B.C.	1C	3C	2C	3C	3	3C	4
8	MAMBA	1C	4	3	3	3C	3C	3C
9	DERESELIGN	2C	3	4	3	3	1C	3C
10	ISRAEL	3	3	4	3	3	2C	4
11	BONDE	2C	4	3C	4	4	1N	3C
12	SALAMAYO	2^{+}C	4	2C	2C	3	3	3
13	LAKECH	2C	3	2C	3	4	4	4
14	PAVON 76	;	1N	;	3	3	4	4
15	DASHEN	;	1N	3C	1N	3	;N	;N
16	BATU	0	;	;	;	3	;N	;N
17	GARA	0	;N	;N	;N	3	;N	;N
18	HAR 407	;	1N	;N	;N	3	1N	;N
19	HAR 416	;	;N	;	1N	3C	;N	;N
20	HAR 1685 (KUBSA)	1N	4	4	4	4	3C	3C
21	HAR 710 (WABE)	0	;	;	1N	;	3	1N
22	HAR 604 (GALAMA)	1	;N	1N	1N	;	1N	3
23	HAR 1522 (ABOLA)	0	1N	;	1N	;	1N	3
24	HAR 1407 (TUSIE)	0	1N	;	;	;	;	;
25	HAR 1595	;	2C	3	3	3	1N	1N
26	HAR 1706	;	2C	1N	3	;	1N	;N
27	HAR 1775 (TURA)	;	;N	;	1N	;	1N	;N
28	HAR 1863	0	3	;	;	3	0	;N
29	HAR 1868 (SHINA)	1N	3C	3	3	4	3C	3C
30	HAR 1901	1	3C	2C	4	3C	;N	3C

[a] Results confirmed from two separate tests.

Table 3. (Contd).

No.	Entry	Pathogen and pathotype						
		P. triticina					*P. striiformis*	
		UVPrt2	UVPr3	UVPrt5	UVPrt9	UVPrt13	6E16A	6E22A
31	HAR1920	0	;	;	;	;	0	;
32	HAR2192	0	;N	;	1N	1N	;N	;
33	HAR2501	1N	3C	4	3	3	4	4
34	HAR2508	0	1N	;	;	3	;	;
35	HAR2534	0	;	;	;	;	;N	;
36	HAR2536	0	;	;	;	;	;N	;N
37	HAR2561	;	;	;N	;	;	;	;N
38	HAR2563	0	1N	;	;	;	;	;N
Durum wheat								
39	E-26	;	3C	1N	3	3	3C	4
40	DZ-114–08	;	1N	1N	1N	;	1N	2C
41	AL-138	0	1N	0	;	;	;	;
42	AL-69	;	1N	;N	;	;	;N	;
43	CADU#17	4	4	4	4	4	4	4
44	BAHIRSEDED	3	4	3	4	3	3C	4
45	BOOHAI	3	3	3	4	;N	3C	3C
46	BOOHAI "S"	;N	;N	3	;N	;	3	;
47	FOKA	;	;	;	;	;	3C	;
48	Kilinto	;	3	;	;	;	3C	;
49	LD-357	;N	2C	;N	;	;N	3C	;
50	QUAMI	;N	;N	;N	;	;N	3C	;
51	TOB-66	;	;	1N	;	3	3C	;
52	FETAN(TOP-2)	1N	3	4	3	;	2C	2C
53	DZ-393–4	2C	4	4	2C	3	3C	;
54	DZ-2023	;N	0	;N	;N	;N	3C	;
55	DZ-1691	;	;N	;N	;N	;N	3C	;
56	DZ-2085 (ASASSA)	3	3	4	3	3	4	4
57	DZ-1050	1N	2C	3	2C	;N	3C	3C
58	DZ-1052	1N	3C	4	;N	1N	3C	4
59	GERARDO	1N	3C	3	2C	2C	3C	3C
60	COCORIT 71	;	3	2C	1N	;N	;	3C
61	DZ-575	1N	1N	3C	1N	;N	3C	3C
62	DZ-1640	1	2C	3C	2C	3	;	3C
63	DZ-966	1N	3	3	1N	3	2C	2C
64	DZ-1928–2	2C	3C	4	3	3	3C	3C
Supplemental lines								
65	RL 6003	;	4	1N	3	3		
66	RL 6002	3	1N	3	3	1N		
67	Thew	1N	2	4	4	1N		
68	Gamtoos	;	;N	;	1N	3		
69	Morocco	2^+C	4	4	3	3	4	4
70	Reichersberg 42						;N	3C
71	Heines Peko						;	3
72	Chinese 166						0	;N
73	Heines Kolben						3C	3

RESULTS

Selection for leaf rust resistance

Infection types of both bread wheat and durum wheat varieties and lines against five *P. triticina* are summarized in Table 3. The result indicated that 20 lines had resistance reactions to the pathotypes (ITs <2+). The varieties and lines included Et-13, HAR 710 (Wabe), HAR 604 (Galama), HAR 1522 (Abola), HAR 1407 (Tusie), HAR 1775 (Tura), HAR 1920, HAR 2192, HAR 2534, HAR 2536, HAR 2561, HAR 2563, DZ-114–08, AL-138, AL-69, Foka, LD-357, Quami, DZ-2023, and DZ-1691. The first 12 lines are bread wheat and the remaining durum wheat. Bread wheat varieties and lines including Enkoy and Israel and durum wheat Cadu#17, Bahirseded, and DZ-2085 (Assasa) were susceptible to all the leaf rust pathotypes (ITs ≥2+) similar to the susceptible standard 'Morocco'. The remaining 39 varieties and lines expressed heterogeneous reaction types to one or four of the pathotypes. UVPrt13 was relatively the most aggressive pathotype to the tested materials. Fifty percent of tested lines showed susceptible reactions to the pathotype. This pathotype was remarkably more aggressive to the bread wheat varieties and lines than durum wheat. Pathotypes UVPrt3 and UVPrt5 were the most aggressive to durum lines to which 50% were susceptible. Leaf rust pathotype UVPrt2 was the least aggressive. Only about 11% of tested lines (three bread wheat and four durum wheat lines) displayed susceptible reactions to pathotype UVPrt2.

Selection for stripe rust resistance

The seedling reactions of 64 wheat varieties and lines tested against two pathotypes of stripe rust are presented in Table 3. Twenty-one bread wheat lines [Et-13, K 6295-4A, Enkoy, Kanga, Dashen, Batu, Gara, HAR 407, HAR 416, HAR 1407 (Tusie), HAR 1595 (MAGAL), HAR 1706, HAR 1775 (Tura), HAR 1863, HAR 1920, HAR 2192, HAR 2508, HAR 2534, HAR 2536, HAR 2561, HAR 2563] and five durum lines [DZ-114–08, AL-138, AL-69, Fetan, D-Z695] expressed resistant reactions. Eight bread wheat lines (Romany B.C., Mamba, Salamayo, Laketch, Pavon 76, HAR 1685 (Kubsa), HAR 1868 (Shina), and HAR 2501) and 10 durum wheat (E-26, Cadu#17, Bahirseded, Boohai, DZ-2085 (Assasa), DZ-1050, DZ10-52, Gerardo, DZ-575, DZ-1928-2) were uniformly susceptible to the two pathotypes. Both stripe rust pathotypes were virulent to 50% of tested varieties and lines (Table 3). Pathotype 6E16A was more aggressive to durum wheat than bread wheat. Cadu#17, Bahirseded and DZ-2085 (Assasa) had susceptible reactions similar to 'Morocco' (Table 3).

Twelve of the tested varieties and lines had resistance against five leaf rust and two stripe rust pathotypes of South African origin. These lines include Et-13, HAR 1407 (Tusie), HAR 1775 (Tura), HAR 1920, HAR 2192, HAR 2534, HAR 2536, HAR 2561, HAR 2563, DZ-114-08, AL-138, and AL-69. The first nine are bread wheat and the last three durum wheat. The bread wheat varieties and lines identified with resistance are either released or candidates for large area productions. The resistant durum lines are landraces, which are largely grown in Ethiopia.

DISCUSSION

Sixty-four Ethiopian grown bread and durum wheat were tested under controlled glasshouse conditions to study leaf rust and stripe rust seedling resistance. Nine bread wheat varieties and lines {Et-13 A2, HAR 1407 (Tusie), HAR 1775 (Tura), HAR 1920, HAR 2192, HAR 2534, HAR 2536, HAR 2561 and HAR 2563} and three durum varieties and lines (DZ-114–08, AL-138 and AL-69) possess resistance to five leaf and two stripe rust pathotypes recurring in South Africa. Except line Et-13 A2 that was released in 1981 others including HAR 1407, HAR 1775, HAR 1920, and HAR 2536 were recent releases. Bread wheat varieties and lines HAR 2192, HAR 2534, HAR 2561, and HAR 2563 are advanced or recent releases and currently expressed adequate resistance. The tetraploid landraces DZ-114–08, AL-138 and AL-69 displayed resistant reactions.

The result indicated that bread wheat variety K 6290-bulk possessed resistance to four leaf rust pathotypes except UVPrt3. This line was developed from crosses with variety Mayo. Mayo 52 and 54 were reported to carry *Lr10* by Anderson (1961). Further, HAR 2563 was considerably resistant to the studied pathotypes. Singh (1992) reported Jupateco, one of the progenitors of this line, as carrier of *Lr17a* and *Lr27.* Singh and Rajaram (1994) described Jupateco carrying *Yr18*, which might have conferred stripe rust resistance in HAR 2563. Et-13 A2 showed resistance against the two stripe rust pathotypes. The pedigree of line Et-13 A2 indicates that Enkoy is one of its progenitors. Ayele Badebo *et al*. (1990) identified Enkoy with *Yr3*. Presently Enkoy is found resistant towards both stripe rust pathotypes. The current study has also identified Dashen to be resistant to the two stripe rust pathotypes. This variety was the result of crosses to Veery#5 reported to carry *Yr7* and *Yr9* by Dubin *et al*. (1989). Dashen also expressed resistance reactions to UVPrt2, UVPrt3 and UVPrt9 owing to the presence of *Lr9* descended from variety Veery (Merker, 1982). Variety HAR 1407 (Tusie) has shown resistance reactions to both stripe rust pathotypes. One of the parents of HAR 1407 is Maris Dove that carries *Yr6* (McIntosh *et al*., 1998).

There is no earlier report that described durum landraces DZ-114–08, AL-138 and AL-69 as a source of leaf rust or stripe rust resistance. Therefore, the lines could be considered as sources of resistance to increase the genetic diversity in breeding programs. Landraces of wheat are considered as a primary genepool (Friebe *et al*., 1996) to enhance genetic variation in bread wheat (*Triticum aestivum* L., AABBDD, 2n=6x=42). Wheat landraces from Ethiopia have been reported as valuable genetic resources because of their rust resistance, long coleoptile, short culm, low tillering, early maturity and drought resistance (Perrino and Porceddu, 1990). There are also evidences that suggest the presence of considerable level of resistance among Ethiopian wheat germplasm that could be selected for strategic breeding for rust resistance (Tesfaye Tessema, 1987; Ayele Badebo *et al*., 1990).

The study concluded that a considerable level of seedling plant resistance is available from Ethiopian grown wheat varieties and lines when tested by known leaf rust and stripe rust pathotypes presently recurring in South Africa. Since the two countries fall in the same epidemiological zone of wheat rusts (Knott, 1989) the information could be useful to wheat rust researchers. It is worthwhile, however, to note a possible occurrence of virulence shifts from area to area within a zone. This could be attributed by differences in the predominant cultivars grown in these areas that may carry different genes for resistance. Consequently it is required to make detailed studies by including the prevailing rust pathotypes of Ethiopian origin and using diverse germplasm as well as standard differential lines. Further, it is imperative to examine adult-plant resistance as it is a common source of durable resistance.

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