Field-based Assessment of the Effectiveness of Rust Resistance Genes Under Field Conditions in Lebanon, Morocco and Tunisia in 2024

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Introduction

The development of rust-resistant varieties relies on the presence of efficient rust resistance genes, and the utilization of these genes in breeding programs relies on the evaluation of their effectiveness. Analyzing the races can offer insights into the pathogenic variations among rust pathogens and the responses of characterized genes in seedlings and the field assessments conducted under natural infection conditions provide valuable information regarding the efficacy of seedling resistance genes. Alongside the assessment of seedling resistance genes, the evaluation of sources containing adult-plant resistance genes can be carried out during the adult-plant stage but not at seedling stage. This innovation focuses on validating and assessing the resistance performance of rust resistance genes under natural field conditions. A successful breeding program for rust resistance relies on the availability of effective resistance sources, particularly genetic sources with well-characterized rust resistance genes. This knowledge ensures that the selected genes will provide adequate protection against rust pathogens under local environmental conditions.

Summary
Trap nurseries comprising yellow, stem, and leaf rust resistance genes planted under natural infection in two locations in Lebanon and Morocco. Despite the availability of differential seeds, the trap nurseries were not planted in Tunisia. In Morocco, a high level of susceptibility to leaf rust was observed in several leaf rust genes, including *Lr10*, *Lr11*, *Lr12*, *Lr13*, and others across different locations, such as Allal Tazi and Marchouch. In contrast, resistance was noted in genes such as *Lr2b*, *Lr3*, *Lr9*, *Lr19*, *Lr34*, and others. In Lebanon, field observations indicated differences in yellow rust resistance across two locations, with various resistance genes (e.g., *Yr1*, *Yr2+*, *Yr3*, *Yr5*, *Yr6+*, *Yr15*, and others) remaining effective at Tel Amara and Kfarchakhna. In Marchouch, stem rust resistance genes like Sr*21*, *Sr11*, and *Sr38* showed effectiveness, while others, including *Sr5*, *Sr6*, and *Sr36*, were ineffective. Details of effectiveness of *Yr*, *Sr*, and *Lr* genes in Morocco and Lebanon is provided.

Materials and Methods

To evaluate the effectiveness of rust resistance genes under the natural infection, three wheat rust trap nurseries, containing yellow (43 lines), stem, and leaf (43 genes) rust resistance genes, were planted at Allal Tazi and Marchouch research station in Morocco and at Tel Amara and Kfarchakhna research stations in Lebanon. The susceptible cultivar Morocco was used as susceptible check in all locations. Seeds of differential lines were provided from the Turkey-ICARDA Regional Cereal Rust Research Center. The list of differential lines for yellow, leaf and stem rust are presented in table 1, 2, and 3. Each line was planted in 1 m row with row space of 30cm (Figure 1 and 2). Field scoring was conducted at heading stage for disease severity on scale 0 to 100 using the Modified Cobb's scale (Peterson et al., 1948) and the resistance responses were recorded according to Roelfs et al (1992).

Results

A high level of infection (susceptibility) for a group leaf rust genes were observed for *Lr10, Lr 11, Lr12, Lr13, Lr14a, Lr14b, Lr15, Lr16, Lr17, Lr20, Lr21, Lr22a, Lr25, Lr26, Lr28, Lr37, Lr38, Lr44, Lr45, Lr63*, and *Lr1, Lr3, Lr3bg, Lr3ka, Lr10, Lr11, Lr12, Lr13, Lr14a, Lr14b, Lr15, Lr16, Lr17, Lr20, Lr25, Lr26, Lr29, Lr30, Lr33, Lr37, Lr38, Lr44, Lr45, and Lr63* in Allal Tazi and Marchouch in Morocco, respectively. Overall, the leaf rust genes *Lr2b, Lr2c, Lr3, Lr3bg, Lr3ka, Lr9, Lr18, Lr19, Lr23, Lr24, Lr29, Lr32, Lr33, Lr34, Lr36, Lr47, Lr51, Lr60, and Lr64* showed resistance in Morocco (Table 1). The field observation of yellow rust genes in Lebanon indicated the difference of at leat two races in two lcoaitons in lebanon. Yellow rust resistance genes *Yr1, Yr2+, Yr3, Yr4, Yr5, Yr6+, Yr7+, Yr9+2, Yr15, Yr24, Yr32+, YrSP+, YrSD*, and Tres remained resistant at Tel Amara while the *Yr1, Yr2+, Yr3, Yr4, Yr5, Yr6+, Yr7, Yr9+2, Yr10, Yr15, Yr24, Yr32+, YrSP+, YrND, Yr SD*, and Tres were resistant at Kfarchakhna (Table 2). The field data of stem rust trap nursery in Marchouch showed effectiveness of stem rust resistance genes *Sr21, Sr11, Sr9g, Sr24, Sr31, Sr38, Sr24+31* while the *Sr5, Sr9e, Sr7b, Sr6, Sr8a, Sr36, Sr9b, Sr30, Sr17, Sr9a, Sr9d, Sr10, SrTmp*, and McNair remained ineffective (Table 3).

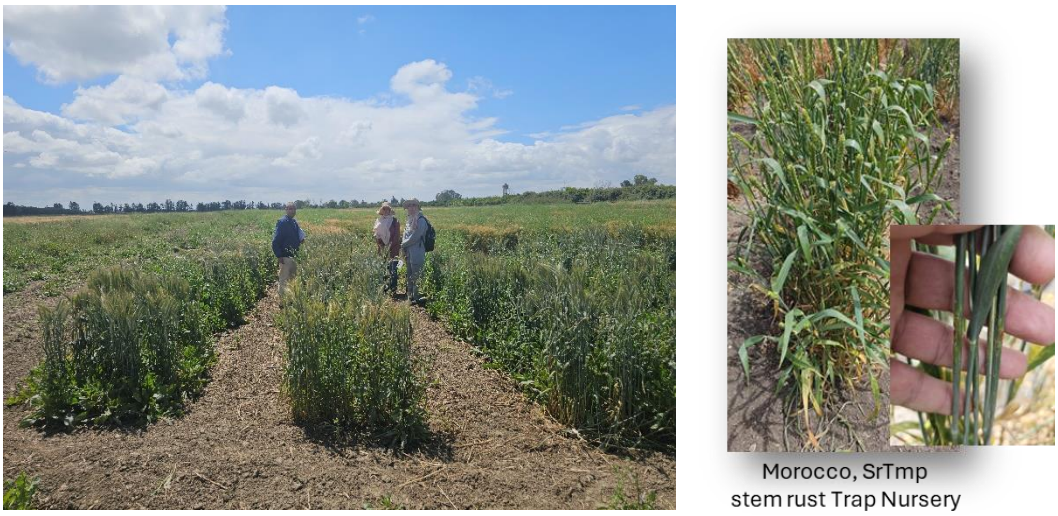

Figure 1. Leaf and stem rust Trap Nurseries, Marchouch in Morocco, 2024.

Figure 2. Yellow trap Nursery Tel Amara, Lebanon, 2024

Reffrences

Peterson R. F., A. B. Campbell and A. E. Hannah. A diagrammatic scale for estimating rust intensity on leaves and stems of cereals. Can. J. Res.. 1948. Vol. 26c(5):496-500. DOI: 10.1139/cjr48c-033.
Roelfs, A.P., Singh, R.P. and Saari, E.E. (1992) Rust diseases of wheat: concepts and methods of disease management. CIMMYT, Mexico, 80.

Table 1. Field responses of leaf rust genes planted as Trap Nursery at Allal Tazi and Marchouch in Morocco 2024

Entry No.	Seed Source	Lr gene	Morocco Allal Tazi	Morocco Marchouch	Entry No.	Seed Source	Lr gene	Morocco Allal Tazi	Morocco Marchouch
1	RCRRC-2023	Lr1	20R-MR,60S	40SMS	23	RCRRC-2023	Lr23	50MR	TR
2	RCRRC-2023	Lr2a	5R	5R	24	RCRRC-2023	Lr24	20RMR	TR
3	RCRRC-2023	Lr2b	10R	5R	25	RCRRC-2023	Lr25	80S	40SMS
4	RCRRC-2023	Lr2c	20R	10MR	26	RCRRC-2023	Lr26	80S	60S
5	RCRRC-2023	Lr3	5R	90S	27	RCRRC-2023	Lr28	80S	10R-60MSS
6	RCRRC-2023	Lr3bg	10R,20MS	60MS	28	RCRRC-2023	Lr29	5R	80S
7	RCRRC-2023	Lr3ka	5SM-S	80S	29	RCRRC-2023	Lr30	20MS	80S
8	RCRRC-2023	Lr9	5R,70S	5R,90S	30	RCRRC-2023	Lr32	10MR	10MR
9	RCRRC-2023	Lr10	50S,5R	80S	31	RCRRC-2023	Lr33	20MR	50S
10	RCRRC-2023	Lr11	50S,10R	80S	32	RCRRC-2023	Lr34	5R	10R
11	RCRRC-2023	Lr12	50S-MS	80S	33	RCRRC-2023	Lr36	5R,20MS	10R
12	RCRRC-2023	Lr13	60S	70S	34	RCRRC-2023	Lr37	70S	80S
13	RCRRC-2023	Lr14a	80S	90S	35	RCRRC-2023	Lr38	70S	90S
14	RCRRC-2023	Lr14b	50S	80S	36	RCRRC-2023	Lr44	60S	80S
15	RCRRC-2023	Lr15	60S	90S	37	RCRRC-2023	Lr45	60S	80S
16	RCRRC-2023	Lr16	80S	90S	38	RCRRC-2023	Lr47	5MR	5R
17	RCRRC-2023	Lr17	80S	90S	39	RCRRC-2023	Lr51	5R	5R
18	RCRRC-2023	Lr18	10MR	20R	40	RCRRC-2023	Lr52	5MS-10RMR	5R
19	RCRRC-2023	Lr19	5RMR	5R	41	RCRRC-2023	Lr60	20MR-MS	5RMR
20	RCRRC-2023	Lr20	90S	80S	42	RCRRC-2023	Lr63	70S	60SMS
21	RCRRC-2023	Lr21	70MR-MS	10RMR	43	RCRRC-2023	Lr64	30RMR	20RMR
22	RCRRC-2023	Lr22a	50MS	5R	44	RCRRC-2023	Morocco	80S	80S

Table 2. Field responses of yellow rust genes planted as Trap Nursery at Tal Amra and Kfarchakhna in Lebanon 2024

Entry No.	Genotype	Yr gene	Lebanon TAL AMARA	Lebanon KFARCHAKHNA	Entry No.	Genotype	Yr gene	Lebanon TAL AMARA	Lebanon KFARCHAKHNA
1	Morocco	-	100S	50S	23	Moro	10+	80MRMS	tR
2	Avocet 'S'	-	100S	30S	24	Yr15/ 6* Avocet S	15	0	tR
3	Avocet 'R'	A	100S	30S	25	YR17/6*Avocet S	17	100S	40S
4	Yr1/ 6* Avocet S	1	10RMR	0	26	VPM 1	17	70S	40S
5	Chinese 166	1	10R	0	27	Yr24/6*Avocet S	24	30RMR	tR
6	Kalyansona	2	50MRMS	10MR	28	TP 981	25	90S	50S
7	Heines VII	2+	20MRMS	10MRMS	29	TP1295	25?	70S	40S
8	Vilmorin 23	3	30MRMS	tR	30	Yr26/6*Avocet S	26	100S	40S
9	Hybrid 46	4	20RMR	tR	31	Yr27/6*Avocet S	27	100S	30S
10	Yr5/ 6* Avocet S	5	10RMR	tR	32	OPATA 85	27,18	60S	30S
11	Triticum spelta	5	10RMR	tR	33	Yr32/6*Avocet S	32	100S	50S
12	Yr6/ 6* Avocet S	6	100S	30S	34	Carstens V	32+	10R	tR
13	Heine's Kolben	6+	50MRMS	tR	35	YrSP / 6* Avocet S	SP	100S	40S
14	Heine's Peko	6+	MISSING	tR	36	Spaldings Prolific	SP+	10R	tR
15	Yr7/ 6* Avocet S	7	100S	30S	37	Suwon 92/ Omar	Su Long	100S	50S
16	Lee	7	50MSS	10MRMS	38	Suwon 92/Omar	Su Short	100S	50S
17	Reichersberg 42	7+	50RMR	tR	39	Nord Desprez	ND	70MSS	10MR
18	Yr8/ 6* Avocet S	8	100S	40S	40	Strubes Dickopf	SD	50MRMS	10MR
19	Compare	8	70MSS	30S	41	Tres/6* AVS	?	10MR	10MR
20	Yr9/ 6* Avocet S	9	100S	30S	42	Cham 1	DW	10MRMS	10MR
21	Clement	9,2	10MR	tR	43	Cham 8 (Kauz)	BW	20MR	10MR
22	Yr10/ 6* Avocet S	10	10MR	tR	44	Morocco	BW	100S	100S

Table 3. Field responses of stem rust genes planted as Trap Nursery at Allal Tazi and Marchouch in Morocco 2024.

Entry No.	Pedigree	Sr gene	Seed Source	Morocco Allal Tazi	Morocco Marchouch
1	ISr5-Ra CI 14159	Sr5	RCRRC-2022	50S	tS
2	T. monococcum/8*LMPG-6 DK13	Sr21	RCRRC-2022	10R-5S	5S
3	Vernstein PI 442914	Sr9e	RCRRC-2022	60S	5S
4	ISr7b-Ra CI 14165	Sr7b	RCRRC-2022	90S	5MS
5	Lee/6*LMPG-6 DK37	Sr11	RCRRC-2022	10S	10S
6	ISr6-Ra CI 14163	Sr6	RCRRC-2022	90S	10MSS
7	CI 14167/9*LMPG-6 DK04	Sr8a	RCRRC-2022	60SMS	20S
8	Chinese Spring*7/Marquis 2B	Sr9g	RCRRC-2022	tMS	tS
9	W2691SrTt-1 CI 17385	Sr36	RCRRC-2022	40S	0
10	Prelude*4/2/Marquis*6/Kenya 117A	Sr9b	RCRRC-2022	70MS	5S
11	Selection from Webster F3:F4 #6	Sr30	RCRRC-2022	80S	5S
12	Prelude/8*Marquis*2/2/Esp 518/9	Sr17	RCRRC-2022	60MS	10S
13	ISr9a-Ra CI 14169	Sr9a	RCRRC-2022	60S	20S
14	ISr9d-Ra CI 14177	Sr9d	RCRRC-2022	40S	20S
15	W2691Sr10 CI 17388	Sr10	RCRRC-2022	80S	10S
16	CsSSrTmp	SrTmp	RCRRC-2022	80S	20S
17	LcSr24Ag	Sr24	RCRRC-2022	30RMR	5MR
18	Sr31 (Benno)/6*LMPG-6 DK42	Sr31	RCRRC-2022	20MR	0
19	Trident Sr38	Sr38	RCRRC-2022	5R	0
20	McNair 701	SrMcN	RCRRC-2022	100S	30S
21	CDL Sr24+31	Sr24+31	RCRRC-2022	10MR	0
22	CDL Sr36+31	Sr36+31	RCRRC-2022	70S	0
	Morocco	-	RCRRC-2022	90S	50S