Identification of multiple root disease resistant wheat germplasm against Cereal Nematodes and Dryland Root Rot and their validation in regions of economic importance

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INTRODUCTION

Soil Borne Pathogens (SBPs), including dryland cereal root rots and cereal nematodes are a major constraint to cereal production worldwide, particularly where cereals dominate rotations, and sub-optimal growing conditions and or cultural practices are common. Dryland root rots also commonly known as root, crown, or foot root rots include a complex of fungi with one or more species of Crown Root (CR) (*Fusarium* spp.) and Common Root Rot (CRR) (*Bipolaris sorokiniana* (syns. *Helminthosporium sativum*, *H. sorokiniana*, teleomorph *Cochliobolus sativus* (Ito & Kurib.) Dresch.ex Dast.)). The two most reported *Fusarium* species are *F. pseudograminearum* (formerly *F. graminearum* Group 1, Teleomorph *Gibberella coronicola*) and *F. culmorum*. Furthermore two groups of microscopic nematodes are commonly found on wheat roots and include several species of the Cereal Cyst Nematode (CCN) *Heterodera* spp. and at least two important species of the Root Lesion Nematode (RLN) *Pratylenchus thornei* and *P. neglectus*. Frequently two or more SBPs can occur in the soil at one time and hence a holistic approach in management based primarily on resistance but where possible integrated with rotational options is required.

Yield loss caused by these SBPs has been reviewed and documented in many regions of the world including Europe, America and in particular the more marginal cereal production areas of West Asia, North Africa, Australia and Canada with losses reported between 3-50% (2, 3, 4, 5). Similarly in Australia SBPs including CR, CRR, CCN and RLN cause significant yield loss to cereal production in Australia in the order of 104MAus$/yr (1). Wheat is a food staple for much of West Asia and North Africa where rainfed monoculture cereal production is common. In order to provide effective control of SBP where other integrated control options such as rotation are limited, the use of host genetic resistance, which is defined as a reduction in the multiplication of the pathogen, is one of the best methods to control these diseases.

MATERIALS AND METHODS

Fifty seven wheat lines were identified globally with resistance to one or more of these pathogens through the joint CIMMYT /Turkey efforts to work on SBP with other international partners. These were compiled and distributed by CIMMYT to more than 24 partners globally, with 14 of these in Australia and 10 overseas. The material was screened under replicated greenhouse or field conditions against local pathogens of importance. The known molecular disease resistance markers for cereal cyst nematode (*Cre1* and *Cre3*) and currently available QTLS for CR (2B Sunco, 1A and 1D 2-49) were also used on a limited set of the germplasm.

RESULTS AND DISCUSSION

The data has indicated that more than 25% of the lines express root disease resistance to more than one SBP. The published genes for CCN were effective but had variable reaction depending on the country, and several of the synthetic hexaploids from CIMMYT were found to provide new sources of CCN resistance in several countries. CR resistant sources were validated, with several of these offering resistance to the related foliar pathogen Fusarium head scab (*F. graminearum* and *F. culmorum*). Molecular markers for CCN, RLN and CR were used to identify known resistance QTLs, Some of the most useful multiple disease resistant lines are given in Table 1, and their reaction to the most important SBP in Australia and regional locations in Table 2.

The most useful and effective sources of multiple root disease resistance have been identified and confirmed for Australia and other global locations which should serve as valuable sources for breeding programs.

As indicated in Table 1 the value of the germplasm is determined not only by its disease reaction but also its adaptability and easy use within a breeding program. It is clear from some of the most promising sources of multiple SBP resistance that some very adapted germplasm is available. Furthermore, this work should help prioritize the sources which could undergo further genetic studies to understand where the resistances are found and how they can best be deployed.

ENTRY 1st RDRN 0506	CROSS NAME	COMMENT	CIMMYT TUK Acc *	CID - CIMMYT CROSS IDENTIFIER NO.	SID - CIMMYT SELECTION IDENTIFIER NO.	AWCC AUS NO.	SW/WW/BW/TW/TS/DW/DS
1	6R(6D)	Rye translocation	30883			33864	SW
18	AUS13124 (Morocco 426)	Land race				13124	SW
20	AUS4926 (Iraq 43)	Land race				4926	SW
21	CPI133842	Synthetic derivative				33368	WW
22	CPI133859	Synthetic derivative				33367	WW
25	AUS GS50AT34/SUNCO//CUNNINGHAM	Advanced line CIMMYT Mexico	30795	431762	28	33791	SW
26	AUS GS50AT34/SUNCO//CUNNINGHAM	Advanced line CIMMYT Mexico	030798	431762	31	1	SW
28	CROC_1/AE.SQUARROSA (224)//OPATA	Adapted Synthetic derivative	20616	72726	532	33797	SW
31	CROC_1/AE.SQUARROSA (224)//OPATA	Adapted Synthetic derivative	20615	72726	531	33736	SW
34	2-49	CR Partial Resistance Source		377152	1	29532	SW
35	Sooty_9/Rascon_37	Advanced line CIMMYT Mexico		148682	27	30785	SDW
36	SUNCO	Released cultivar Australia	20650	76058	0	33803	SW
51	SABUF/3/BCN//CETA/AE.SQUARROSA (895)	Adapted Synthetic derivative	31038	167178	253	33828	SW
52	MAYOOR//TK SN1081/AE.SQUARROSA (222)	Adapted Synthetic derivative	31035	167144	420	33825	SW
54	SUMAI 3	Chinese source of FHS resistance		0	0	25315	SW

Table 1: Selected entries from the 1st Root Disease Resistance Nursery which have been validated as multiple sources of SBP (Soil Borne Pathogen) resistance.

	CEREAL CYST NEMATODE RESISTANCE RATING					ROOT LESION NEMATODE RATING		CROWN ROT FIELD AND GREENHOUSE RESISTANCE RATING						FUSARIUM HEAD SCAB FIELD RESISTANCE RATING		
ENTRY 1st RDRN 0506	AUSTRALIA *Heterodera avenae* Ha 13 (F. Ogbonnaya)	TURKEY *Heterodera filipjevi* (CIMMYT TURKEY)	INDIA - *Heterodera avenae* (Rajasthan)Dr SP Bishnoi)	INDIA - *Heterodera avenae* Hisar (Dr SP Bishnoi)	INDIA - *Heterodera avenae* Karnal (Dr AK Singh)	TURKEY - Greenhouse resistance rating Pratylenchus thornei (CIMMYT/Turkey - Nicol)	AUSTRALIA - Field Tolerance Rating *Pratylenchus thornei* (Meiqin and Obrien)	AUSTRALIA - Field Resistance Rating *F. pseudograminearum* (Meiqin and Obrien)	AUSTRALIA - Field Resistance Rating *F. pseudograminearum* (Herde)	AUSTRALIA - Field Terrace resistance rating *F. pseudograminearum* (Wallwork)	AUSTRALIA - Greenhouse resistance rating *F. pseudograminearum* (Chakraborty)	TUNISIA - Greenhouse resistance rating *F. pseudograminearum*. Gargouri	TURKEY Greenhouse *F. culmorum* resistance rating (CIMMYT/Turkey Nicol)	AUSTRALIA - *F. graminearum* (Simpfendorfer)	MEXICO - *F. graminearum* (Durellier)	Austria *F. culmorum* (Buerstmayr)
1	**R**	**MR**	S	HS	S	S			S	S	**MR**	**MR-MS**	**MR-MS**	**MR**		**MR**
18	HS	**MR**	S	HS	S	**R**		**R**	S	S	**MR**	HS	S	**MR**	MS	MS
20	HS		**MR**	HS	**MR**			**R**	**MR**	**MR**	S	N/A		MS	MS	HS
21	HS	**MR**	S	HS	S	**R**			**MR**	S	**MR**	N/A		**MR-MS**	MS	HS
22	HS	MS	HS	**MR**	**MR**	**R**			**MR**	S	S	N/A	S	MS-S	MS	S
25	HS	MS	S	HS	S	**MR-MS**	**TOL**	**MR-MS**	MS	MS-S	**MS**	**MR-MS**		MS-S	S	S
26	HS	**MR**	S	HS	S	**MR**	**TOL**	**MR-MS**	MS	MS-S	S	MS	S	MS	MS	HS
28		MS	**R**	**MR**	**MR**	**MR-MS**			**MR**			S	S	**MR-MS**	MS	HS
31	**R**	S	**MR**	**MR**	S	**MR-MS**			**MR**	S	S	S	**MR**	**MR-MS**	MS	HS
34	HS	**MR**	**MR**	HS	S	S			**MR**	**MR**	S	S	**MR**	**MR-MS**	S	
35	HS	**R**	**MR**	HS	S	**MR**	**M TOL**	S	S	S	S	S	**MR-MS**	MS	HS	HS
36	HS	**R**	S	HS	S	S		**MR**	**MR**	MS	**MS**	**MR**	**MR-MS**	MS	MS	S
51	HS	MS	S	HS	S	S	**M TOL**	**MR**	**MR**	S	HS	**MR-MS**	**MR**	MS	MS	**MR**
52	HS	MS	HS	HS	HS	S		**MR**	S	S	MS	MS	**MR**	**MR-MS**	MS	**MR**
54	HS	**R**	S	HS	S	S		**R**	MS	S	S	MS	**MR**	**R-MR**	**R**	**R**

Table 2: Performance of selected entries from the 1st Root Disease Resistance Nursery which have been validated as multiple sources of SBP (Soil Borne Pathogen) resistance against cereal cyst nematode, root lesion nematode, crown rot and Fusarium head scab from different regional collaborators.

R: Resistant, MR: Moderately Resistance, MS: Moderately Susceptible, S: Susceptible, HS: Highly Susceptible. TOL: Tolerant, M TOL: Moderately Tolerant. Blank – no data available.

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