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Variability for resistance to cereal cyst nematodes in *Triticeae:* Potential use for *Triticum turgidum* L. var. *durum* improvement

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SUMMARY – Eleven populations of *Heterodera avenae* originating from six circum-mediterranean countries (Algeria, France, Israel, Morocco, Spain, Syria) and one population of *Heterodera latipons* (Syria) have been studied for their development capability (virulence) on different *Triticeae*. Several of these plant genotypes are known to carry resistance genes. The host reactions of *Aegilops geniculata* populations sourced from different locations in the Mediterranean area were also investigated. Results are presented on resistance levels of these genetic resources which differ according to the fitness and the virulence spectrum of the nematode populations tested.

Key words: Cereal cyst nematodes, *Triticeae*, resistance, fitness, virulence.

RESUME – *"Variabilité pour la résistance aux nématodes à kystes des céréales chez* Triticeae *: Utilisation potentielle pour l'amélioration de* Tritucum turgidum *L. var.* durum*". Onze populations d'*Heterodera avenae *originaires de six pays circum-méditerranéens (Algérie, France, Israël, Maroc, Espagne, Syrie) et une population d'*Heterodera latipons *(Syrie) ont été testées pour leur capacité à se développer (virulence) sur différentes* Triticeae. *Plusieurs de ces génotypes sont connus pour porter des gènes de résistance. Les capacités d'hôte de populations d'*Aegilops geniculata, *collectées sur le pourtour méditerranéen, ont été également étudiées. Les résultats renseignent sur les niveaux de résistance exprimés par ces ressources génétiques qui différent en fonction de la fitness et du spectre de virulence des populations de nématodes testées.*

Mots-clés : *Nématodes à kystes des céréales,* Triticeae, *résistance, fitness, virulence.*

Introduction

Previous reviews (Rivoal and Cook, 1993; Nicol, in press) have established that cereal cyst nematodes (CCN), especially *Heterodera avenae*, cause yield loss on *Triticum turgidum*. These nematodes are widely distributed in regions such as South Europe, West Asia and North Africa (SEWANA), where cereal production is essential for human alimentation. In such regions cereals dominate the rotational, hence resistance offers one of the best control methods, both agronomically and environmentally. The durums to date have not offered any effective sources against CCN (Bekal *et al*., 1998), hence the possible introgression of other resistant sources from bread wheat and wild grass relatives are being investigated. The objectives of this study were to evaluate the efficiency of different plant genotypes for their resistance to a wide range of CCN populations, which could be incorporated in specific breeding programs of durum wheat.

Material and methods

Table 1 shows resistance genes to *H. avenae*, which are currently used in bread wheat breeding programs. *Triticum aestivum* AUS 4930 is known as a source of resistance to both *H. avenae* and *Pratylenchus thornei* (Nicol *et al*., in press). *T. aestivum* Arminda and *T. turgidum* Cham1 are the susceptible controls for *H. avenae*. Table 2 gives the origin of the different *Aegilops geniculata* accessions which were tested. These have also been evaluated for their resistance to several biotic and abiotic stresses (Zaharieva, unpublished).

Table 1. Plant response (resistance or susceptibility) of genotypes tested against populations of CCN

Species	Line or cultivar	Resistance genes	Species	Line or cultivar	Resistance genes
Triticum aestivum	Loros	*Cre*1	*Aegilops variabilis*	var1	*Rkn-Mn1*[†]
	AUS4930	Unknown	*Aegilops ventricosa*	vent11	*Cre*2
	Arminda	Susceptible	*Triticum tauschii*	AUS18913	*Cre*3
Triticum durum	Cham1	Susceptible	*Triticum tauschii*	CPI110813	*Cre*4

[†] See Jahier *et al.* (1998).

Table 2. Origin of Aegilops geniculata accessions tested for their host reactions to populations of CCN

Genotypes	Source	Country	Location
1 MZ98	IIPGR-Sadovo	Bulgaria	Burgas
19 MZ98	INRA-Montpellier	France	Montpellier
27 MZ98	IAV-Rabat	Morocco	Azrou
61 MZ98	ICARDA	Tunisia	Bizerte
63 MZ98	ICARDA	Libya	Jabal Al Akhdar
77 MZ98	ICARDA	Jordan	Irbid
124 MZ98	INIA-Madrid	Spain	Cordoba
121 MZ98	ICARDA	Tunisia	Beja

Nematode inoculum was collected directly from the field in Syria (E156, E125) or produced after rearing nematodes on the susceptible control plants, Arminda or Cham1. Species identification of these CCN populations was assessed upon PCR/CAPS of the ribosomal DNA (Bekal and Rivoal, 1997).

Resistance/virulence tests were conducted in controlled conditions as previously described (Bekal *et al.*, 1998), with eight replicates per genotype and nematode population. The number of white females or cysts were counted on the plant roots after 2.5 months of development. Complete resistance is defined as females/cysts <1 per plant while intermediate resistance is ≥ 1 and ≤ 3 females/cysts per plant.

Results and discussion

On susceptible hosts, the CCN populations exhibited significant differences in their capability to produce females or cysts (fitness) on plants ranging from an average of 21.7 ± 4.36 (Ha41) to 2.50 ± 1.50 (E156) on cv. Arminda and from 24.5 ± 6.20 (Ha41) to 2.0 ± 1.40 (E142) on cv. Cham1.

Plant genotypes with known resistance genes indicated a wide variation in resistance spectrum against CCN (Table 3). All sources, except *Ae. ventricosa*, showed different responses to the populations of *H. avenae* tested. The AUS4930 line was effective for all populations except one from Syria and Israel. However the Loros source (*Cre*1) was less effective proving to be susceptible to both Syrian populations and also the Israeli and the Morrocan. This suggests that the unknown source of resistance in AUS4930 is different from the *Cre*1.

A similar variation in virulence spectrum was also observed towards the genotypes of *Ae. geniculata* (Table 4). There was no clear relationship between the (a)virulence status of the nematode population and the geographical origin of *Ae. geniculata* genotypes. But 1, 77 and 124 MZ98 originating from Bulgaria, Jordan and Spain, respectively showed a wide resistance efficiency which would be useful for breeding.

As with Bekal *et al.* (1998), our results confirm that different tetra or hexaploid *Triticeae* species could be crossed to durum wheat and produce resistant varieties. Increasing our knowledge of the efficiency of resistant genotypes and the virulence of CCN populations is necessary as it is known that several species of CCN as *H. avenae*, *H. latipons* and *H. filipjevi* could occur sympatrically in the regions cropped with durum wheat.

Table 3. Means and standard deviation of females and cysts of CCN per plant of *Triticeae*

CCN populations	AUS18913 (*Cre*3)	Loros (*Cre*1)	var1 (*Rkn-Mn1*)	CPI110813 (*Cre*4)	AUS4930 (?)	vent11 (*Cre*2)
H. avenae						
E125 (Syria)	0.6 ± 1.06	9.1 ± 6.60	1.3 ± 1.39	0.3 ± 0.46	3.4 ± 2.88	0.5 ± 0.76
E126 (Syria)	0	4.8 ± 1.58	1.0 ± 0.76	0	0.6 ± 1.06	0
E57 (Israel)	7.1 ± 0.36	3.0 ± 0.76	0	1.3 ± 0.46	3.3 ± 0.89	0.1 ± 0.35
E129 (Algeria)	1.3 ± 1.67	0.6 ± 0.52	1.5 ± 1.69	0.1 ± 0.35	0.1 ± 0.35	0.1 ± 0.35
E142 (Algeria)	–†	–	–	0	0	–
E46 (Morocco)	12.0 ± 5.21	3.6 ± 3.29	5.3 ± 2.71	3.4 ± 1.51	0.4 ± 0.74	1.3 ± 1.04
E48 (Spain)	2.0	0	0.5 ± 0.54	0.6 ± 0.74	0.1 ± 0.35	0
E147(France)	2.9 ± 4.01	0	0.5 ± 0.76	0	0	0
Ha12 (France)	1.3 ± 1.04	0	0.3 ± 0.46	0	0	0
FR2 (France)	4.9 ± 2.64	1.5 ± 1.60	0.8 ± 0.89	3.0 ± 2.07	0	0
Ha41 (France)	7.5 ± 3.82	0.4 ± 0.52	3.8 ± 2.96	4.1 ± 3.44	0.9 ± 1.46	0
H. latipons						
E156 (Syria)	1.1 ± 0.99	1.9 ± 1.81	0	1.0 ± 1.20	1.3 ± 1.04	1.3 ± 0.71

†– Untested.

Table 4. Means and standard deviation of females and cysts of CCN per plant of *Aegilops geniculata*

CCN populations	1 MZ98	19 MZ98	27 MZ98	61 MZ98	63 MZ98	77 MZ98	121 MZ98	124 MZ98
H. avenae								
E125 (Syria)	0.6 ± 1.19	11.8 ± 4.53	5.1 ± 3.09	0.6 ± 0.74	7.4 ± 3.96	0	3.4 ± 2.00	0
E126 (Syria)	0.1 ± 0.36	4.0 ± 3.96	3.5 ± 2.93	0.3 ± 0.46	2.4 ± 1.69	0	1.5 ± 1.41	0.5 ± 0.76
E57 (Israel)	1.8 ± 0.89	19.5 ± 3.12	6.6 ± 1.30	5.8 ± 1.28	4.3 ± 1.28	9.4 ± 1.77	4.0 ± 1.41	1.8 ± 1.28
E129 (Algeria)	0	1.4 ± 1.85	1.6 ± 1.60	0.5 ± 1.07	0.1 ± 0.35	0.1 ± 0.35	0.9 ± 0.99	0
E142 (Algeria)	0	0	4.0 ± 2.39	0	–†	0	–	0.1 ± 0.38
E46 (Morocco)	1.5 ± 1.41	2.9 ± 3.91	3.1 ± 2.80	2.5 ± 1.86	3.6 ± 2.33	1.3 ± 0.89	6.3 ± 3.06	0
E48 (Spain)	0.1 ± 0.35	1.0 ± 0.76	0.4 ± 1.06	0.4 ± 0.52	1.0 ± 0.93	0	2.3 ± 1.58	0
E147 (France)	0	0.1 ± 0.35	0	0	0.1 ± 0.35	0	0.9 ± 2.48	0
Ha12 (France)	0	0	0.4 ± 0.52	0	0.1 ± 0.4	0	0	0
FR2 (France)	0	0.4 ± 0.74	0.1 ± 0.35	0	0.1 ± 0.35	0	0.8 ± 1.75	0
Ha41 (France)	0.1 ± 0.35	2.3 ± 1.28	3.9 ± 1.36	0	0.8 ± 0.71	0	6.5 ± 3.96	0
H. latipons								
E156 (Syria)	1.3 ± 1.67	3.0 ± 3.16	2.6 ± 1.51	1.1 ± 0.99	1.0 ± 1.07	0.9 ± 0.84	2.0 ± 0.93	0.5 ± 0.76

†– Untested.

Convenient miniaturized tube tests are not only useful for screening but can also assist breeding programs to check the introgression of resistance genes identified to control CCN. Their use is essential to understand the genetics of resistance in addition to confirming the use of marker-assisted selection programs, some of which are currently implemented in breeding programs as reviewed by Nicol (in press). Future breeding strategies for both durum and bread wheat could seek to pyramid different genes into the same variety. In the case of *Ae. geniculata* the indicated CCN resistance offered by some lines could be coupled with the known resistance to several biotic and abiotic stresses common in regions such as SEWANA.

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