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The reaction of x *Tritordeum* and its *Triticum* spp. and *Hordeum chilense* parents to rust diseases

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Summary

Hexaploid and octoploid tritordeums and their parents *Hordeum chilense* and *Triticum* spp. were screened for resistance to isolates of wheat and barley yellow and brown rusts. All *H. chilense* lines were highly resistant to both wheat and barley brown rust, few lines were susceptible to wheat yellow rust while susceptibility to barley yellow rust was common. In general the resistance of tritordeum is predominantly contributed by the wheat parent and apparently the genes for resistance in *H. chilense* are inhibited in their expression by the presence of the wheat genome.

Abbreviations: WYR – wheat yellow rust, WBR – wheat brown rust, BYR – barley yellow rust, BBR – barley brown rust

Introduction

Hordeum chilense Roem. & Schult., a diploid wild barley species, native of South America, has been used extensively in wide crosses in the Triticeae since the hybrid with *Triticum aestivum* L. was obtained (Martín & Chapman, 1977). The high crossability of this species with *Triticum, Hordeum* and *Secale* (Martín & Cubero, 1981), the three genera of main agronomical interest in the Triticeae, gives *H. chilense* value for breeding purposes.

H. chilense by itself, has agronomical interest given that this extremely polymorphic species which colonizes quite different habitats is used in South America as a pasture grass. Its perennial growth habit and its tolerance to high temperatures are characters that have relevance to its use by man. Nevertheless, there are only limited data about its agronomical characters. It is interesting to note that as early as 1919 yellow and brown rust were found in Chile on *H. chilense,* the former being the first record of *Puccinia striiformis* in South America (Arthur, 1925). Its diseases resistance is one of the traits that could be of interest for introduction in cultivated Triticeae species and, for this reason, should be investigated.

Among the hybrids involving *H. chilense* and other species of the Triticeae, we have found that the amphiploids *H. chilense* × *T. turgidum* (Martín & Sánchez-Monge Laguna, 1982) and *H. chilense* × *T. aestivum* (Martín et al., 1987) could be the starting point of a plant breeding program aimed at producing a new cereal crop for which we have proposed the name Tritordeum. In the framework of this program disease resistance to fungal diseases to which wheat and barley are suceptible are among the characters for which we make selection in early generations. In addition, when planning new crosses to obtain primary tritordeums, it could be important to know the expected reaction of the amphiploid on the basis of the reaction of the parents to such pathogens.

We present in this paper results of the reactions of the parental lines of *H. chilense* and wheat used in synthesizing amphiploids and the reaction of these amphiploids to yellow and brown rusts of wheat and barley.

Material and methods

1. Plant material

The source of the *H. chilense* lines used are presented in Table 1. These lines were the female in crosses with *Triticum* in the production (after chromosome doubling with colchicine) of the tritordeum amphiploids. The primary amphiploids and the origin of the wheat parents are presented in Table 2. The lines have been recoded as presented in Tables 1 and 2. Some of the primary amphiploids have been reported previously (Martín & Sánchez-Monge Laguna, 1982; Martín et al., 1987; Padilla & Martín, 1987).

2. Rust material

British isolates from the Plant Breeding International Cambridge, UK (PBIC) of barley and wheat yellow and brown rust were used: four isolates of WYR = wheat yellow rust (*Puccinia striiformis* West f. sp. *tritici* Eriks) (Table 3); three isolates of WBR = wheat brown rust (*P. recondita* Rob. ex Desm. f. sp. *tritici* Eriks) (Table 3); three isolates of BYR = barley yellow rust (*P. striiformis* f. sp. *hordei* Eriks) (Table 4); three isolates of BBR = barley brown rust (*P. hordei* Otth) (Table 4).

3. Disease tests

Standard sets of differential cultivars were used in each test to confirm the identity of the rust isolates used. A mixture of talc and spores of each isolate was dusted onto the seedlings with their first leaf fully expanded. The plants were kept 24 hours after inoculation in the dark with high humidity at 12° C and then transferred to a glasshouse until the infection type (IT) was recorded twelve days later.

Results and discussion

1. Reaction to wheat yellow rust

Table 3 shows the infection types of the amphiploids and the parents with WYR. The *H. chilense* reaction ranged from resistant to intermediate and even susceptible. Vallega (1947) reported this susceptibility of *H. chilense* and other wild barleys to WYR. Also on cultivated barley stripe rust can be of the form that infects wheat (Stubbs, 1985).

The majority of the wheats tested showed susceptibility to the isolates tested. The reaction was homogeneous except for *T. dicoccoides* which reflects the heterogeneity of the line used. The isolate

Table 1. Source of the *Hordeum chilense* lines.

Line	Code name	Source	Identification
Hch 1	H1	Plant Breeding Institute, Cambridge, UK	
Hch 7	H2	U.S.D.A.	PI 255753
Hch11	H3	U.S.D.A.	PI 283374
Hch12	H4	Dr. W. Lange, Wageningen, The Netherlands	
Hch13	H5	Dr. W. Lange, Wageningen, The Netherlands	
Hch16	H6	Prof. R. von Bothmer, Svalöf, Sweden	H 1814
Hch17	H7	Prof. R. von Bothmer, Svalöf, Sweden	H 1816
Hch55	H8	Prof. D. Contreras, Santiago, Chile	

107E139 was the most virulent on *H. chilense* but the least virulent on the wheats.

The reaction of tritordeum to WYR shows that amphiploids usually react as their wheat parents. Exception are e.g. HT6.13 and HT2.8 in which some plants showed susceptibility to one isolate to which the wheat parent is resistant. This could be explained by aneuploidy, since tritordeums have aneuploidy rates varying from 4 to 23% (Padilla & Martín, 1986). The opposite pattern was found in one case. HT7.10 was resistant to one isolate to which the wheat parent was susceptible while the barley parent, Hch17, was resistant. In general the resistance of tritordeum is predominantly contributed by the wheat parent and apparently the genes for resistance in *H. chilense* are inhibited in their expression by the presence of the wheat genome. The results show a race-specificity in tritordeum derived from the wheat parent similar than what found in triticale with *P. recondita* f. sp. *tritici* (Quinones et al., 1972) and was suspected with *Ustilago tritici* (Nielsen, 1973) but Niks and Dekens (1987) found that both rye and wheat may contribute to the hypersensitive resistance of triticale to WBR.

2. Reaction to wheat brown rust

All of the *H. chilense* lines were resistant to WBR (Table 3) while most wheat parents were susceptible to one or more isolates. Again the reaction of the amphiploids was very similar to that of the wheat parent. Some exceptions were found; e.g., wheat T14 was resistant but its derived tritordeum HT8.14 was susceptible to the isolates tested. The same pattern was found with HT6.13 and HT2.7.

3. Reaction to barley yellow rust

The *H. chilense* reactions ranged from susceptible to resistant (Table 4). The wheat parents and the tritordeums were all resistant but a degree of sporulation (1 −, 1, 1 + reaction) was observed in some lines. This tended to be related to susceptibility of *H. chilense* parent.

Niks & Dekens (1987) found that the rye genome does not make the triticale a host to rye leaf rust. The nonhost resistance brought in by the wheat genome dominates over the basic compatibility

Table 2. Tritordeums (HT) and their barley (H) and wheat (T) parents

Tritordeum		Level of ploidy	*Hordeum chilense*	*Triticum*	
Line	Code name			Source	Code name
HT16	HT1.1	6×	Hch1	*dicoccoides,* P.B.I., Cambridge, UK	T1
HT17	HT1.2	6×	Hch1	*georgicum,* P.B.I.	T2
HT19	HT1.3	6×	Hch1	*polonicum,* P.B.I.	T3
HT22	HT1.4	6×	Hch1	*durum,* cv. Cocorit, CIMMYT, México	T4
HT24	HT1.5	6×	Hch1	*durum* cv MA, Prof. E. Sánchez-Monge	T5
HT26	HT1.6	8×	Hch1	*aestivum* line ST31, Dr. A. Refoyo	T6
HT27	HT2.4	6×	Hch7	*durum* cv. Cocorit, CIMMYT	T4
HT49	HT2.7	6×	Hch7	*durum* line 125 crossing block CIMMYT-86	T7
HT18	HT2.8	8×	Hch7	*sphaerococcum,* P.B.I.	T8
HT20	HT2.9	8×	Hch7	*aestivum* line ST4, Dr. A. Refoyo	T9
HT48	HT3.10	6×	Hch11	*durum* line 173 crossing block CIMMYT-86	T10
HT46	HT3.6	8×	Hch11	*aestivum* line ST31	T6
HT23	HT4.11	6×	Hch12	*durum* cv. Jerez, Prof. E. Sánchez-Monge	T11
HT59	HT4.7	6×	Hch12	*durum* line 125	T7
HT41	HT5.4	6×	Hch13	*durum* cv. Cocorit	T4
HT44	HT6.12	6×	Hch16	*durum* line 81 crossing block CIMMYT-86	T12
HT60	HT6.13	6×	Hch16	*durum* line 221 crossing block CIMMYT-86	T13
HT78	HT7.10	6×	Hch17	*durum* line 173 crossing block CIMMYT-86	T10
HT43	HT8.14	6×	Hch55	*durum* line 32 crossing block CIMMYT-86	T14

Table 3. Reaction of *H. chilense* (H), wheat (T) and tritordeum (HT) lines to wheat yellow and brown rust isolates

Line	WYR isolates				WBR isolates		
	107E139	47E142	110E143	237E141	85-31	82-1	85-2
H1	0,3 –	1 –	1 +	1 +	;	e	;
H2	0	0	0	0	;	e	;
H4	2 +	1 +	2	–	;	;	e;
H5	3 –	1	2	2 –	;	;	;
H6	1 –, 3	1	1	–	–	e;	e
H7	0	0	0	0	;	e	e
H8	–	–	1 –	0	;	–	–
T1	3 –	0,2 +	0,3	0,2 –	3	3 +	3
HT1.1	–	–	3 –	4 –	–	3	–
T2	4 –	4 –	4 –	4 –	4 –	4 –	4 –
HT1.2	3 –	3	3	–	–	–	–
T3	3 –	3 –	2 +	2 –, 3 –	4 –	4	4 –
HT1.3	–	3 –	3	3 +	3	3 +	–
T4	3 –	2 +	2 +	3 –	3 +	3 +	2 +
HT1.4	–	–	3	3	3 –	–	–
HT2.4	3	3	3	–	–	3	3 +
HT5.4	–	–	–	3 +	3 –	–	–
T5	4 –	4 –	3	3 +	–	–	–
HT1.5	–	–	3 +	–	–	–	–
T6	0	0,1 –	0	4 –	3 –	;	0,1 –
HT1.6	1	1 –	0	–	–	;	;
HT3.6	0	1 –	0	4 –	3 +	;	;, 1
T7	0	3 +	3	3 –	1 –	2	1 –
HT2.7	0,1 –	3	3	–	–	3 –	3
HT4.7	–	–	3 +	–	–	1 +	–
T8	2 +	2 –	0,2 –	0,2 +	4 –	4	4 –
HT2.8	3	2	1 –, 3	2,3	4	4	4 –
T9	3 –	3 –	2 +	2 +	4	4 –	3 +
HT2.9	3 –	3 –	2 +	3 –	4 –	3 +	4 –
T10	0	3	3	3	1 –	1 +	1 –
HT3.10	–	–	3	–	–	–	–
HT7.10	–	–	0,1 –	–	–	–	–
T11	3	3 +	3 +	3	3 +	4	3 +
HT4.11	3 +	3 +	3 +	–	–	3 +	–
T12	0	3	3	3 –	3	4 –	1 –, 3 –
HT6.12	0	3 +	4 –	3	3	4	3
T13	0	3	3	–	0,2 –	1 –, 3 –	1 –
HT6.13	0,3 +	4 –	4 –	4	3 –	3	4 –
T14	0	4 –	4 –	3	0,1 –	2 –	1 –
HT8.14	0	3	4 –	–	–	4 –	3 +

Footnotes:
– = not determined.
e = no visible infection.
;, o = resistant, flecks or little chlorosis without sporulation.
1 –, 1, 1 + = resistant reaction, small amount of sporulation.
2 –, 2, 2 +, 3 – = intermediate reaction.
3, 3 +, 4 –,4 = susceptible.

Table 4. Reaction of wheat (T), *H. chilense* (H) and tritordeum (HT) lines to barley yellow and brown to rust isolates

Line	BYR isolates			BBR isolates		
	82-6	24	84-3	79-2	60-3-1	83-3
T1	e;, 1 –	;0	;0	–	e;	e;
T2	e;	;	;	–	;	;
T3	0	0	0	–	;0	;0
T4	;0	;	0	–	;0	e
T5	e, 0	;0	;0	–	0	e;
T6	e	;	e	–	e;	e;
T7	e, 0	;	e;	–	e;	e;
T8	e;	;	;	–	e;	;
T9	e	;	e	–	;	e
T10	–	;	0	–	;	;
T11	0	0	0	–	;	e;
T12	0	;0	;0	–	;	;
T13	e, 0	;0	;0	–	;	;
T14	;	0	;	–	;	e;
H1	–	3	3	–	;	;
HT1.1	1	–	0,1	–	;	–
HT1.2	0,1	–	–	–	;	–
HT1.3	0,1 –	–	0,1 –	–	–	;
HT1.4	0	–	;0	–	–	0
HT1.5	1 –	–	–	–	–	–
HT1.6	;	–	–	–	–	;
H2	0	0,1	0	;	;	;
HT2.4	0	–	–	–	0	–
HT2.7	;0	–	–	–	0	–
HT2.8	;	;0	;	;	;	;
HT2.9	e;	;	e	;	;	;0
H4	3	3	–	;	;	;
HT4.11	1 –	–	0	–	;	–
HT4.7	;, 1 +	–	–	–	0	–
H5	3 +	3	3 –	–	;	;
HT5.4	–	–	0	–	–	0
H6	1	3 –	3	–	;	;
HT6.12	;	0	e	;	;	;
HT6.13	;0	1 –	0	;0	0	0
H7	0	0	0	;	;	e;
HT7.10	e;	–	–	–	–	–
H8	1, 3	–	;	e	e;	e;
HT8.14	;	–	e	–	;	–

Footnotes:
– = not determined.
e = no visible infection.
;, 0 = resistant, flecks or little chlorosis without sporulation.
1 –, 1, 1 + = resistant, small amount of sporulation.
2 –, 2, 2 +, 3 – = intermediate reaction.
3, 3 +, 4 –, 4 = susceptible.

conferred by the rye genome. Also in the tritordeums the susceptibility of *H. chilense* is apparently overruled by the resistance of the wheat to BYR.

4. Reaction to barley brown rust

All the amphiploids and their parents were resistant to BBR (Table 4). In this case we can not draw conclusions about which parental resistance is being expressed.

Genes for disease resistance have been transferred to wheat from its relatives, including the immediate tetraploid and diploid progenitors within the wheat genus, the closely related genera *Aegilops, Secale* and some species of *Agropyron* (see the reviews by Dick & Kerber, 1985; Gale & Miller, 1987; Knott, 1987). Introgression of wheat yellow mosaic virus resistance from *H. bulbosum* to wheat has already been reported (Wang et al., 1986). Also recent experiments indicate that Tritordeum is more resistant than wheat to *Septoria tritici* (Rubiales, unpublished results). However in the barley-wheat hybrids the transfer of barley yellow dwarf virus resistance from barley to wheat gave inconclusive results (Fedak, 1986). The data presented here show that *H. chilense* rust resistance is not expressed in Tritordeum. This parallels the observations at the morphological level that Tritordeum is more similar to wheat than to barley. It is probably too simple to explain the wheat-like behaviour of Tritordeum by a 'genome dose effect' of wheat. The (1976) reported that amphiploids (AAAABB) of *T. Monococcum* (AA) and tetraploid wheat (AABB) were susceptible to WBR while *T. monococcum* was almost completely resistant. Furthermore the spike morphology of the hybrid (HD) *H. chilense* (HH) × *A. squarrosa* (DD) resembles that of *Aegilops* (Martín, 1983) and all other reported *Triticum* × *Hordeum* hybrids resemble the *Triticum* parent in morphology (Fedak, 1986) what may be an indication of the suppression by the latter of the traits carried by the *Hordeum* parent.

We conclude that when synthesizing primary tritordeums the resistance to rust diseases of the wheat parent is decisive.

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