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Leaf rust of durum wheats

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SUMMARY – Leaf rust caused by *Puccinia triticina* is a major disease of durum wheat in the Mediterranean region. This pathogen has a complex life cycle. It alternates between wheat and the secondary host, *Anchusa italica.* The latter was found to be functional in Morocco. The populations of the pathogen, alternating on *Anchusa italica,* belong to a separate compatibility group than those alternating on *Thalictrum speciosissimum* in the temperate areas. The virulence spectrum of the leaf rust population alternating on *Anchusa italica* is diverse with the dominance of a pathotype avirulent on most of the *Lr* genes. Although many sources of resistance to leaf rust are identified among durum wheat cultivars, very little is known about the inheritance and the expression of resistance in this host species. The available studies on the expression of resistance to leaf rust in durum wheat indicate a recessive type of resistance in most cases.

Key words: Leaf rust, durum wheat, *Puccinia triticina*, *Anchusa italica,* virulence, resistance.

RESUME – *"La rouille brune des blés durs". La rouille brune, causée par* Puccinia triticina *est une des principales maladies foliaires du blé dur dans la région méditerranéenne. Le cycle de vie de cet agent pathogène est complexe et fait intervenir* Anchusa italica *comme hôte alternatif. Les populations de* Puccinia triticina *ayant* Anchusa italica *comme hôte alternatif, appartiennent à un groupe de compatibilité différent de celui des populations ayant* Thalictrum speciosissimum *comme hôte alternatif dans les zones tempérées. Le spectre de virulence des populations de* P. triticina, *alternant sur* A. italica, *est diversifié, mais dominé par un pathotype avirulent sur la majorité des gènes* Lr *de résistance. Quant à l'expression de la résistance chez le blé dur, elle est récessive dans la majorité des cas étudiés.*

Mots-clés : *Rouille brune, blé dur,* Puccinia triticina, Anchusa italica, *virulence, résistance.*

Introduction

Durum wheat (*Triticum turgidum* L. var. *durum*) is cultivated in the Mediterranean region along with bread wheat (*Triticum aestivum* L.) under a wide range of environmental and cultural conditions. In addition, wild relatives of wheat occur naturally in the region. Thus, within this complex range of hosts, leaf rust, caused by *Puccinia triticina* Erikss*.,* occurs annually and causes significant damage to cultivated wheats (Samborski, 1985).

The control of the disease is based on resistance genes found either in cultivated wheat or in some wild relatives of wheat (*Aegilops* spp.). The occurrence of a functional alternate host *Anchusa italica* in the region requires the use of durable resistance in order to cope with the rapid changes of the virulence spectrum of the pathogen. Thus, the knowledge of the host-pathogen relationships in the Mediterranean area is essential for successful genetic control of leaf rust in durum wheat.

In this paper, we review the available information on the life cycle and the virulence patterns of *Puccinia triticina* in the region and the expression of resistance in durum wheats.

Characterization of the leaf rust complex on wheats

The populations of *P. recondita* on cultivated and wild wheats are part of a species complex composed of leaf rust pathogens of four tribes of grasses with alternate (pycnial-aecial) hosts in four dicotyledonous families (Balsaminaceae, Boraginaceae, Hydrophyllaceae and Ranunculaceae).

Because of the overlapping spore morphology and host range, Cummins (1971) has classified this broad group of leaf rust pathogens a single species, *Puccinia recondita*. Other workers have classified these fungi into more than one species (Viennot-Bourgin, 1941; Savile, 1984). Among these species, we find *P. tritici-duri* V.-Bourgin and *P. triticina* Erikss.

In general, the concept of the *P. recondita* complex as a single broad species is widely accepted in North America; while in Europe, the concept of more narrowly defined leaf rust species predominates. In this paper, we use *P. recondita* to describe the host range of leaf rust and *P. triticina* as the leaf rust species found on cultivated wheats.

The commonly found alternate host in the temperate zones is *Thalictrum speciosissimum* L. (in the Ranunculaceae). In the Mediterranean region, *Anchusa italica* Retz. (in the Boraginaceae) was described as the alternate host for leaf rust of wheat (Viennot-Bourgin, 1941; D'Oliveira and Samborski, 1966; Ezzahiri *et al.,* 1992).

Based on differences in pycnial-aecial and uredial-telial host range, Anikster *et al.* (1997) have distinguished two groups (I and II) of *P. recondita* collections. Collections of each of the two groups were interfertile only with collections of the same group and not with collections of the other group. This indicated that the two groups are genetically isolated from each other. Group I contains collections that have *Thalictrum speciosissimum* as the principal pycnial-aecial host. Group II has collections that have one or more species in the Boraginaceae as pycnial-aecial host. In this group, the type A which includes a Moroccan collection of *P. recondita*, was compatible with *T. turgidum* as well as *T. aestivum*. The other collections from wild wheats within group II, did not include cultivated wheats, and were classified as types B, C and D. The authors stated the type A leaf rust within group II from *Anchusa italica* can bridge the barriers that prevent types B, C and D from colonizing cultivated wheats.

Virulence patterns of *P. Triticina*

Race surveys have shown that leaf rust populations from durum and bread wheats presented different virulence patterns in many countries including Morocco (Huerta-Espinosa and Roelfs, 1992; Ezzahiri *et al.,* 1994).

In Morocco, the race surveys of *P. triticina* were conducted annually in areas where durum wheats are widely cultivated. The collected samples were tested on seedlings of differential lines. Each line carried a single *Lr* gene for leaf rust resistance. The obtained results of the period 1990-98 indicated that the virulence spectrum has changed significantly in the last ten years (Table 1). The levels of virulence of the pathogen were low to most of the tested genes.

The combinations of virulence [Unified Numeration (UN) races] on selected *Lr* genes (*Lr*1, 2a, 2c and 3) were analyzed for the years 1992 and 1994 (Table 2). Among the races identified, the race UN1, avirulent on the genes *Lr*1, 2a, 2c and 3, was frequently isolated from *T. turgidum*.

Currently, one pathotype predominates the leaf rust populations in Morocco. This pathotype is virulent on the genes *Lr*10, 30, 33 and 34 and avirulent on the genes *Lr*1, 2a, 2c, 3, 3ka, 9, 11, 16, 17, 19, 24, 26, 29 and 32. A similar pathotype was described by Park *et al.* (1996) in southern France. These authors found that this pathotype was distinguished from all other European pathotypes on the basis of pathogenicity and RAPD markers.

In addition, the pattern of the seedlings reactions of the commercially grown and the recently released cultivars in Morocco, to isolates of *P. triticina,* varied according to the host species (Ezzahiri *et al.,* 1996). The proportion of susceptible durums was negatively correlated (-0.33*) with the level of virulence of the tested isolates of the pathogen to the tested isolates. Twelve out of thirteen cultivars of durum wheats were susceptible to 30% isolates of the pathogen. These isolates were virulent on less than four *Lr* genes of the tested 16 differentials.

For bread wheats, the level of susceptibility was positively correlated (0.72***) with the number of virulent factors of *P. triticina* isolates.

Table 1. Percent virulence of *Puccinia triticina* to selected leaf rust resistance genes from collections made in Morocco in the period 1990-98

Lr genes	1990	1992	1994	1996	1997	1998
1	69	81	20	0	0	03
2a	39	36	17	0	3	1.5
2c	78	63	22	0	8.5	3
3	86	79	22	0	3	3
3ka	02	09	15	0	0	0
9	07	–	10	0	0	0
10	84	72	100	100	100	100
11	53	38	25	0	3	6.5
16	90	87	76	45	17	16
17	85	77	89	43	31	10
19	–[†]	0	0	0	0	0
24	0	0	0	0	0	0
26	0	0	0	0	0	0
29	–	–	–	0	0	0
30	–	–	–	100	64.5	92
32	–	–	–	45	25	18
33	–	–	–	72.5	67	93.5
34	–	–	–	87	56	90
Number of samples	148	135	156	62	36	62

[†]– Not tested.

Table 2. Percent distribution of UN races of *Puccinia triticina* identified in Morocco in 1992 and 1994

Year/host	UN races											
	1	2	3	5	6	9	10	11	12	13	14	17
1992[†]												
Bread	4	2	2	19	27	2	2	4	–	37	–	2
Durum	30	7	–	10	17	–	3	10	–	13	7	3
1994[††]												
Bread	59	1	3	3	5	–	–	4	4	20	–	1
Durum	88	–	–	–	2	–	6	2	–	2	–	–

[†]135 isolates (105 from bread wheat and 30 from durum wheat) were tested in 1992.
[††]158 isolates (92 from bread wheat and 66 from durum wheat) were tested in 1994.

Resistance of durum wheats of leaf rust

Genetic resistance is the most economical method of controlling leaf rust. Genetic resistance can be most fully utilized by knowledge of the identity of resistance genes in commonly used germplasm and released cultivars.

Currently, 46 leaf rust resistance genes (*Lr*) have been isolated, mapped to specific chromosome and given official designation (McIntosh *et al.,* 1998). Twenty four genes were isolated directly from hexaploid wheats and only two were from *T. turgidum* (Table 3). Thus, very little is known on the genes for resistance in durum wheat cultivars. Many of these cultivars express however, high level of resistance to leaf rust in the field.

Table 3. Sources of wheat leaf rust (LR) resistance

Source	Genome	Loci for LR resistance
T. aestivum	ABD	1, 2, 3, 10, 11, 12, 13, 14b, 15, 16, 17, 18, 20, 22b, 27, 30, 31, 33, 34, 44, Tb, VPM, W, W2
T. turgidum	AB	14a, 23
T. tauschii	D	21, 22a, 32, 39, 40, 41, 42, 43
T. ventricosum	Dun	37
T. speltoides	S	28, 35, 36
Agropyron elongatum		19, 24, 29
Agropyron intermedium		38
Secale cereale	R	25, 26, 45
T. umbellulatum	U	9

Analysis of leaf rust resistance in durum wheat cultivars

Two methods have been commonly used to elucidate the leaf rust resistance genotypes of wheat cultivars: gene postulation and genetic analysis. The first method has been applied almost exclusively to bread wheats, while the genetic analysis of durum wheats for leaf rust resistance was limited to few studies.

In all the reports on durum wheats, the resistance was recessive in most of the studied cultivars (Statler, 1973; Rashid *et al.,* 1976; Zhang and Knott, 1990; Singh *et al.,* 1993; Ezzahiri *et al.,* 1998).

Statler (1973) found that the resistance in the cultivar Leeds was controlled by two complementary recessive genes. Zhang and Knott (1990) genetically determined that the cultivars Stewart 63 and Medora had two seedling resistance genes and four other culivars had a single gene.

Ezzahiri *et al.* (1998) have found that the resistance to leaf rust in the culivars Sarif, Cocorit and Kyperounda was controlled by one dominant, one recessive and two recessive genes, respectively (Table 4).

Table 4. Segregation for resistance to *Puccinia triticina* of F_2 populations of crosses between three durum wheat cultivars and the susceptible Local Red

Cross	Population	Number of F_2 plants and reaction		Ratio R:S	P-value
		Resistant	Susceptible		
Sarif/	1	57	14	3:1	0.50-0.25
Local Red	2	39	16	3:1	0.50-0.25
Cocorit/	1	21	76	1:3	0.25-0.10
Local Red	2	14	36	1:3	0.70-0.50
	3	14	41	1:3	0.90-0.80
Kyperounda/	1	05	63	1:15	0.70-0.50
Local Red	2	06	54	1:15	0.50-0.25

Conclusions

Leaf rust, an important disease of durum wheat in the Mediterranean region, has only been partially investigated in this host species when compared to bread wheat.

The populations of the leaf rust pathogen are diverse and complex in the region due to the occurrence of the alternate host, *Anchusa italica*. This alternate host was found to be functional in Morocco and Portugal.

Studies of the virulence patterns of *Puccinia triticina* in Morocco indicated that isolates from durum wheats were avirulent to most of the known *Lr* genes, especially *Lr*1, 2a, 2c and 3. Thus, it is essential to know which leaf rust populations are present in an area in order to breed for resistance in durum wheats.

Genetic studies of specific resistance of durum wheat to leaf rust are still scarce. The available information indicated that the characterized resistance genes are recessive in most cases. In addition, studies on partial resistance are lacking for durum wheats.

The successful control of leaf rust in the region should be based on an overall characterization of the host-pathogen system. This characterization includes a complete study of the virulence spectrum of the pathogen in the region. Genetic studies of resistance are also necessary for future strategic deployment of genes for durable control of the pathogen.

References

Anikster, Y., Bushnell, W.R., Eilam, T., Manisterski, J. and Roelfs, A.P. (1997). *Puccinia recondita* causing leaf rust on cultivated wheats, wild wheats, and rye. *Can. J. Bot.,* 75: 2082-2096.

Cummins, G.B. (1971). *The Rust Fungi of Cereals, Grasses and Bamboos*. Spring-Verlag, New York.

D'Oliveira, B. and Samborski, D.J. (1966). Aecial stage of *Puccinia recondita* on Ranunculaceae and Boraginaceae in Portugal. In: *Proc. First European Brown Rust Conference, Cereal Rusts Conferences*, Cambridge (UK), 1964. Plant Breeding Institute, Cambridge, pp. 133-150.

Ezzahiri, B., Diouri, S. and Roelfs, A.P. (1992). *Anchusa italica* as an alternate host for leaf rust in Morocco. *Plant Dis*., 76: 1185.

Ezzahiri, B., Diouri, S. and Roelfs, A.P. (1994). Pathogenicity of *Puccinia recondita* f. sp. *tritici* in Morocco during 1985, 1988, 1990, and 1992. *Plant Dis*., 75: 65-73.

Ezzahiri, B., Mzada, K. and Nsarallah, N. (1998). Inheritance of leaf rust in three durum cultivars from Morocco. In: *Proc. IX Int. Wheat Genetics Symposium*, Vol. III, Slinkard, A.E. (ed.). Saskatoon, Saskatchewan, 1998. University Extension Press, Saskatoon, pp. 267-269.

Ezzahiri, B., Ouassou, A. and Mzada, K. (1996). Pathogenicity of *Puccinia recondita* f. sp. *tritici* in Morocco in the period 1993-1995. In: Proc. IX European and Mediterranean Cereal Rusts and Powdery Mildews Conference, Kema, G.H.J., Niks, R.E. and Daamen R.A. (eds.), Lunteren (The Netherlands), 1996. *Cereal Rusts and Powdery Mildews Bull.,* 24 Suppl.: 83-85.

Huerta-Espinosa, J. and Roelfs, A.P. (1992). Leaf rust on durum wheats. In: Proc. VIII European and Mediterranean Cereal Rusts and Mildews Conference, 1992, Weihenstephan (Germany). *Vorträge für Pflanzenzüchtung,* 24: 100-102.

McIntosh, R.A., Hart, G.E., Devos, K.M., Gale, M.D. and Rogers, W.J. (1998). Catalogue of gene symbols for wheat. In: *Proc. IX Int. Wheat Genetics Symposium*, Vol. V, Saskatoon, Saskatchewan, 1998. University Extension Press, Saskatoon, pp. 267-269.

Park, R.F., Jahoor, A. and Felsenstein, F.G. (1996). Genetic variation in European populations of *Puccinia recondita* f. sp. *tritici* using pathogenicity and molecular markers. In: Proc. IX European and Mediterranean Cereal Rusts and Powdery Mildews Conference, Kema, G.H.J., Niks, R.E. and Daamen R.A. (eds), Lunteren (The Netherlands), 1996. *Cereal Rusts and Powdery Mildews Bull*., 24 Suppl.: 92-94.

Rashid, G., Quick, J.S. and Statler, G.D. (1976). Inheritance of leaf rust in three durum wheats. *Crop Sci*., 16: 294-296.

Samborski, D.J. (1985). Wheat leaf rust. In: *The Cereal Rusts*, Vol. II, Roelfs, A.P. and Bushnell, W.R. (eds). Academic Press, Orlando, pp. 39-52.

Savile, D.B.O. (1984). Taxonomy of the cereal rust fungi. In: *The Cereal Rusts*, Vol. I, Bushnell, W.R. and Roelfs, A.P. (eds). Academic Press, Orlando, pp. 79-112.

Singh, R.P., Bechere, E. and Abdalla, O. (1993). Genetic analysis of resistance to leaf rust in nine durum wheats. *Plant Dis.,* 77: 460-463.

Statler, G.D. (1973). Inheritance of leaf rust resistance in Leeds durum wheat. *Crop Sci.,* 13: 116-117.

Viennot-Bourgin, G. (1941). Diagnose Latine de *Puccinia tritici-duri*. *Ann. Ecole Nationale Agric. Grignon Paris C. Amat. Ser*., 2: 146.

Zhang, H. and Knott, D.R. (1990). Inheritance of leaf rust resistance in durum wheat. *Crop Sci*., 30: 1218-1222.