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Tan Spot Disease of Wheat: race characterization

Pictures: Flávio M. Santana, Paulo Pereira

Flávio Martins Santana[1]
Timothy Lee Friesen[2]

Embrapa

Abstract

Tan spot, one of the most important diseases of wheat, is caused by *Pyrenophora tritici-repentis*, a necrotrophic fungus which survives in wheat straw. Methods of disease control include fungicide application, crop rotation, and the use of resistant cultivars; however, in Brazil there are no cultivars in the market with a good level of resistance. In North America, a system of race identification is used based on symptom development on a differential set of wheat lines. Symptom development on the differential wheat lines is known to be at least partly due to the production of toxins by the pathogen. The Embrapa Trigo, with the collaboration of the USDA-ARS in the USA, has introduced this set of differential wheat lines into the Active Germplasm Bank. Besides the race indentification, a set of microsatellite markers will be used to characterize the *P. tritici-repentis* population from Brazil. The data obtained will be beneficial to the breeding program for the introgression of genes into the Embrapa wheat cultivars.

[1] Plant Pathologist Researcher. Embrapa Trigo, Caixa Postal 451, 99001-970 Passo Fundo, RS, Brazil. E-mail: fsantana@cnpt.embrapa.br.
[2] Plant Pathologist Researcher. USDA, Fargo, North Dakota, USA. E-mail: Timothy.Friesen@ARS.USDA.GOV.

Introduction

Tan spot of wheat is one of the major wheat diseases in southern Brazil. This disease is caused by *Pyrenophora tritici-repentis*, a necrotrophic fungus, which survives in organic residue between planting seasons (Fig. 1). The capacity of survival in wheat straw associated with the no-tillage system makes this disease very important, especially if the producer does not practice crop rotation, thus, causing great losses particularly in rainy years, which favor the development of this disease. In addition, wet years increase the difficulty of fungicides application due to the impediment of the machinery to get into the fields (Prestes et al., 2002). In recent years, it has been more difficult to control diseases in wheat. In 2004, tan spot was found widespread in the early stages of wheat production (Forcelini, 2007).

Image: Paulo Pereira

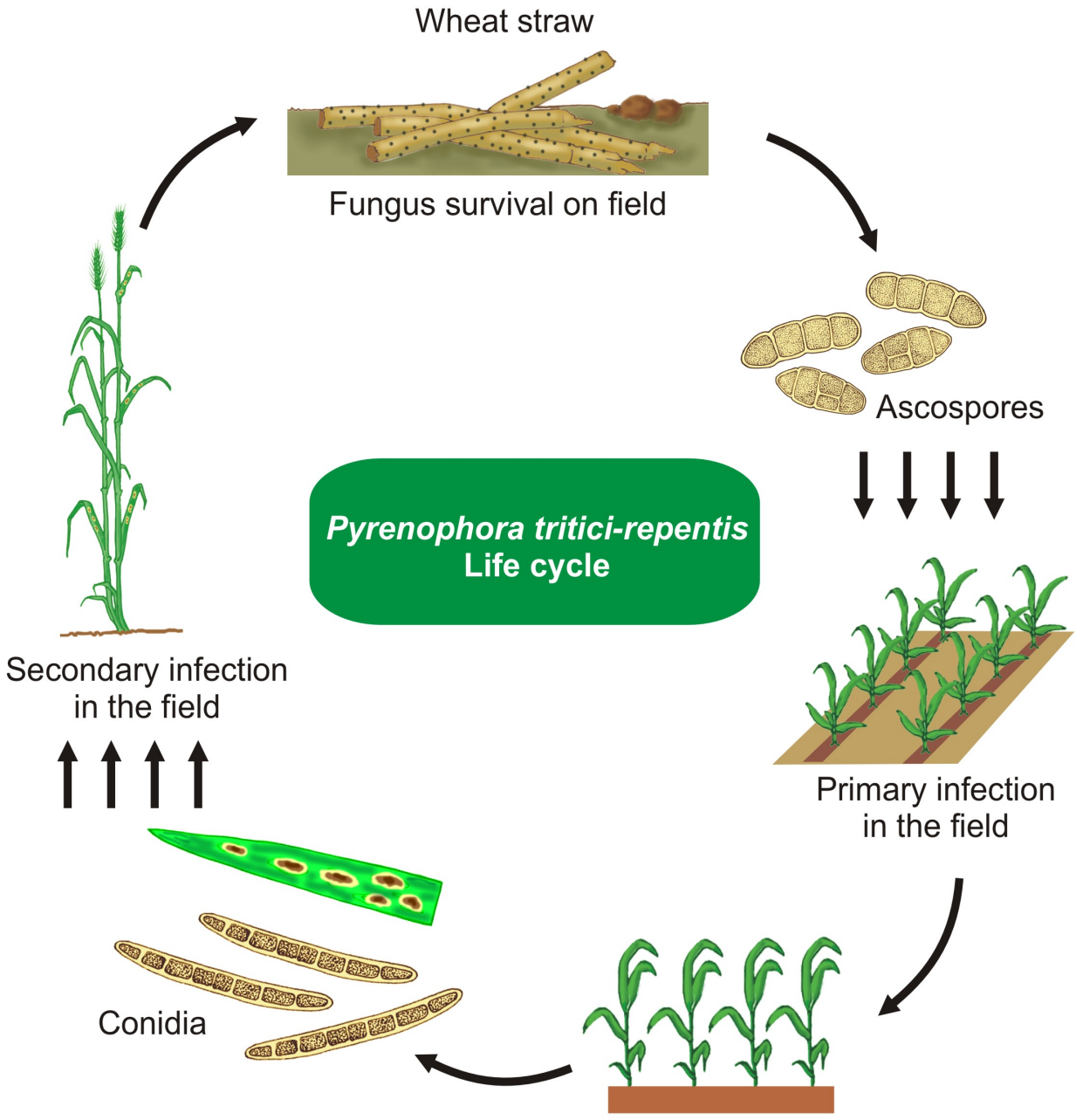

Fig. 1. Life cycle of *Pyrenophora tritici-repentis*.

In the 1970s and 80s, tan spot was reported to have produced losses ranged from 3 to 50% in the US (Hosford & Busch, 1974; Hosford et al., 1987) and between 13 and 48% in Australia (Rees & Platz, 1983). In the 'Cone Sul' tan spot became predominant in the 1980s and 90s. In Brazil, this disease has been reported in Paraná, Santa Catarina, Rio Grande do Sul, São Paulo and Mato Grosso do Sul, with 36% of losses in yield of wheat due to tan spot (Linhares,1995).

The race structure of *P. tritici-repentis* has been analyzed for more than 10 years by various groups in North America (Reviewed in Ciuffetti and Tuori 1999). The method of identification is based on symptom development on a set of differential wheat lines. Each race can produce one or more toxins which produce symptoms of necrosis or chlorosis on these susceptible host lines (Lamari et al., 2003).

The control

Basically, there are three control strategies for this disease. 1) Chemical control: can be obtained by means of application of fungicide including those with triazole-base, strobilurins-base, or a mixture of both. For the diseases caused by *Bipolaris sorokiniana*, *Stagonospora nodorum*, or *Septoria tritici*, which produce symtoms similar to tan spot, the application of fungicides are recommended when the foliar incidence reaches 70%; but for tan spot caused by *P. tritici-repentis*, application is recommended at the first symptoms, due to the aggressivenessof the fungus; 2) Crop management: crop rotation is crucial to reduce the primary inoculum of the fungus, which survives in wheat straw. The wheat straw can decompose in soil within 18 months, constituting in this period a source of primary inoculum of the pathogen (Reis & Casa, 2007); 3) Resistant cultivars: in many pathosystems the use of resistant cultivars is considered the ideal control strategy; however, there are few wheat cultivars presently available in the market with satisfactory levels of resistance to tan spot (Reunião... 2006).

Race structure

There are two characteristic symptoms of this disease which include chlorosis (Fig. 2A) and necrosis (Fig. 2B). A clear-cut distinction of these symptoms is not always observed in the field, however the classic reaction to this disease involves necrotic (tan colored) regions surrounded by a chlorotic (yellow) halo (Fig. 3). The occurrence of these two symptoms is due to the presence of toxins produced by *P. tritici*-repentis (Lamari et al., 2003). Three toxins have been isolated, characterized and associated with the infection process of *P. tritici-repentis*. These include Ptr ToxA and Ptr ToxB, both of which are proteins, and Ptr ToxC, which has been shown to be a polar nonionic low molecular weight compound. Depending on the race, one or more toxins are produced, inducing necrosis, chlorosis, or both (Lamari et al., 2003, Ciuffetti & Tuori, 1999, Ciuffetti et al., 1998). A system of identification and classification of isolates of *P. tritici-repentis* into different races has been developed based on the symptoms produced on a series of differential wheat cultivars (Table 1)(Lamari et al., 2003). With this method of identification of races it is possible to separate *P. tritici-repentis* in to eight races, since the combination of genes is 2^3 (Lamari at al., 2003). The Embrapa Trigo, placed in Passo Fundo, RS, is beginning to apply this aproach for race identification in Brazil, and additionally a molecular characterization will be undertaken in collaboration with researchers at the United States Department of Agriculture-Agricultural Research Service (USDA-ARS). The focus of this work is to use the knowledge acquired to aid in the development of wheat cultivars resistant to tan spot.

Picture: Timothy Lee Friesen

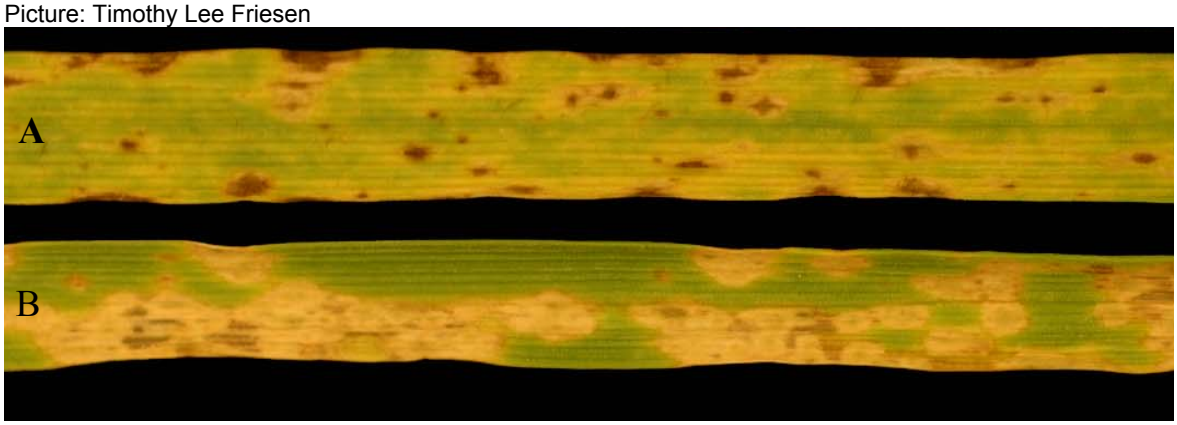

Fig. 2. Typical symptoms of necrosis and clorosis caused by *P. tritici-repentis*. A – clorosis in the wheat line 6B365, due to Ptr ToxC; B – necrosis, without yellow halo, in the cultivar Glenlea, due to Ptr ToxA.

Picture: Flávio Martins Santana

Fig. 3. Susceptible wheat cultivar with typical tan spot symptoms, on field.

Table 1. Reaction of differential cultivars to infection by various races of *P. tritici-repentis*. (Lamari et al., 2003).

	Differential series				Typical symptoms	Toxin procuced
Race	**Glenlea**	**6B662**	**6B365**	**Salamouni**		
1	Nec*	R	Chl	R	$Nec^{+}Chl^{+}$	Ptr ToxA Ptr ToxC
2	Nec	R	R	R	$Nec^{+}Chl^{-}$	Ptr ToxA
3	R	R	Chl	R	$Nec^{-}Chl^{+}$	Ptr ToxC
4	R	R	R	R	$Nec^{-}Chl^{-}$	-------
5	R	Chl	R	R	$Nec^{-}Chl^{+}$	Ptr ToxB
6	R	Chl	Chl	R	$Nec^{-}Chl^{+}$	Ptr ToxB Ptr ToxC
7	Nec	Chl	R	R	$Nec^{+}Chl^{+}$	Ptr ToxA Ptr ToxB
8	Nec	R	Chl	R	$Nec^{+}Chl^{+}$	Ptr ToxA Ptr ToxB Ptr ToxC

*Nec = necrosis; Chl = chlorosis; R = resistant; (+) or (-) = with or without the symptom.

In the United States, where populations of this pathogen have been well characterized using this system of differential plants, it was observed that race 1 is predominant in cultivated wheat (about 90%), with race 4 being the most common in other grasses (98%). In *Triticum durum* there was also predominance of race 1 (89%) as well as being the only species where race 5 was identified (Table 2) (Ali & Francl, 2003).

Table 2. Percentage of race occurrence of *P. tritici-repentis* in northern USA.

	Tested isolates (Nº)	**Races (%)**				
		1	**2**	**3**	**4**	**5**
Common Wheat	107	93	2	0	5	0
Durum	71	89	0	0	0	11
Grasses	92	2	0	0	98	0

Source: Ali & Francl (2003) – adapted.

In Brazil, the occurrence and the distribution of such races of this pathogen are not yet known. Thus, Embrapa Trigo has been developing a project to identify the possible races that occur in southern Brazil. By means of cooperation with researchers at the USDA-ARS, the differential series has been introduced by the Active Germplasm Bank of Embrapa. Also, a set of molecular markers, developed in the USDA, will be used to obtain the molecular characterization of the Brazilian isolates.

Perspectives

The knowledge of the putative races and its monitoring in the field and additionally its molecular characterization are highly important for the process to obtain wheat cultivars with a good resistance level to tan spot disease. Such approach is more precise and can help the breeders to test the resistance of new cultivars to a specific pathogen group.

With such action, it is expected that better support will be obtained for the introgression of effective genes for resistance to tan spot into the cultivars of Embrapa, contributing to less frequent use of fungicides and leading to reduced environmental pollution.

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