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Quantification of leaf tip necrosis, a trait linked with *Lr34/Yr18*

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Abstract

The development of tip necrosis on flag leaves of 80 wheat cultivars was observed. The necrosis started appearing from tip of the flag leaf as a creamy-white streak, which progressed along both margins of leaf blade. The progress of necrosis along the blade margins of the same leaf was unequal. The final expression of tip necrosis on flag leaves of different cultivars was variable. This variation was quantified on 1 to 4 scale. The cultivars with flag leaves showing progress of necrosis from tip of the flag leaf to nearly 25 percent of leaf blade margin were scored as 1. The cultivars with flag leaves showing upto 50 percent and 75 percent margins covered with necrosis were scored 2 and 3, respectively. Cultivars with necrosis covering entire leaf blade margin were scored as 4.

Key words: Wheat, leaf tip necrosis, leaf rust, stripe rust, flag leaf, coefficient of infection

Introduction

Leaf rust caused by *Puccinia triticina* (*P. recondita* Roberage ex. Desmaz f. sp. *tritici*) is one of the most important diseases of wheat which can affect yield upto 70 percent in epidemic years [1]. Various sources of resistance to leaf rust have been identified and utilized in breeding programmes. The genes for race specific resistance to leaf rust, offer complete protection from rust but this type of resistance is often short lived. In contrast, the genes conferring only partial resistance do not force selection pressure on the pathogen and thus remain effective for a longer duration [2]. The adult plant leaf rust resistance genes *Lr34* and *Lr46* are known to contribute towards durable resistance to leaf rust and thus has special significance to breeding programmes [3]. The gene Lr34 is located on chromosome 7DS [4] and it is tightly linked to the stripe rust resistance gene Yr18 also important for durable resistance [5]. However, detection of *Lr34* and *Yr18* in terms of gene-for-gene hypothesis is difficult because of almost near complete absence of avirulence in the pathogen races against these two genes. Singh [4] reported a morphological marker leaf tip necrosis, to be tightly linked with these two genes which has helped breeders in many parts of the world in postulation of the genes *Lr34* and *Yr18*. However, the detection of leaf tip necrosis in India is difficult, because during the period when this trait can be assessed under field conditions the weather is particularly favorable for the growth of many saprophytes also causing necrosis on wheat leaves. Variation in expression of this trait in wheat cultivars is also observed which further complicates the detection of the genes *Lr34* and *Yr18*. The present paper describes the development of leaf tip necrosis on wheat cultivars to facilitate detection of the genes *Lr34* and *Yr18* in field nurseries. A scale for quantification of leaf tip necrosis is also described.

Materials and methods

Seventy nine bread wheat cultivars showing partial resistance to leaf rust and stripe rust and also showing leaf tip necrosis were used for the present work along with a susceptible cultivar WL711. These cultivars were planted in 2m long paired rows placed 60 cms apart at the experimental area of the Department of Genetics and Biotechnology during the crop seasons 1998-99, 1999-2000 and 2000-2001. Because the leaf tip necrosis occurs only on flag leaves, the flag leaves of each cultivar were observed for the development of tip necrosis. The cultivar (s) where the progress of necrosis from the tip of the flag leaf along the margins was up to 25% of the leaf blade length, were classified as having rating '1'. The cultivars showing travel of necrosis upto 50%, 75% and 100% (necrosis touching the leaf base) of the leaf blade margin, respectively were classified as having rating of '2', '3' and '4'. The observations on leaf rust and stripe rust severity were also recorded each year according to modified Cobb scale as suggested by Peterson *et al.* [6] and expressed as average coefficient of infection for the years 1998-99 to 2000-2001 according to Roelfs *et al.* [7]. Accordingly, the non-quantitative response on adult plants was allocated response values of 0.2, 0.4, 0.6, 0.8 and 1.0 corresponding to the pustule type i.e. resistant, moderately resistant, mesothetic, moderately susceptible and susceptible, respectively. The terminal leaf rust and stripe rust severity for each cultivar recorded as

percentage of leaf area covered with rust was multiplied by the appropriate response values to derive coefficient of infection.

Results and discussion

The leaf tip necrosis expressed on a cultivar only when it crossed boot leaf stage. The appearance of necrosis always started from the tip of the flag leaf as a creamy-white streak, which progressed along both margins of the flag leaf blade. The progress of necrosis on both the margins of leaf blade was not equal (Fig. 1a). In cultivars where the necrosis progressed beyond 50 percent of leaf blade margin the flag leaves often rolled down giving them a ribbon like appearance (Fig. 1b). This rolling occurred because of the stress caused

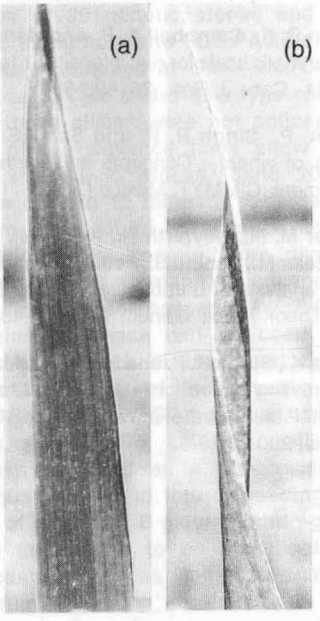

Fig. 1. Leaf tip necrosis (a) Unequal progress of necrosis on the margins of leaf blade; (b) rolling of flag leaf giving it ribbon like appearance

by unequal movement of necrosis along the margins of the leaf blade. In contrast the necrosis caused by saprophytes starts as light brown spots scattered anywhere on the leaves. These spots coalesce later to form bigger spots. Almost entire leaf chlorophyll can be lost in case of extreme infection. The rolling was not observed on flag leaves showing necrosis caused by saprophytes. The rolling of flag leaves of a cultivar was thus a confirmation for the presence of leaf tip necrosis but the reverse is not always true. With subsequent senescence of the flag leaves, the necrotic margins close to the tip of the flag leaf rolled inside on the adaxial leaf surface giving them a needle like appearance. The progress of necrosis along the leaf blade margins of different flag leaves within a cultivar was often synchronous. The grouping of 79

Table 1. Leaf tip necrosis score of eighty wheat cultivars and their average coefficient of infection (ACI) for leaf and stripe rust

Cultivar*	Leaf tip necrosis score	ACI (1998-2001)	
		Leaf rust	Stripe rust
Lerma Rojo 64, Mukta, Nainari 60, Romany, Wialki, RL6061, CIM10	1	20.03	17.38
Anza, Arz, Blue silver, CPAN1922 (Rohini), Girija, Era, K8020, Kathadin, Nuri 70, Raj 1972, Supressa, Takari, Tobari 66, UP1109, RL6050, RL6058, RL6059, RL6077, 90RN2559, Kauz, Bob hite, CIM25, Minivet, CIM30, CIM33, CIM37, Sonoita 81, Tesia 79, CIM52, CIM60	2	11.86	12.04
Bajio 67, Brochis, BW1, Canario, CSP44, Dove, Erget, Emu, FKN, Flinders, Frontana, HW741, Mentana, Moncho, Myna, Norteno 72, Opata, Parula, WG138, WL410, Yaqui 50, Yaco, 90RN2491, CIM5, CIM21, CIM27, CIM32, Burion, Kavkaz, CIM42, Esmeralda 86, Ocoroni 86	3	10.07	9.28
Chris, CPAN1796, Cocoroque 75, Diaz, Marcos Jaures Inta, NP846, VL404, Veranopolis, CIM31, CIM41	4	11.76	8.48
WL711	0	80.00	55.00

*The CIM numbers are local numbers given by the authors to unnamed derivatives received from Dr. R.P. Singh (CIMMYT, Apdo. Postal 6-641, 06600, Mexico- DF, Mexico) in 1989. According to Dr. R.P. Singh these derivatives showed resistance to leaf rust in many countries. Following is the parentage of these derivatives: CIM5 = Roussalka/Azteca 67/Pavon 76 'S'; CIM10 = Parula'S'/Veery#6; CIM21 = Maya'S'; CIM25 = Kavkaz/3/Tobari 66/Centrifen/Bluebird/4/Bolillo; CIM27 = Sapsucker'S'/Moncho'S'; CIM30= GOV/Azteca 67/Musala'S'; CIM31 = Teznos Pintos Precoz//IRN46/Ciano 67/3/II64.27/4/Jaral 66/Ciano 67/Centrifen/Ciano 67/3/Saric 70; CIM32= Iaasul 63/Aldan'S'; CIM33= Patio/Alondra'S'/PAT72300/3/Pavon'S'; CIM37= Sparrow'S'/5/Bluebird//Sonora 64/Klein Rendidor/3/Chanate/4/ Gabo (K)/6/Veery#5; CIM41, CIM42, CIM52,CIM60 = Parentage not known.

cultivars for leaf tip necrosis according to the 1 to 4 scale devised by us and their leaf rust and stripe rust reaction is given in Table 1. Seven cultivars showing leaf tip necrosis score of '1' were grouped together and the average coefficient of infection of these cultivars for leaf rust and stripe rust were 20.03 and 17.38, respectively. Thirty cultivars showed leaf tip necrosis score '2' and the average coefficient of infection of these cultivars for leaf rust and stripe rust was 11.86 and 12.04, respectively. Thirty two cultivars showed leaf tip necrosis score of '3' and the average coefficient of infection of these cultivars for leaf rust and stripe rust was 10.07 and 9.28, respectively. Ten cultivars

showed leaf tip necrosis score of '4' and the average coefficient of infection of these cultivars for leaf rust and stripe rust was 11.76 and 8.48, respectively. Cultivar WL711 did not show leaf tip necrosis and the average coefficient of infection of this cultivar was 80.00 and 55.00 for leaf rust and stripe rust, respectively. The average coefficient of infection for leaf rust and stripe rust of cultivars with the leaf tip necrosis rating of 1 were higher than those with a leaf tip necrosis rating 4. Therefore, cultivars having higher leaf tip necrosis score were more resistant to both the rusts as compared to the cultivars with lower leaf tip necrosis score. The studies by Messmer *et al.* [8] also demonstrate that leaf tip necrosis is a quantitatively inherited trait and there are four QTLs for this trait, located on 4 different chromosomes of a winter wheat cultivar Forno. However, Suenaga *et al.* [9] identified only one major QTL located on chromosome 7DS which contributed about 40% towards leaf tip necrosis. It is therefore, likely that all cultivars showing leaf tip necrosis may not contain *Lr34* but these may be important sources of durable resistance to leaf rust and stripe rust.

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