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Genetic analysis of two wheat cultivars, 'Sonalika' and 'WL 711' for reaction to leaf rust (*Puccinia recondita*)

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Summary. Genetic analysis for leaf rust reaction of two widely adapted cultivars, 'Sonalika' and 'WL 711', has been done using 21 near isogenic Lr lines and rust culture IL004 – avirulent on the two cultivars and all the Lr lines used. The segregation pattern in the F_2 generation indicated the presence of a recessive gene in 'Sonalika' and of a dominant gene in 'WL 711'. These genes in cultivars 'Sonalika' and 'WL 711' have been identified as *Lr 11* and *Lr 13*, respectively. Gene *Lr 13* is no longer effective in 'WL 711' but it continues to give field resistance in the backgrounds of 'Chris', 'Prelude' and 'Thatcher'. There has been no significant change in the virulence spectrum of the leaf rust pathogen in India with the release of 'WL 711'. High susceptibility of 'WL 711' seems to be due to the evolution of more aggressive forms of the pathogen to this cultivar. The gene *Lr 11*, which behaves as a recessive in 'Sonalika', was effective against leaf rust when this cultivar was released. The high susceptibility of 'Sonalika' is probably due to an increase in the frequency of race 77 virulent on *Lr 11*. *Lr 11* has shown a dominance reversal in the background of 'Sonalika'. Present results suggest that interaction of resistance genes with the background genotype must be studied for their effective use in breeding programme.

Key words: Avirulence – Virulence – Resistance – Susceptibility – Near isogenic – *Lr* gene

Introduction

'Sonalika' and 'WL 711' are two cultivars of wheat which occupied large areas in India soon after their release in 1968 and 1976, respectively. Good field resistance to leaf rust, a high yielding ability and bold amber grains were largely responsible for their popularity. 'Sonalika' started showing susceptibility to leaf rust around 1975. Heavy incidence of leaf rust was observed on 'WL 711' in many areas around 1980. Analysis of these cultivars for the number and nature of genes for leaf rust resistance was done using 21 near isogenic *Lr* lines. These observations and other factors which probably led to the "loss" of resistance in the two cultivars, are presented here.

Materials and methods

Cultivars 'Sonalika' ('Andes' × 'Pitic 'S'' × 'LR 64') and 'WL 711' [('Ska' × 'Chris') × 'Kalyansona'] were crossed with a universal susceptible cultivar 'Agra Local' and near isogenic lines for genes *Lr 1, Lr 2a, Lr 2b, Lr 2c, Lr 2d, Lr 3, Lr 3*(Ka), *Lr 3*(Bg), *Lr 10, Lr 11, Lr 12, Lr 13, Lr 14a, Lr 14b, Lr 15, Lr 16, Lr 17, Lr 18, Lr 21, Lr 22* and *Lr 23*. These were obtained through the courtesy of Prof. P. L. Dyck of Canada. F_2 generations from the above crosses were tested against leaf rust culture IL-004, which carries avirulence genes against all the above-mentioned *Lr* genes (Gupta and Saini 1981). The tests were conducted at the seedling stage in a growth chamber maintained at 20° ± 1 °C and 90% relative humidity. Seedlings were classified as resistant or susceptible according to the scale given by Stakman et al. (1962). Simple Chi-square test was used to test the fitness of genetic ratios.

Results

All the *Lr* lines involved in crosses, and the two cultivars used, gave resistant reactions to culture IL-004 while cultivar 'Agra Local' was susceptible. The F_2 generation from the crosses of 'Agra Local' with 'Sonalika' and 'WL 711' segregated in a 1(R) : 3(S) and 3(R) : 1(S) ratio, respectively, indicating the presence of

Table 1. Reactions to leaf rust culture IL-004 of F_2 populations of crosses with 'Sonalika' and 'WL 711'

Cross	F_2 Seedlings			Ratio	Chi-square
	Resistant	Susceptible	Total		
'Sonalika' × 'Agra Local'	194	598	792	1:3	0.03
'Sonalika' × *Lr* 11 (Tc^6 × 'Hussar')	496	–	496	–	–
'WL 711' × 'Agra Local'	576	186	762	3:1	0.13
'WL 711' × *Lr* 13 (Pr^4 × 'Manitou')	970	–	970	–	–

single recessive gene in 'Sonalika' and a dominant gene in 'WL 711' (Table 1). The F_2 generation from the cross of 'Sonalika' with *Lr 11* (Tc^6 × 'Hussar') and from the cross of 'WL 711' with *Lr 13* (Pr^4 × 'Manitou') did not segregate (Table 1). Segregation for susceptibility was observed in the F_2 populations of all crosses of these two cultivars with other near isogenic *Lr* lines. These observations indicate the presence of *Lr 11* in 'Sonalika' and *Lr 13* in 'WL 711'.

Discussion

'Sonalika' was highly resistant to leaf rust in its early years of release but has been showing leaf rust infection ranging from 30S to 70S between the years 1974–75 and 1981–82 in many parts of India. Reddy and Rao (1978) reported that one or more genes from amongst *Lr 2, Lr 11, Lr 12, Lr 13, Lr 14, Lr 18* and *Lr 22* may be present in 'Sonalika'. Our observations rule out the presence of all other genes except *Lr 11*. The source of *Lr 11* in 'Sonalika' is not known because the genes of its parents have not yet been identified. *Lr 11* confers resistance to most of the prevalent Indian leaf rust races (10, 11, 12, 63, 104, 106, 162) but shows susceptibility to race 77. Race 77 has been present in low frequencies since the release of 'Sonalika' in 1968 but its frequency increased in the mid 70's (Singh et al. 1979) which perhaps led to the loss of resistance in 'Sonalika'.

The rust intensity on 'Sonalika' is still lower than other cultivars because it possesses slow-rusting resistance (Saini and Gupta 1978; Kulkarni and Chopra 1980; Kapoor and Joshi 1982). Browder (1973) analysed slow-rusting of 'Bulgaria-88' and concluded that the slow-rusting of this cultivar owed origin to a specific resistance gene, *Lr 11*, which conditioned a low reaction against most of the races of *Puccinia recondita* in the USA. It seems that the expression of slow-rusting is modified by the background genotype of a cultivar. 'Hussar', in which *Lr 11* was first identified, is not a slow-ruster. *Lr 11* in 'Sonalika' appears to be highly effective in conferring slow-rusting to leaf rust.

'WL 711', a selection from a cross involving 'Kalyansona', 'Sonalika' and 'Chris', showed susceptibility to leaf rust at one or two locations in the early years of its release. Reddy and Rao (1978) reported that 'Kalyansona' has *Lr 12, Lr 13, Lr 14, Lr 18* and *Lr 22*. However, our observations indicate that 'Kalyansona' carries only *Lr 12* and *Lr 21* (Gupta and Saini, unpublished). None of the genes from 'Sonalika' (*Lr 11*) or 'Kalyansona' (*Lr 12, Lr 21*) are present in 'WL 711'. This is to be expected as both these parents were showing susceptibility to leaf rust when the breeding of 'WL 711' was done. The third parent of 'WL 711' is 'Chris', which carries *Lr 13* (Samborski 1977). Observations presented here show that resistance in 'WL 711' is derived from 'Chris', and is due to *Lr 13*.

There has been no significant change in the spectrum of virulence in the leaf rust pathogen in India since the release of 'WL 711' in 1976 (Singh et al. 1979; Bahadur et al. 1982) and races virulent on *Lr 13* still exist. 'Chris' has maintained its resistance while 'WL 711' is now susceptible, though both cultivars carry *Lr 13*. Gene *Lr 13* confers resistance to races 63 and 107 at the seedling and adult plant stages but only adult plant resistance to most other races. The high level of resistance in 'Chris' is probably due to the presence of modifiers in this cultivar (Samborski 1977). *Lr 13* also confers effective resistance when present in 'Prelude' and 'Thatcher' backgrounds (Saini and Gupta 1979). It appears that only *Lr 13* was transferred to 'WL 711' and the modifiers present in 'Chris' were not incorporated while breeding this cultivar. It is possible that large scale cultivation of 'WL 711' resulted in a quick evolution of more aggressive variants of existing races which led to high susceptibility of this cultivar.

Expression of resistance genes is known to be modified by the background genotype of a cultivar. Soliman et al. (1963) reported that *Lr 11* confers resistance in 'Hussar' and behaves as a dominant whereas this gene behaves as a recessive in 'Sonalika'. Reversal of dominance with change in genetic background can pose difficulties while incorporating resistance based on such genes. The efficiency of single genes such as *Lr 11* and *Lr 13* can be enhanced if appropriate rust cultures enabling selection of modifiers along with the major gene are used in breeding programmes.

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Note added in proof

Dr. R. A. McIntosh of Australia believes that both 'WL 711' and 'Sonalika' carry *Lr13* (personal communication, May 25, 1983). However, our observations on allelic tests made so far and seedling reactions show that 'Sonalika' has only *Lr11*. Culture IL004 gives 2^+ reaction on *Lr13* and 'WL711' but only 0; type reactions on *Lr11* and 'Sonalika'. An IT of 3^N type is observed on *Lr11* and 'Sonalika' with culture IL009 which gives susceptible (type 4) reactions on *Lr13* and 'WL 711'.