Hypothetical Genotypes for Low Reaction to *Puccinia recondita* in Eight Wheat Cultivars of India

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ABSTRACT

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Eight commercial Indian wheat cultivars were tested, analyzed, and grouped with leaf rust resistant (LR) monogenic lines LR1, LR2A, LR2D, LR3, LR9, LR10, LR11, LR16, LR17, LR18, and LR19 by inoculating them with 14 American cultures of *Puccinia recondita* f. sp. *tritici* of known pathogenic specificity. The grouping showed that cultivars Pusa Lerma, Sharbati Sonora, and Shera each possess gene *Lr*1 and an additional gene not in the monogenic lines used in this study. Cultivar UP301 had only gene *Lr*1; Safed Lerma possessed two genes, *Lr*1 and *Lr*17; Hy. 65 had gene *Lr*10 and at least one additional gene; Kalyansona possessed gene *Lr*18 and one or more additional genes; and cultivar NP4 showed high (susceptible) reaction to all the cultures and hence was considered to be universally susceptible. The presence of these genes was confirmed by examinations of the pedigrees of cultivars. Testing the immediate parents of the cultivars with these cultures may add to the proficiency of the system.

The gene-for-gene hypothesis states that for each gene that conditions host reaction there is a corresponding gene in the pathogen that conditions pathogenicity (7). For simplicity we will assume there are two alleles at each locus for host reaction, low (LH) and high (HH) and two alleles for pathogenicity, low (LP) and high (HP). The low infection type (LIT) interaction is only possible when there is an LH allele in the host and an LP allele in the pathogen, whereas other combinations give high infection types (HIT). A LIT at one parasite/host gene pair is epistatic to HIT at other gene pairs (8,9). From LIT data, probable genotypes of either member of an interaction can be inferred from information available on the opposite member (2). From these relationships, Loegering et al (10) and Browder and Eversmeyer (4) suggested computer analysis of infection type data to derive hypothetical genotypes for reaction of host cultivars to pathogens. This system was used to find the hypothetical genes present for low reaction to leaf rust in eight commercial cultivars of wheat, *Triticum aestivum* L. em. Thell, from India (M. S. S. Reddy, *unpublished* thesis).

MATERIALS AND METHODS

The host material consisted of eight commercial wheat cultivars of India viz., Hy. 65, Kalyansona, NP4, Pusa Lerma, Safed Lerma, Sharbati Sonora, Shera, and UP301, and 11 monogenic and near-isogenic resistant lines with the following background and accession numbers: LR1 (TC), RL6003; LR2A (TC), RL6000; LR2D (PL), RL6001; LR3 (TC), RL6002; LR9 (TC), RL6010; LR10 (TC), RL6004; LR11 (WI), KS7110704; LR16 (TC), RL6005; LR17 (TC), RL6008; LR18 (TC), RL6009 and LR19 (TC), CI 14048. Host line LR1 contained gene *Lr*1, LR2A had *Lr*2A, etc. Morocco (W1103) was used as a check cultivar. The 14 North American uredial cultures of *Puccinia recondita* Rob. ex. Desm. sp. *tritici* used (0578-2, 0641-2, 0709-1, 0817-2, 0953 bulk, 0967-1, 65284-1, 65359-01, 66-763, 6B-NA65-9, UN01-68A, UN02-66A, UN2-70-22 and UN09-66A) were furnished by L. E. Browder.

The Indian wheat cultivars along with LR monogenic lines were planted in 20.3 × 20.3 × 2.5-cm (8 × 8 × 1-inch) metal trays with a mechanized seeder (2). The seedlings were grown at ~20C, with a 12-hr day length, supplemented by artificial lighting. Ten days after seeding one set of plants was inoculated with each of the 14 uredial cultures of *Puccinia recondita* f. sp. *tritici*. Inoculations were made either by spraying with spores suspended in oil or by dusting the spores. The inoculated plants were kept overnight in a refrigerated moist chamber at 15–20C (2). Twelve days after inoculation, the infection types were recorded as suggested by Browder (3) and Browder and Young (5).

The reactions of the single-gene differentials were compared to the reactions of the eight commercial cultivars. This comparison was used to deduce which *Lr* genes account for the resistance of each of the commercial cultivars.

RESULTS AND DISCUSSION

The eight commercial cultivars were classified in five groups according to patterns of infection type to 14 cultures of leaf rust (Table 1). Four cultivars, namely Pusa Lerma, Sharbati Sonora, Shera, and UP301, had reactions similar to LR1(TC). All four cultivars gave low infection type to the six cultures to which gene *Lr*1 gives LIT. The presence of additional gene(s), other than those in the study was indicated by LIT of Pusa Lerma to cultures 0641-2 and 65359-01, and of Sharbati Sonora and Shera to culture UN0-66A. The additional gene(s) present in Pusa Lerma is (are) different from those in Sharbati Sonora and Shera. Cultivar UP301 may have an additional LIT gene for culture 66-763. Sonora 64 and Lerma Rojo 64 are parents of both Shera and UP301, and Sharbati Sonora is a mutant with amber grain from Sonora 64. The presence of gene *Lr*1 in Sonora 64 and Sharbati Sonora was reported earlier (11). The pedigree of Pusa Lerma contains Yaqui 50, which might explain the presence of gene *Lr*1, as *Lr*1 frequently is found in cultivars with that parent.

Cultivar Safed Lerma probably has genes *Lr*1 and *Lr*17. The cultivar showed LIT to all the six cultures to which gene *Lr*1 conditions LIT, and to the seven cultures to which gene *Lr*17 conditions LIT. No additional genes are indicted as both genes *Lr*1 and *Lr*17 together confer low reaction to all the eight cultures to which the cultivar confers LIT.

Cultivar Hy. 65 had reactions similar to LR10(TC). This cultivar showed LIT to all the five cultures to which gene *Lr*10 confers LIT. The presence of additional gene(s) not in the study is indicated by the LIT of Hy. 65 to cultures 0953-bulk and 0967-1. The gene *Lr*10 may have come from cultivar Gabo, one of its parents (1).

Cultivar Kalyansona had reactions similar to LR18(TC). This cultivar showed LIT with two cultures to which gene *Lr*18 confers LIT. Additional genes not in the study are indicated by LIT of Kalyansona to cultures 65359-01 and UN02-70-22. Red Egyptian is in the pedigree of this cultivar and may have contributed gene *Lr*18 (6).

Cultivars NP4 and Morocco gave high infection type with all the cultures used and did not match with any of the isogenic LR lines used in this study. Cultivar NP4 matched with Morocco, a check and universal suscept, and hence could be considered for the time

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TABLE 1. Infection types produced on different groups of wheat cultivars and leaf rust resistant (LR) lines inoculated with 14 cultures of *Puccinia recondita* f. sp. *tritici*

(no.) Cultivar or LR line	Leaf rust cultures[a] 0578-2	0641-2	0709-1	0817-2	0953-Bulk	0967-1	65284-1	65359-01	66-763	6B-NA65-9	UN01-68A	UN02-66A	UN2-70-22	UN09-66A	Low infection types
Group 1															
Pusa Lerma	01C[b]	23X	23N	13C	88P	88P	99P	23C	88P	88P	14C	14C	13C	88P	8[c]
Sharbati Sonora	01C	99P	14C	01C	88P	56X	99P	79P	88P	88P	01C	02C	03C	23C	7
Shera	02C	99P	02C	01C	88P	56X	99P	88P	88P	99P	01C	01C	02C	23C	7
UP301	01C	99P	01C	01C	88P	88P	99P	99P	56P	88P	01C	01C	00–	88P	6
LR1 (TC)	00–	99P	01C	01C	88P	99P	78P	88P	88P	99P	01C	02C	01C	99P	6
Group 2															
Safed Lerma	23X	78X	01C	03C	88P	88P	67X	13C	23C	88P	01C	03C	13C	88P	8
LR1 (TC)	00–	99P	01C	01C	88P	99P	78P	88P	88P	99P	01C	01C	01C	99P	6
LR17 (TC)	67P	99P	23C	03C	78P	88P	78P	03C	13C	88P	04C	03C	13C	88P	7
Group 3															
Hy. 65	03X	99P	88P	14C	23X	23C	24C	88P	23C	88P	56P	88P	88P	03C	7
LR10 (TC)	03C	99P	99P	03C	99P	99P	13C	99P	13C	99P	88P	88P	88P	03C	[illegible]
Group 4															
Kalyansona	34C	99P	88P	88P	88P	88P	78P	34C	88P	88P	23C	88P	02C	88P	4
LR18 (TC)	45C	99P	78P	88P	78P	99P	78P	88P	88P	78P	03C	78P	66P	88P	2
Group 5															
NP4	88P	99P	88P	88P	88P	88P	88P	88P	88P	88P	88P	88P	88P	88P	0
Morocco	99P	99P	99P	99P	99P	99P	99P	99P	99P	99P	99P	99P	99P	99P	0
LR2A (TC)	01C	15N	04C	02C	23C	99P	23C	01C	88P	23C	01C	02C	01C	99P	11
LR2D (PL)	02C	89P	24N	03C	88P	99P	24P	03C	88P	99P	03C	04C	03C	99P	8
LR3 (TC)	88P	03C	99P	88P	03C	03C	89P	88P	88P	88P	03C	88P	88P	03C	5
LR9 (TC)	00–	00–	01C	01C	01C	04C	01C	01C	00–	01C	01C	01C	01C	01C	14
LR11 (WI)	46X	56X	24X	78P	34C	56P	56P	23X	34X	99P	23X	67P	56X	56P	6
LR16 (TC)	46C	37N	99P	24N	25N	14N	34N	88P	24C	55N	24C	25N	24C	34N	12
LR19 (TC)	01C	02C	02C	01C	02C	02C	01C	01C	00–	01C	01C	02C	00–	02C	14

[a] North American uredial cultures of known pathogenic specificity furnished by L. E. Browder, Kansas State University, Manhattan.

[b] Infection type coding: first integer indicates relative amounts of sporulation, 0 = no sporulation to 9 = maximum sporulation; second integer indicates coded lesion size, 0 = no visible lesion to 9 = largest lesion; and the third descriptive code: C = chlorosis; N = necrosis; P = pale green; X = classic X type and – indicates no signs or symptoms. Infection types were recorded as proposed by Browder (3) and Browder and Young (5).

[c] Number of cultures inducing low infection type. Cultivars with infection type values of 55 or less were considered to be low infection types.

being as another universally susceptible cultivar. This cultivar can be used as a background for developing isogenic LR lines for India.

The pedigrees of cultivars help to a certain extent to confirm hypothetically identified genotypes, but we cannot expect that all the parental genes are transferred into the cultivar in question. Determination of the reactions of the immediate parents of the cultivars being tested would add to an understanding of the genetics of these cultivars.

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