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# Chromosomal location of a gene suppressing powdery mildew resistance genes *Pm8* and *Pm17* in common wheat (*Triticum aestivum* L. em. Thell.)

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**Abstract** The chromosomal location of a suppressor for the powdery mildew resistance genes *Pm8* and *Pm17* was determined by a monosomic set of the wheat cultivar Caribo. This cultivar carries a suppressor gene inhibiting the expression of *Pm8* in cv Disponent and of *Pm17* in line Helami-105. In disease resistance assessments, monosomic $F_1$ hybrids (2n = 41) of Caribo × Disponent and Caribo × Helami-105 lacking chromosome 7D were resistant, whereas monosomic $F_1$ hybrids involving the other 20 chromosomes, as well as disomic $F_1$ hybrids (2n = 42) of all cross combinations, were susceptible revealing that the suppressor gene for *Pm8* and *Pm17* is localized on chromosome 7D. It is suggested that genotypes without the suppressor gene be used for the exploitation of genes *Pm8* and *Pm17* in enhancing powdery mildew resistance in common wheat.

**Key words** Suppressor gene · Powdery mildew resistance · Gene location · *Triticum aestivum* · *Secale cereale* · Monosomic analysis

## Introduction

The superior performance of *Triticum aestivum* cultivars with the T1BL·1RS wheat-rye translocation had been attributed to disease resistance and other desirable agronomic characteristics (Moreno-Sevilla et al. 1995). The powdery mildew resistance gene *Pm8* located on the rye segment 1RS of the T1BL·1RS translocation was introduced into common wheat through hybridization with *Secale cereale* cv Petkus, and was developed independently in Weihenstephan and Salzmünde, Germany (Zeller 1973). Another wheat-rye translocation, T1AL·1RS, present in the wheat cultivar Amigo (Zeller and Fuchs 1983), also conferred resistance to powdery mildew (Zeller and Hsam 1983). The resistance gene in Amigo was derived from the rye cultivar Insave (Sebesta and Wood 1978) and has been designated *Pm17*.

Not all cultivars possessing the rye chromosome arm 1RS are resistant to races of the powdery mildew pathogen *Erysiphe graminis tritici* avirulent to *Pm8* (Friebe et al. 1989; Jönsson 1991; Hanušová 1992; Lutz et al. 1992, 1995). To explain the non-expression of *Pm8* resistance it was suggested that either *Pm8* was not located on the 1RS chromosome arm, that the 1RS arm had been mutated, or that there was genetic suppression of *Pm8* (Friebe et al. 1989; Hanušová 1992).

Recently Hanušová et al. (1996) showed that a dominant suppressor for *Pm8* was operating in wheat cultivars possessing T1BL·1RS, but not expressing *Pm8* resistance. Inhibition of *Pm17* expression was not studied. The objective of the present work was to assign the suppressor of resistance genes *Pm8* and *Pm17*, respectively, to a specific chromosome by monosomic analysis.

## Materials and Methods

The wheat cultivar Disponent carries the powdery mildew resistance gene *Pm8* on its T1BL·1RS wheat-rye translocated chromosome pair. Helami-105 is a derivative from a hybrid between cvs Amigo (T1AL·1RS) and Helios (T1BL·1RS). The gene *Pm17* on T1AL·1RS in Amigo was transferred to the T1BL·1RS translocation of line Helami-105 (Hsam et al. 1995). Resistance genes *Pm8* and *Pm17* on the T1BL·1RS chromosome are allelic (unpublished results). From preliminary crosses with *Pm8*-resistant cultivars, Caribo turned out to possess a suppressor for *Pm8* resistance. Hence the 21 Caribo monosomic lines (Chae et al. 1979) with the suppressor gene were used as female parents in crosses with Disponent and Helami-105 possessing the resistance genes *Pm8* and *Pm17*, respectively. The disomic and monosomic $F_1$ plants, verified by chromosome counts using the Feulgen method, were tested for resistance genes *Pm8* or *Pm17*. Four to thirteen monosomic $F_1$ plants were analyzed for each cross combination.

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**Table 1** Genetic analysis of the gene in cultivar Caribo suppressing powdery mildew resistance genes *Pm8* in cultivar Disponent and *Pm17* in the line Helami-105

| Hybrids | Generation | No. of plants | Isolate no. | No. of Plants | | $\chi^2_{3:13}$ |
|---|---|---|---|---|---|---|
| | | | | Res. | Susc. | |
| Caribo × Disponent (*Pm8*) | $F_1$ | 6 | 2 | 0 | 6 | |
| | | | 9 | 0 | 6 | |
| | $F_2$ | 132 | 2 | 17 | 115 | 2.64 |
| | | | 9 | 16 | 116 | 3.38 |
| Caribo × Helami-105 (*Pm17*) | $F_1$ | 8 | 13 | 0 | 8 | |
| | | | 16 | 0 | 8 | |
| | $F_2$ | 95 | 13 | 21 | 74 | 0.50 |
| | | | 16 | 20 | 75 | 0.20 |

Mildew resistance tests were carried out on segments of primary leaves cultured in Petri dishes on 6g/l of agar and 35 mg/l of benzimidazole. The methods for inoculation of the leaf segments and for disease assessment were as described by Lutz et al. (1995). *Erysiphe graminis tritici* (*Egt*) isolates Nos. 2 and 9 avirulent to *Pm8*, and isolates Nos. 13 and 16 avirulent to *Pm17*, were used to test mildew resistance.

## Results

### Inheritance of the suppressor gene for *Pm8* and *Pm17*

Six $F_1$ plants between cv Caribo, possessing a suppressor gene for *Pm8*, and cv Disponent (*Pm8* ) were all susceptible when tested against *Egt* isolates Nos. 2 and 9 (Table 1). The $F_2$ generation did not differ significantly from the expected ratio of 3 resistance to 13 susceptible plants. The resistance gene *Pm8* was not expressed in the presence of the suppressor gene in the $F_1$ generation. However, 3/16 of the plants in the $F_2$ generation possessed the *Pm8* gene in the absence of the dominant suppressor and were resistant, whereas 13/16 of the plants either carried *Pm8* in combination with the suppressor or were homozygous recessive for both *Pm8* and the suppressor gene, and were susceptible. Similarly, eight $F_1$ hybrids from the cross of Caribo and Helami-105 (*Pm17*) tested against *Egt* isolates Nos. 13 and 16 were all susceptible. The $F_2$ generation segregated in a ratio of 3:13 (resistant:susceptible), indicating that the suppressor gene in Caribo also inhibits the expression of *Pm17* (Table 1).

### Chromosomal location of the suppressor gene

$F_1$ hybrid plants from crosses of the 21 Caribo monosomic lines with Disponent and Helami-105 were inoculated with either *Egt* isolate No. 9 (avirulent to *Pm8*) or isolate No. 13 (avirulent to *Pm17*). Disomic $F_1$ hybrid plants ($2n = 42$) from the 21 cross combinations inoculated with the respective *Egt* isolates were all susceptible. Similarly, the monosomic $F_1$ hybrid plants ($2n = 41$) from 20 cross combinations showed a susceptible response to avirulent isolates. However, the monosomic $F_1$ hybrids involving Caribo monosomic 7D with either cv Disponent (eight plants) or Helami-105 (eight plants) were resistant.

## Discussion

The mode of inheritance of the $F_1$ and $F_2$ plants from the cross between Caribo and Disponent, and between Caribo and Helami-105, clearly showed that Caribo carries the dominant gene suppressing the expression of *Pm8* and *Pm17* powdery mildew resistance genes (Table 1). Hanušová et al. (1996) have reported that 16 wheat cultivars carrying the wheat-rye translocation T1BL·1RS did not express *Pm8* powdery mildew resistance. Among these cultivars, Florida, Ikarus and Sabina have the common ancestor Caribo, which does not possess the T1BL·1RS translocation, in their pedigress.

The disease response of the monosomic $F_1$ plants between Caribo monosomics and Disponent and Helami-105, respectively, indicated that Caribo carries the dominant suppressor gene located on wheat chromosome 7D. In monosomic $F_1$ plants resulting from crosses of Caribo mono 7D × Disponent and Caribo mono 7D × Helami-105, the Caribo chromosome 7D is missing. In the absence of this chromosome carrying the suppressor gene all monosomic $F_1$ plants expressed the respective resistances.

In common wheat, expression of resistance to fungus diseases is often reduced when genes are transferred from related species, particularly from a lower level to a higher level of ploidy. This phenomenon has been observed for various foliar diseases (Kerber and Dyck 1969; Lutz et al. 1994). In addition, complete suppression of resistance genes for leaf rust, stem rust and stripe rust transferred from alien species to common wheat has also been reported (Kerber and Green 1980; Bai and Knott 1992; Kema et al. 1995).

Kerber and Green (1980) found that the long arm of chromosome 7D in the wheat cultivar Canthatch possesses a suppressor gene of stem rust resistance. It would be interesting to know whether the suppressor gene in Caribo also inhibits the expression of stem rust resistance. Recently, the stem rust suppressor gene on 7D was mutated, by using ethyl methane sulphonate, into a

non-suppressor allele which permits the expression of resistance (Kerber and Aung 1995). The resistance of wheat cultivars carrying *Pm8* has been overcome in Europe (Lutz et al. 1992). However, the resistance gene *Pm17* is very effective against various *E. graminis tritici* races (Hsam et al. 1995). Thus genotypes without the suppressor gene are needed for the exploitation of *Pm17* in common wheat breeding.

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