

Mode of inheritance and allelic relationships of gene(s) governing resistance to gall midge (*Orseolia oryzae* Wood Mason) in some rice cultivars

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ABSTRACT

Mode of inheritance and allelic relationships of genes conferring resistance to gall midge (*Orseolia oryzae* Wood Mason) were investigated in four rice (*Oryza sativa* L.) genotypes viz. ARC 5984, ARC 6619, RP 2068-16-4-5 and R-296-421-2. Inheritance studies revealed presence of a single dominant gene for resistance in ARC 6619 and R-296-421-2, whereas resistance to gall midge was found to be governed by a single recessive gene in ARC 5984. Two independent dominant genes for resistance were observed in RP 2068-16-4-5. Susceptible parent R-2270 was found to possess a single dominant gene for resistance along with an inhibitory gene, which inhibits manifestation of resistance. Allelic tests also confirmed the presence of a recessive gene for resistance to gall midge in ARC 5984. This recessive gene was non-allelic to Gm-1 (Samridhi) and Gm-2 (Surekha). ARC 6619 was found to possess the same gene for resistance as present in Surekha (Gm-2). Out of the two independent dominant genes conferring resistance in RP-2068-16-4-5, one was found to be allelic to Gm-1 (Samridhi). The single dominant gene present in R-296-421-2 was non-allelic to Gm-1 and Gm-2.

Key words: Gall midge, inheritance, *Orseolia oryzae*, *Oryza sativa*, resistance, rice.

INTRODUCTION

Rice is the host of 60 disease organisms and 100 species of insects. Gall midge (*Orseolia oryzae* Wood Mason) is one of the most destructive pests of rice in South and South-East Asian countries including China, Japan, Sri Lanka, Burma, Indonesia and India (Hidaka *et al.* 1974). Globally, the losses caused by this insect have been estimated to exceed US \$ 550 million annually (Herdt 1991).

Gall midge is an endoparasite and its chemical control is not very successful. Therefore, more attention to developing resistant varieties has been suggested (Heinrich and Pathak 1981). Information on the nature of genetic control of the trait is an important prerequisite for using a new donor in any breeding programme.

Biotype variability of gall midge appears to be the major factor for the variable reaction of resistant donors. Evidence for biotype variability was presented by Shastry *et al.* (1972). Presence of at least four biotypes in India and China is now beyond doubt (Kalode and Bentur 1988; Yujian *et al.* 1993).

Thus, identification of more than one source of resistance is necessary, considering different biotypes. Accordingly, Chaudhary *et al.* (1985) reported two non-allelic dominant genes Gm-1 and Gm-2, present in Eswarakora and Siam-29 derivatives, respectively. Further, a new dominant gene for resistance was identified by Shrivastava *et al.* (1993) in variety Abhaya. The present investigation was undertaken with the objective of understanding inheritance of gall midge resistance and allelic relationships of gene (s) governing resistance to gall midge in some newly identified donors.

MATERIALS AND METHODS

The experimental material comprised of four resistant donors viz. ARC-5984, ARC 6619, RP 2068-16-4-5 and R-296-421-2, their F₁, F₂ and F₃ populations of crosses made between resistant donors (whose sources of resistance were unknown) with known resistant parents and resistant donors with susceptible parents. The known resistant donors were Samridhi (Gm-1) and Surekha (Gm-2), derivatives of Eswarakora and Siam-29 respectively.

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Susceptible parents used in the investigation were R-2270 and T(N)-1. Crosses were made and F₁, F₂ and F₃ populations generated were tested along with the parents for gall midge reaction. Field experiments were conducted at the Research Farm, Raipur, India where gall midge is known to occur in a severe form year after year and thus considered as a "hot spot" for this pest. In the field, each F₁ population was planted as a single row bordered by a susceptible purple dwarf check R-2270 on both sides. The distance was 30 cm between rows and 25 cm between plants.

The F₂ population was grown family-wise (as produce of single F₁ plant) in rows spaced 20 cm apart. After every two rows a row of susceptible check was grown. The plant to plant distance was maintained at 15 cm.

The F₃ population was grown on raised beds of 4 m width. The seeds of each F₂ plant were drilled in one row and later thinned to 150 to 250 plants per row. The row to row distance was maintained at 25 cm. The observations were made on a row basis classifying each as either breeding true for resistance (R) or susceptible (S) and segregating (Sg). The presence of a single silver shoot per plant was taken as a criterion of susceptibility (Shastry *et al.* 1972).

The sowing of experimental material was adjusted (last week of August) to coincide the maximum tillering stage of crop with peak insect infestation period. Observations were recorded in the second week of November. Fields were fertilized at the rate of 150 Kg N, 80 Kg P₂O₅ and 50 kg K₂O per hectare. The X² test was applied to test the goodness of fit of genetic ratios.

RESULTS AND DISCUSSION

Both R-2270 and T(N)-1, which were used as susceptible parents recorded 100 percent infestation by gall midge, whereas the resistant parents were free from attack (Table 1).

Table 1. Reaction of parental genotypes to gall midge under natural conditions (Results based on two year testing)

Parents	Parentage	No. of Plants			% Sus.	Reaction*
		Total	R	S		
ARC 5984	N/A	10	10	0	0	R
ARC 6619	N/A	10	10	0	0	R
RP 2068-16-4-5	IET 5656/ Vellutha-Cheera	10	10	0	0	R
R-296-421-2	CR-157-392/ OR-57-21	10	10	0	0	R
Surekha	IR 8/Siam 29	10	10	0	0	R
Samridhi	IR-22/W 1263	10	10	0	0	R
T(N)-1	Deo-geo-woo- gen/Tsai-yuvan -Chung	10	0	10	100	S
R-2270	B 11/2/T(N)-1	10	0	10	100	S

a: R - Resistant; S - Susceptible; N/A - Not available

The F₁ of cross ARC 5984/T(N)-1 exhibited a susceptible reaction indicating presence of a recessive gene for resistance in ARC 5984. The F₂ generation showed segregation in 1R : 3S ratio (Table 2), confirming the presence of a single recessive gene in this parent. Sahu *et al.* (1990) also reported the presence of a single recessive gene in this donor.

The F₁s involving cross combination ARC 6619/T(N)-1 and RP 2068-16-4-5/T(N)-1 were found resistant, indicating involvement of dominant genes for resistance in donors ARC 6619 and RP 2068-16-4-5. The 3R : 1S ratio of F₂ population of cross ARC 6619/T(N)-1 suggested that the resistance to gall midge in ARC-6619 is controlled by a single dominant gene. Resistance to gall midge governed by a single dominant gene was also reported by Chaudhary *et al.* (1985), Sahu *et al.* (1990) and Shrivastava *et al.* (1993). The 15R : 1S F₂ segregation of cross RP-2068-16-4-5/T(N)-1 clearly indicated that resistance in donor RP 2068-16-4-5 was under the control of two independent dominant genes.

Cross R-296-421-2/R-2270 gave 51R : 13S ratio in F₂ generation (Table 2). This indicated involvement of 3 pairs of genes for resistance; i.e. two independent dominant genes, one in each of the parents (resistant parent and susceptible parent) and one dominant inhibitory gene in susceptible parent R-2270 which inhibits the expression of the resistant gene present in R-2270, resulting in a susceptible reaction. Presence of such inhibitory gene action in susceptible varieties was also reported by Chaudhary (1988).

Allelic relationships of ARC 5984 were studied in relation to Gm-1 (Samridhi- a derivative of Eswara Kora) and Gm-2 (Surekha- a derivative of Siam-29) genes (Table 3). The F₂ segregation was observed to be in 13R : 3S ratio in both cases, indicating that resistance to gall midge is governed by one dominant resistant gene (either Gm-1 or Gm-2) and one recessive gene of ARC 5984. The F₃ progenies (7R : 8Sg : 1S) also confirmed the F₂ findings. It is also in conformity with the results of cross of ARC 5984 with susceptible parent T(N)-1 (Table 2). Thus it may be concluded that resistance carried by ARC 5984 is due to a recessive gene, which is non-allelic to Gm-1 and Gm-2.

The F₂ reaction of ARC 6619 with Samridhi (Gm-1) gave 15R : 1S ratio, indicating involvement of two independent non-allelic genes for resistance in these two parents. F₂ population of ARC 6619/Surekha did not show any segregation for reaction to gall midge. This again confirmed that resistance in ARC 6619 is governed by a single

Table 2. Reaction of F₁, F₂ and F₃ populations of crosses involving resistant donors and susceptible parents.

Cross	F ₁ Reaction ^a	Year	F ₂ Plants (Numbers) R : S	Ratio R : S	χ ² value	P value	F ₃ Progenies ^a (Numbers) R : Sg : S	Ratio	χ ² value	P value
ARC 5984/T(N)-1	S	1988	228 639	1 : 3	0.788	0.70-0.50	10 : 18 : 9	1:2:1	0.313	0.70-0.60
ARC 6619/T(N)-1	R	1988	62 18	3 : 1	0.304	0.70-0.60				
RP 2068-16-4-5/T(N)-1	R	1988	181 9	15 : 1	1.487	0.30-0.20				
R-296-421-2/R-2270	R	1986 1988	423 115 234 48	51 : 13 51 : 13	0.375 1.1886	0.70-0.60 0.50-0.30				

^a: R - Resistant; S - Susceptible; N/A - Not available

Table 3. Reaction of F₁, F₂ and F₃ progenies of crosses involving resistant donors and known resistant parents.

Cross	F ₁ Reaction ^a	Year	F ₂ Plants (Numbers) R : S	Ratio R : S	χ ² value	P value	F ₃ Progenies ^a (Numbers) R : Sg : S	Ratio	χ ² value	P value
ARC 5984/Samridhi	R	1986	250 71	13 : 3	2.391	0.30-0.20	9 : 19 : 2	7:8:1	2.973	0.10-0.05
ARC 5984/Surekha	R	1986	327 67	13 : 3	0.841	0.70-0.50				
ARC 5984/Surekha	R	1988	655 160	13 : 3	0.461	0.55-0.45				
ARC 6619/Samridhi	R	1986	322 23	15 : 1	0.293	0.70-0.60				
ARC 6619/Samridhi	R	1988	862 64	15 : 1	2.698	0.10-0.05				
ARC 6619/Surekha	R	1986	232							
ARC 6619/Surekha	R	1988	119				119			
RP 2068-16-4-5/Samridhi	R	1988	168				9			
R-296-421-2/Samridhi	R	1986	310 12	15 : 1	3.498	0.10-0.05	12 : 19 : 2	7:8:1	0.8168	0.30-0.20
R-296-421-2/Samridhi	R	1988	312 24	15 : 1	0.457	0.50-0.30				
R-296-421-2/Surekha	R	1986	317 24	15 : 1	1.035	0.30-0.20				
R-296-421-2/Surekha	R	1988	123 16	15 : 1	0.381	0.70-0.60				

^a: R - Resistant; S - Susceptible; Sg - Segregation

dominant gene and it is allelic to gene carried by Surekha (Gm-2). The F₃ progenies of ARC 6619 with Surekha confirmed the findings of F₂ progenies (Table 3).

The 15R : 1S segregation pattern was observed with donor R-296-421-2/Samridhi and R-296-421-2/Surekha. This indicated involvement of two independent genes for resistance, one each coming from donor and known resistant parent. Therefore, the resistance gene of R-296-421-2 was found to be non-allelic to Gm-1 and Gm-2 gene.

CONCLUSIONS

The present studies have resulted in the identification of a new gene in rice for resistance to rice gall midge. A new dominant gene non allelic to Gm-1 and Gm-2 appears to be present in R 296-421-2, which needs conformation by a study of F₃ progenies. Similarly, RP 2068-16-4-5 has two independent dominant genes for resistance to gall midge of which one is a known gene (Gm-1). The allelic relationship of the other gene is to be ascertained. The dominant resistant gene of ARC 6619 is allelic to the gene carried by Surekha (Gm-2).

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