Tropical Agricultural Research and Extension. 2 (1): 13-16, 1999

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

R. Mishra[1], A.K. Sarawgi*[2], M.N. Shrivastiva[2] and N.K. Rastogi[2]

[1]Department of Plant Breeding and Genetics, Jawaharlal Nehru Agricultural University, Jabalpur (M. P.) 482 004, India.
[2]Department of Plant Breeding and Genetics, Indira Gandhi Agricultural University, Raipur (M. P.) 492 012, India.

Accepted 01 December 1998

ABSTRACT

Mode of inheritance and allelic relationships of genes conforming 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 posses 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; Yujuan *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 F_1, F_2 and F_3 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.

* Corresponding author

Susceptible parents used in the investigation were R-2270 and T(N)-1. Crosses were made and F_1, F_2 and F_3 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 F_1 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 F_2 population was grown family-wise (as produce of single F_1 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 F_3 population was grown on raised beds of 4 m width. The seeds of each F_2 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 P_2O_5 and 50 kg K_2O per hectare. The X^2 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			%	Reaction[a]
		Total	R	S	Sus.	
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 F_1 of cross ARC 5984/T(N)-1 exhibited a susceptible reaction indicating presence of a recessive gene for resistance in ARC 5984. The F_2 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 F_1s 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 F_2 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 F_2 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 F_2 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 F_2 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 F_3 progenies (7R : 8Sg : 1S) also confirmed the F_2 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 F_2 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. F_2 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 F_1, F_2 and F_3 populations of crosses involving resistant donors and susceptible parents.

Cross	F_1 Reaction*	Year	F_2 Plants (Numbers) R	S	Ratio R : S	χ^2 value	P value	F_3 Progenies* (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	423	115	51 : 13	0.375	0.70-0.60				
		1988	234	48	51 : 13	1.1886	0.50-0.30				

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

Table 3. Reaction of F_1, F_2 and F_3 progenies of crosses involving resistant donors and known resistant parents.

Cross	F_1 Reaction*	Year	F_2 Plants (Numbers) R	S	Ratio R : S	χ^2 value	P value	F_3 Progenies* (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				

*: R - Resistant; S - Susceptible; Sg - Segregation

dominant gene and it is allelic to gene carried by Surekha (Gm-2). The F_3 progenies of ARC 6619 with Surekha confirmed the findings of F_2 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 F_3 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).

REFERENCES

Chaudhary BP 1988 Inheritance and allelic relationships of genes governing resistance to the gall midge (*Orseolia oryzae*, Wood Mason) in some rice cultivars. Ph.D. thesis, Department of Plant Breeding and Genetics, College of Agriculture, Raipur (M.P.), India.

Chaudhary BP, Shrivastava PS, Shrivastava MN and Khush GS 1985 Inheritance of resistance to gall midge in some cultivars of rice. In: Rice Genetics, IRRI, Philippines. pp. 523-527.

Heinrich EA and Pathak MD 1981 Resistance to gall midge *Orseolia oryzae* (Wood Mason) in rice. Insect Sci. Applications. 1: 123-132.

Herdt RW 1991 Research priorities for rice biotechnology. In: Rice Biotechnology (Eds. Khush GS and Toenniessen GH). CAB International, Walling ford, U.K. pp 19-54.

Hidaka T, Vungsilabutun P and Kadkao S 1974 Studies on ecology and control of rice gall midge in Thailand. TARC Tech. Bull. No. 6: 109-113.

Kalode MB and Bentur JS 1988 Characterization of Indian biotypes of rice gall midge (*Orseolia*

oryzae, Wood-Mason) (Diptera: Cecidomyiidae). Insect Sci. Applications. 10(2): 219-224.

Sahu VN, Mishra R, Chaudhary BP, Shrivastava PS and Shrivastava MN 1990 Inheritance of resistance to gall midge in rice. Rice Genet. Newsl. 7: 118-121.

Shastry SVS, Freeman WH, Sheshu DV, Israel P and Ray JK 1972 Host plant resistance to rice gall midge. pp. 353-365. In: Rice Breeding, IRRI, Los Banos, Philippines, 738 p.

Shrivastava MN, Kumar A, Shrivastava SK and Sahu RK 1993 A new gene for resistance to gall midge in rice variety Abhaya. Rice Genet. Newsl. 10: 79-80.

Yujuan T, Ying P and Yang Z 1993 Resistance to (Gm) *Orseolia oryzae* in Chinese rice varieties compared with varieties from other countries. Intl. Rice Res. Newsl. 18 (4): 13-14.