

EFFECT OF LEAF TRICHOMES TO THRIPS RESISTANCE IN RICE

K.S. WICKRAMASINGHE¹, L. NUGALIYADDE², P.K. SAMARAJEEWA³,

~~R.M.T. RAJAPAKSE~~³ and D. AHANGAMA⁴

¹Rice Research and Development Institute, Batalagoda, Ibbagamuwa

²Faculty of Agriculture, University of Ruhuna, Mapalana

³Plant Genetic Resources Centre, Gannoruwa

⁴Faculty of Agriculture, University of Peradeniya

ABSTRACT

Rice thrips, *Stencheatothrips biformis* (Bagnall) (Thysanoptera: Thripidae) is important as an economic insect pest in South Asian countries. In Sri Lanka it is considered as one of the major pests of rice. It damages late-planted crop within the first few weeks after transplanting or seeding, especially if the crop is water stressed. All improved varieties are susceptible to rice thrips infestation, but a number of traditional rice varieties possessing resistance to the pest have been identified. Studies were conducted with the objective of identifying the effect of leaf trichomes on thrips resistance. Leaf trichome density and thrips damage were estimated from 88 accessions of traditional varieties and 13 popular commercial varieties. F1 generation was also formed making single crosses between a Dahanala accession (resistant to thrips), Bg 300 (moderately susceptible) and Suduru Samba (highly susceptible). The trichome density and damage reactions were estimated in F1, F2, and F3 generations. Effect of abrasion of trichomes on thrips resistance was evaluated using traditional variety, Dahanala and improved variety, Bg 300. In order to estimate the most susceptible leaf for thrips damage, the thrips population in the first, second, third, fourth, fifth and sixth leaf of Bg 300 and Suduru Samba were counted separately in detached leaves. Results revealed that there is a significant positive relationship between leaf trichomes and thrips resistance. Identification of leaf characters which are related to thrips resistance is important to select plant materials for future breeding programs.

KEYWORDS: Leaf trichomes, Resistance, Rice thrips.

INTRODUCTION

Rice thrips, *Stencheatothrips biformis* (Thysanoptera: Thripidae) is important as an economic pest in Sri Lanka, India, Thailand, Pakistan, Taiwan, Indonesia, Malaysia, Japan, Philippines and Vietnam. In Sri Lanka it is considered as a major pest of rice affecting 10% of the rice area resulting in 1-2% loss to the annual production valued at Rs. 300-600 million. This is in addition to about Rs. 200 million worth insecticides used for the control of this pest.

The pest infests rice at seedling stage and causes extensive damage to the late planted crop, within the 1st few weeks after transplanting or seeding, especially if the crop is water stressed (Wickramasinghe, 1980). Infested leaves curl inward along the margins. Feeding causes scorching, stunting or death of seedlings and poor crop stand. Severe incidence of thrips damage have been observed specially in areas under rain fed and minor

irrigation schemes in the dry and intermediate zones covering two thirds of the rice lands in the country. Thrips feed on the mesophyll cells of the young leaves through adaxial surface (Lewis, 1973). Rice crops, specially short aged varieties planted late in the season are more prone to thrips infestation and to severe yield losses. At present, early detection of the damage and application of effective chemicals are recommended for the control of the pest (Kudagamage and Nugaliyadde, 1995). As chemical control is expensive and affects the environment, alternate methods that are economical, safer and sustainable are required. In this respect development and cultivation of thrips resistant varieties are considered the best approach for the control of the pest.

A number of traditional rice varieties possessing resistance to the pest have been already identified (Kudagamage, 1979 and Nugaliyadde and Heinrichs, 1984).

Leaf trichomes are epidermal appendages of diverse forms and structure, such as non-glandular and glandular hairs, scales or pelate hairs (Panda and Khush, 1995). According to our preliminary observations, rice leaf trichomes are related to thrips resistance because leaf trichome density of traditional varieties are higher than in improved varieties. Non glandular trichomes frequently impart general antixenosis from landing on the plant surface and prevents movement and feeding (Panda and Khush, 1995). In this regard, an experiment was conducted with the objective of identifying leaf characteristics particularly leaf trichomes, which are related to thrips resistance.

MATERIALS AND METHODS

The experiment was conducted at the Rice Research and Development Institute (RRDI), Batalagoda for 5 seasons from 2002/2003 *maha* to 2004/2005 *maha*.

Level of resistance in some traditional rice varieties to thrips

Eighty eight (88) accessions of Dahanala, Wannu Dahanala, Heenati, Kalu Heenati and Kalu Bala Wee, were collected from the gene banks at Plant Genetic Resources Center (PGRC), Gannoruwa and RRDI, Batalagoda. Planting was done late in the season to ensure heavy insect pressure. Each accession was planted in 3m long rows giving 15cm spacing among hills. The space between rows was kept at 20cm. Each accession was planted in three replicates in a RCB design. A highly susceptible variety, Suduru Samba was planted on either side of each accession as a check. The damage was evaluated according to Standard Evaluation System (SES) having a scale of 0-9 at 14-21 days after seeding are given in Table 1 (IRRI, 1985). This experiment was conducted in 2002/03 *yaha* and 2003 *yala*.

Table 1. Standard Evaluation System (SES 0-9 scale) for thrips damage in rice.

<i>Scale</i>	<i>Rating</i>	<i>Damage</i>
0	HR-Highly Resistant	None
1	R-Resistant	Leaves healthy except for slight rolling of the 1 st and 2 nd leaves
3	MR-Moderately resistant	Slight rolling and withering of the 1 st and 2 nd leaves
5	MR/MS-	1 st and 2 nd leaves withered and dead upper leaves slightly rolled
7	MS-Moderately susceptible	Upper leaves rolled, withered and wilted with few lesions, lower leaves dead
9	S-Highly susceptible	Upper leaves drying with pronounced white lesions, seedling stunted and lower leaves dead

Source: Standard Evaluation System for rice (IRRI, 1985).

Relationship between thrips resistance and trichome density of the adaxial leaf surface

Experiment 1: The trichome density was estimated under a magnification of X 30 on the upper half of the adaxial leaf surface of 3rd leaf of test rice accessions. Ten seedlings per accession and three readings per leaf were taken to estimate the mean number of trichomes per 1mm² for each accession. The trichome density and damage were estimated in 88 accessions of the traditional varieties and 13 popular commercial rice varieties.

Experiment 2: Single crosses between Dahanala and Suduru Samba or Bg 300 were made (Table 2). The F₁ populations of the above crosses were planted in the field at the rate of single plant per hill. F₁ seedlings were planted as described above. Field evaluation was done according to the SES (Table 1) and trichome density was counted on 10 seedlings from each F₁ population.

Table 2. Single crosses made to evaluate the relationship between thrips resistance and trichome density.

<i>Cross number</i>	<i>Female parent</i>	<i>Male parent</i>
1	Dahanala	Bg 300
2	Dahanala	Suduru Samba
3	Bg 300	Dahanala
4	Suduru Samba	Dahanala

The F₁ generation was harvested on single plant basis. The F₂ generations were established as families. Each family contained an average of 500 plants. Each plant was evaluated for thrips damage using 1-9 scale at 14 and 21 days after seeding. Plants showing different damage levels (1, 3, 5, 7, 9 on SES scale) were marked by tagging. Ten plants from each damage scale were taken for estimation of trichome density (10 seedlings per damage scale).

Effect of abrasion of trichomes on thrips resistance

The traditional variety, Dahanala and an improved variety Bg 300 were established in the fields. Highly susceptible variety Suduru Samba was planted on either side of each row. When the plants reached 1st, 2nd and 3rd leaf stages, the trichomes were removed from the adaxial leaf surface of 50% of plant population using a scotch tape. Using the SES 0-9 scale, thrips damage was estimated on both normal plants and plants from which the trichomes of the adaxial surface were removed.

Highly susceptible leaf stage for thrips damage

In order to estimate the most susceptible leaf for thrips damage, the thrips population in the first, second, third, fourth, fifth and sixth leaf of Bg 300 and Suduru Samba were counted separately in detached leaves. Bg 300 and Suduru Samba were planted separately in field plots (1m x 1m) with a spacing of 15cm x 15cm. Each plot had 6 rows of plants and each row had 6 plants. Each variety was planted alternately in 8 plots (4 plots per variety). Planting was done when the thrips population was severe in the field. In order to estimate the thrips population in the first, second, third, fourth and fifth leaves, the leaves were harvested following their emergence. The harvested leaves were kept in polythene bags and examined under microscope to determine the thrips populations.

RESULTS AND DISCUSSION

Level of resistance to thrips in some traditional rice varieties

Of the 88 accessions of Dahanala, Wannu Dahanala, Henati, Kalu Heenati and Kalu Bala Wee, 21 were found to be highly resistant to thrips (Table 3). Out of the 14 accessions of Dahanala, 8 accessions showed high level of resistance to thrips in both seasons. Four accessions gave a moderate level of resistance. However, these accessions had similar agromorphological features. Similarly, only 5 out of 36 accessions of Heenati were highly resistant to the pest. These observations indicated that there is a degree of variation of the level of thrips resistance among different accessions of the same variety. This could be of evolutionary significance of these varieties due to being exposed to thrips infestations over thousand of years (Day, 1974). Therefore, when selecting donor varieties for crop improvement programs, it is critical that the correct accession is selected. About 17 accessions of the above traditional varieties were found to be susceptible to thrips.

Table 3. Damage assessment of different traditional cultivars to thrips and number of their accessions grouped according to damage scale.

<i>Variety</i>	<i>Damage scale</i>				
	<i>1</i>	<i>1/3</i>	<i>3</i>	<i>5</i>	<i>7</i>
Dahanala	03	02	-	02	02
Wanni Dahanala	01	03	-	01	01
Heenati	05	13	03	11	04
Kalau Heenati	05	09	02	02	09
Kalu Bala Wee	02	02	01	-	01
Suduru Samba (Susceptible check)	-	-	-	-	01

Relationship between thrips resistance and trichome density of the adaxial leaf surface

Improved rice varieties

Of the 13 popular varieties tested Bg 357, Bg 359, Bg 379-2, Bg 94-1 and Bg 403 had no trichomes on the adaxial leaf surface. The trichome density of other varieties ranged from 20–31 trichomes/mm² (Table 4). All these varieties were found to be equally susceptible to thrips damage as the susceptible check variety, Suduru Samba.

Table 4. Trichome density and reaction to thrips damage of 13 commercial rice varieties grown in Sri Lanka (n=30).

<i>Variety</i>	<i>Average trichome density (No/mm²)</i>	<i>Reaction to thrips damage</i>
Bg 300	20.0	7
Bg 357	0	7
Bg 358	29.1	7
Bg 352	23.9	7
Bg 304	29.3	7
Bg 360	29.3	7
Bg 305	31.2	7
Bg 359	0	7
Bg 380	28.5	7
Bg 379-2	0	7
Bg 94-1	0	7
Bg 450	28.9	7
Bg 403	0	7
Dahanala (R check)	67.6	1
Suduru Samba (S check)	0	9

R= resistance and S= susceptible.

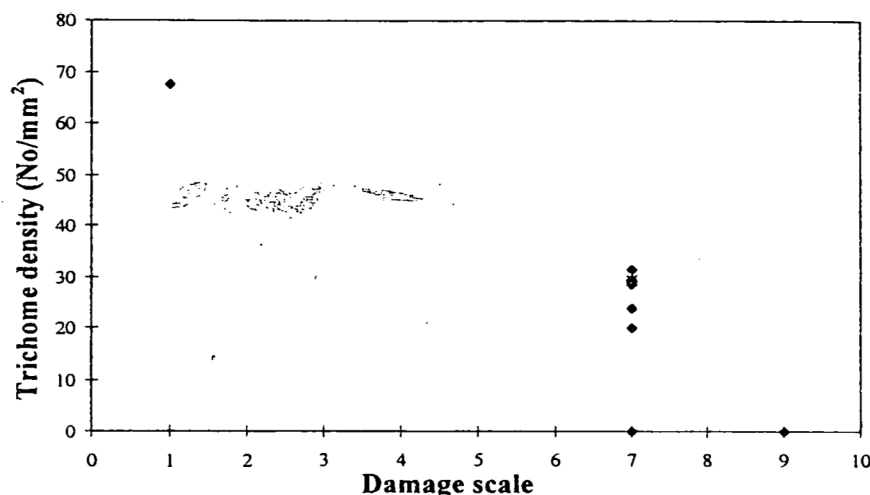


Figure 1. Relationship between trichome density and reaction to thrips damage of 13 commercial rice varieties grown in Sri Lanka (n=30).

Traditional varieties

The trichome density of the 88 accessions of Dahanala, Wannu Dahanala, Henati, Kalu Heenati and Kalu Bala Wee ranged from 3 to 118 (no./mm²). The highly resistant accessions had trichomes densities ranging from 20-112/mm² (Table 5). The trichome density of Dahanala (67/mm²) was significantly higher than those recorded for the commercial varieties. These observations indicated that there is a linear relationship between trichome density and thrips resistance. It suggested that the trichome density could be a quantitative character. Some accessions of moderately resistant traditional cultivars had trichome densities as low as 20 trichomes/mm² as observed on susceptible commercial varieties. However, no resistant varieties with glabrous leaf surface were observed in the experiment. This indicated that there could be other mechanisms involved in making some traditional cultivars resistant to thrips.

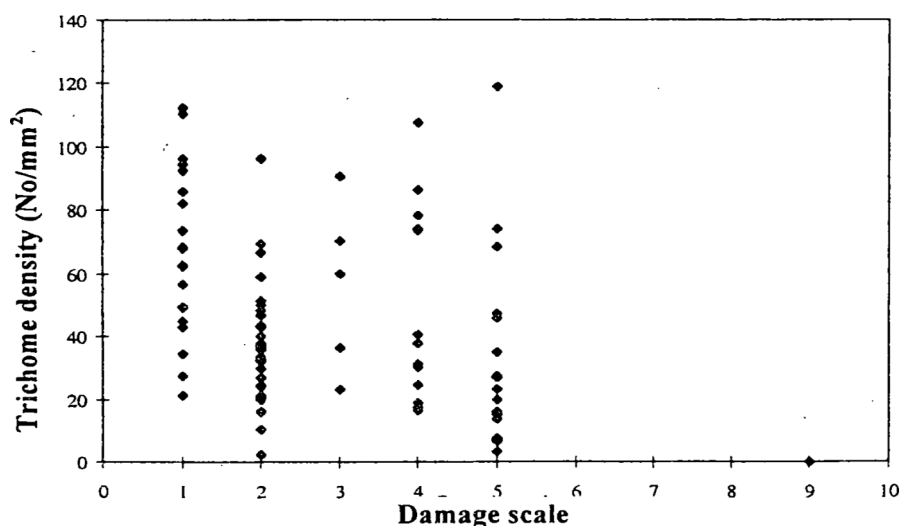


Figure 2. Relationship between trichome density and reaction to thrips damage of 88 traditional varieties with different levels of resistance to thrips (n=30).

Segregating populations

Based on the trichome density of F1 populations of the Dahanala/Bg 300 and Dahanala/Suduru Samba and their reciprocal populations it is clear that pubescence in rice is partly controlled by cytoplasmic genes. F1 generations with Dahanala as the female parent had significantly higher trichome density than the F1 obtained from respective reciprocal cross (Table 5).

Table 5. Trichome density of the adaxial surface of the third leaf of F1 generation, hybrid parents and their reaction to thrips (n=30).

<i>Variety/cross</i>	<i>Trichome density (No./mm²)</i>	<i>Reaction to thrips damage</i>
Dahanala/Bg 300	71.3 a	1/3
Bg 300/Dahanala	54.5 b	1/3
Dahanala/Suduru Samba	75.0 a	1/3
Suduru Samba/Dahanala	43.8 c	1/3
Dahanala	67.6 ab	1
Bg 300	24.4 d	5/7
Suduru Samba	0.0 e	9

Means followed by common letter in trichome density are not significant at 5% probability level by DMRT.

Furthermore, the trichome densities of the F2 populations of the above crosses clearly indicated that trichome density is directly related to thrips resistance. Highly resistant plants had significantly higher trichome densities than the moderately resistant and susceptible plants (Table 6).

Table 6. Trichome density of the adaxial surface of the third leaf of F2 generation seedlings (n=30).

<i>Cross</i>	<i>Grand mean of trichome density (mm²) grouped according to the damage scale of the F2 seedlings</i>				
	<i>1</i>	<i>3</i>	<i>5</i>	<i>7</i>	<i>7/9</i>
Dahanala/Bg 300	83.4 a	42.9 b	42.9 b	36.0 c	38.8 c
Dahanala/Suduru Samba	80.6 a	42.4 b	34.1 c	29.1 d	27.1 d

In a row, means followed by a common letter are not significantly different at 5% level by DMRT.

This is further evident by the fact that the resistant F3 plants derived from resistant F2 plants had more trichomes than resistant F3 plants originated from moderately resistant and susceptible F2 plants (Table 7 and 8).

Table 7. Trichome density of the adaxial surface of the third leaf of the seedlings of the F3 families of the crosses between Dahanala/Bg 300 (n=30).

Damage scale of F2 plants	Trichome density of F3 plants grouped according to damage scale (n=30)						Mean
	1	1/3	3	5	7	7/9	
1	101.1	86.9	50.5	50.7	36.9	41.5	61.3
1/3	-	64.7	43.1	46.3	34.9	38.7	45.5
3	70.2	59.5	45.6	43.9	40.3	31.3	48.5
5	53.8	51	37.4	32.8	27.7	31.6	39.1
7	-	40	35.5	39.9	36.5	34.6	37.3
7/9	-	50.2	34.6	31.7	32.6	30.6	35.9
Mean	75.0	58.7	41.1	40.9	34.8	34.7	

Table 8. Trichome density of the adaxial surface of the third leaf of the seedlings of the F3 families of the crosses between Dahanala/Suduru Samba (n=30).

Damage scale of F2 plants	Trichome density of F3 plants grouped according to damage scale						Mean
	1	1/3	3	5	7	7/9	
1	78.8	-	51.1	45.1	43.4	40.3	51.7
1/3	-	76	51.5	43.2	38.2	34.7	48.7
3	73.5	66.3	48.4	42.5	38.1	34.9	50.6
5	69.6	68.7	47.9	47.9	40.7	33.7	51.4
7	67.2	56.4	50.9	43.4	40.6	36.7	49.2
7/9	-	-	50.9	42.8	41.1	31.6	41.6
Mean	72.3	66.9	50.1	44.2	40.4	35.3	

Effect of abrasion of trichomes on resistance to thrips

Seedlings of Dahanala gave an average damage rating of 1/3 (highly resistant) as compared to those seedlings with the trichomes removed on the first leaf (SES 5 - moderately resistant), second leaf (SES 3 - resistant), and third leaf (SES 5 moderately resistant) (Table 9). Similarly seedlings of the variety Bg 300 gave a damage reaction of 5 (moderately resistant) and those with the trichomes removed on the first, second and third leaves showed damage reaction 9 (highly susceptible), 6 (moderately susceptible) and 7 (susceptible) respectively. These observations indicated that trichomes play a major role in the expression of thrips resistance in Dahanala. Since Dahanala seedlings did not show highly susceptible reaction, trichomes were removed as in the case of Bg 300, there are indications of other resistance mechanisms in addition to trichomes.

Table 9. Effect of abrasion of the adaxial leaf surface trichomes on the average thrips damage rated according to SES (n=10).

Variety	Damage reaction			
	Trichomes not removed	Trichomes removed		
		1 st leaf stage	2 nd leaf stage	3 rd leaf stage
Dahanala	1/3	5	3	5
Bg 300	5	9	5/7	7

Determine the highly susceptible leaf stage for thrips damage

The thrips population reached a maximum of 180 ± 20 thrips/leaf at the 4th leaf stage on both Bg 300 and Suduru Samba (Fig. 3). The number of thrips on the pro leaf was very low as compared to the first, 2nd and 3rd leaves. The thrips population gradually declined when the seedling grew older after reaching a maximum at the 4th leaf stage. This could be attributed to the gradual thickening of the leaf tissues once the seedlings grow older.

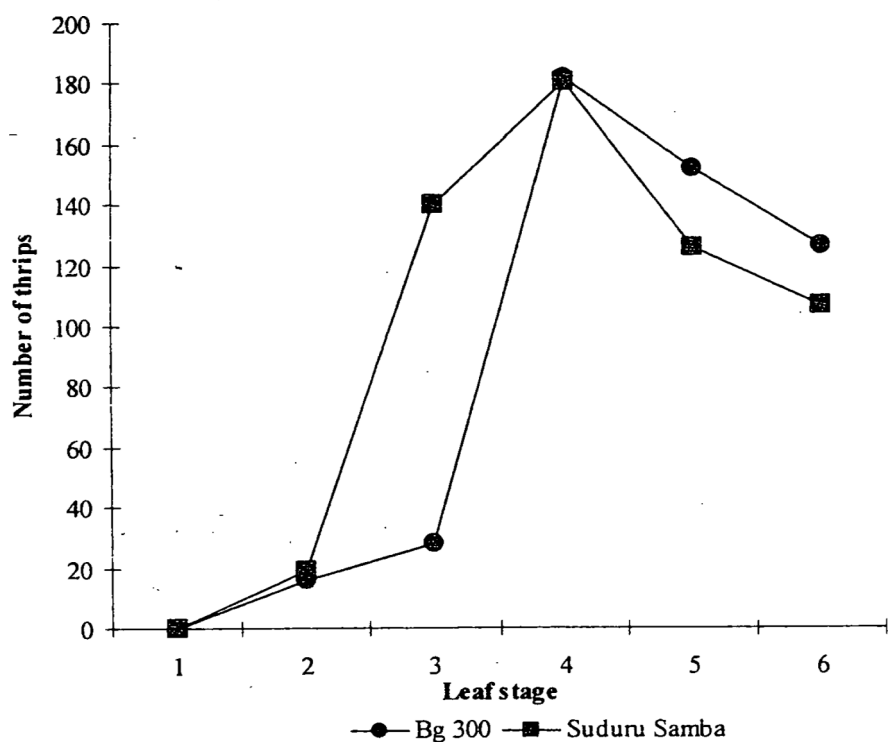


Figure 3. Number of thrips counted on different leaves of the variety Bg 300 and Suduru Samba.

Of the 88 accessions of Dahanala; Wannu Dahanala, Heenati, Kalu Heenati and Kalu Bala Wee, some were found to be highly resistant, some moderately resistant and some susceptible to rice thrips. There is a degree of variation of the level of thrips resistance among different accessions of the same variety. Therefore, when selecting donor varieties for crop improvement programs, it is critical that the correct accession be selected. All improved varieties were found to be equally susceptible to thrips damage like

the susceptible check variety, Suduru Samba. The trichome density of Dahanala was significantly higher than improved varieties. According to literature non glandular trichomes provide an effective barrier for small arthropods and prevent them landing on the leaf surface, prevent movement and feeding (Panda and Khush, 1995 and Lewis, 1997). The results showed that there is a significant positive relationship between trichome density and thrips resistance. Removal of trichomes on the adaxial surface of the leaf of Dahanala seedlings did not show a highly susceptible reaction. Therefore, the trichome density would not be the only character for thrips resistance. According to the results of the F1 generation the leaf trichomes in rice are partly controlled by cytoplasm genes and posse a direct relationship with thrips resistance. Thrips population reached maximum at 4th leaf stage and declined gradually when seedlings grew and plant matured.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the financial support given by the SL-USDA program under project ARS 2 to carry out the research.

REFERENCES

- Day, P.R. 1974. Genetics of host-parasite interaction. Freeman. San Francisco. 238pp.
- IRRI, 1985. Standard Evaluation System for rice, Manila, Phillipines.
- Kudagamage, C. 1979. Varietal resistance to the rice thrips *Baliothrips biformis*/Rice Res. Newsl. 2(5):11.
- Kudagamage, C. and L. Nugaliyadda. 1995. Present status and future direction of insect pest management in rice, Rice Congress, Department of Agriculture, Sri Lanka. 39-54.
- Lewis, T. 1973. Thrips: Their biology, ecology and economic importance. Academic press, London. 349pp.
- Lewis, T. 1997. Thrips as crop pests: Structure, growth and development. University press, London. 9-58.
- Nugaliyadde, L. and E.A. Heinrichs. 1984. Biology of rice thrips, *Stenchaetothrips biformis* (Bagnall) (Thysanoptera: Thripidae) and a greenhouse rearing technique. J. Econ. Entomol. 77: 1171-1175.
- Panda, N. and G.B. Kush. 1995. Host plant resistance to insects: Mechanisms of resistance, Biddles Ltd. UK. 596pp.
- Wickramasinghe, N. 1980. Fifteen years of progress in rice pest control. Rice Symposium, Department of Agriculture, Sri Lanka. 49-66.