Insects and Pathogens Associated with Rice Grain Discoloration and Their Relationship in the Philippines[1]

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李升燦・M.E. 알벤다. J.M. 본만・E.A. 하인리크 : 病害虫과 變色米 發生과의 關係에 관한 硏究

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ABSTRACT Species of pathogens and insects associated with grain discoloration in the Philippines were indentified. *Leptocorisa oratorius* was the most dominant insect species causing discoloration. Pathogenicity tests of fungal organisms isolated from discolored grains showed that *Drechslera oryzae, Curvularia lunata, Trichoconiella padwickii, Sarocladium oryzae, Alternaria tenuis,* and *Fusarium solani* were the common pathogens responsible for "dirty panicle" disease of rice. Discoloration incidence was higher on treatment when both pests were present than when they occurred singly. The discoloration severity was attributed to the pathogens whereas rice bug caused a high decrease in grain weight and unfilled grains. Rice bug feeding on grains enhances the infection caused by the pathogen. Due to this, the quantity and quality of grains produced were affected, resulting in yield reduction.

INTRODUCTION

Rice grain discoloration or "dirty panicle" disease is a very important disease occurring throughout rice growing areas. It is an indication of poor grain quality and reduces appeal to the consumers.

Discolored grains have been attributed to weather factors such as extreme temperatures, strong winds, high humidity and high rainfall, but biological agents like fungal pathogens and insects associated with grain discoloration are the most common (Yamaguchi 1983, Takedani and Yagi 1983). The problem of grain discoloration increased after the introduction of high yielding varieties (Raymundo and Fomba 1979). *Helminthosporium oryzae* B. de Haan which causes brown spot disease, and is associated with discolored grain, was considered a major contributor to the Bengal famine of 1942 (Ghose and Ghatge 1960). According to Bedi and Gill (1960), reductions in grain weight and quality have been associated with this pathogen. In India, Majumbar et al. (1976) reported rice seeds infected with *Helmintho sporium oryzae, Curvularia lunata* (Wakker) Boedijn, *Cochliobolus lunatus* Nelson & Haasis, *Alternaria tenuis* C.G. Nees and *Epicoccum* sp. Later in 1979, Raymundo and Fomba reported that discolored grains are associated with organisms like *Pyricularia oryzae* Cavara, *Trichoconiella padwickii* Ganguly and *H. Oryzae.* Ngala in 1983 reported that *Sarocladium attenuatum* Gams and Hawksworth as the most predominant pathogen causing grain discoloration in Nigeria. In Malaysia, Zainum et al. in 1977 recorded 33 fungal isolates causing grain discoloration of which *T. padwickii* was common. *H. oryzae, Rynchosporium oryzae* Hashioka & Yokogi and *Phyllosticta* sp. were the most common species of fungi identified causing grain discoloration in Colombia(Castaño 1983). In 1977 and 1978, IRRI (Annual Reports 1976 & 1977) found that the most predo-

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minant fungus occurring in both wet and dry season was *T. padwickii*. The principal causal organism of grain discoloration apparently varies from one area to another.

Insects also add to the problem of rice grain discoloration. Rice grain discoloration due especially to rice bug (*Leptocorisa* spp.) damage has become a problem in the southern Kyushu area of Japan (Nagai et al. 1971). Yield reduction due to rice bug ranges from 10 to 100 % (Biswas 1953, Tateishi 1939, Pruthi 1953, Israel and Rao 1961, Srivastava and Saxena 1960).

Mechanical damage and injury caused by insect feeding may facilitate infection of grain by various fungi. Nadi (1941) reported that rice in India was heavily attacked by *Cephalosporium oryzae* Corda in association with insect infestation. Agyen-Sampong et al. (1980) noted that the incidence of grain discoloration was higher with the occurrence of rice bugs.

This study aims to determine the species of pathogens and insects associated with grain discoloration and the existence of a relationship between the two pests in the Philippines.

MATERIALS AND METHODS

Identification of pests associated with grain discoloration

Insect pests associated with grain discoloration were collected from IRRI farm fields of rice varieties IR8, IR22, IR36 and IR56 having high incidence of grain disoloration in the 1983 dry and 1984 wet season. Twenty sweeps were made for each variety and the insect species collected were identified.

Discolored rice grains of IR8, IR36, IR54 and IR56 were also collected from IRRI farm fields in the 1983 wet and 1984 dry season. The blotter test was used to identify pathogens associated with grain discoloration. Two hundred discolored grains were used for each variety. The plates were incubated in 12-hr NUV and 12-hr darkness 21 C° for 8 days. The fungi growing on the seeds were identified and the percentage occurrence of each organism was tabulated. Percent discoloration of grains was recorded also. The fungi that were identified and used for pathogenicity tests.

Pathogenicity tests of organisms associated with grain discoloration

Panicles of IR22 and IR36 were inoculated at flowering by spraying with spore suspensions (50,000~80,000 spores/ml) of either *H. oryzae*, *C. lunata*, *T. Padwickii*, *D. oryzae*, *A. tenuis*, *Fusarium solani* or *Phoma* sp. Distilled water was sprayed on the check plants. After inoculation, the plants were covered with mylar film cages and were incubated at 25°C for 30 hr. Moisture was maintained by spraying the panicles with water twice a day for 3 days. The plants were placed on trays and after appearance of symptoms, the severity of discoloration was assessed. The inoculated fungi were reidentified by using the blotter method and the incidence of each organism was recorded.

Rice bug and pathogen relationship to grain discoloration

To determine the relationship between rice bugs and the fungal pathogen on grain discoloration, experiments using fixed and variable numbers of rice bugs were conducted.

In an experiment with different population densities, IR36 at the early milk stage was infested with 20, 14 and 8 fifth instar rice bugs per 10 panicles 2 days before inoculation with either *C. lunata* or *D. oryzae*. The panicles were covered with mylar film cages after spraying with 50,000~80,000 spores/ml and were incubated at 25°C for 30 hr. After inoculation, the plants were maintained in a glass-

Table 1. Average percentage of organisms associated with rice grain discoloration on IR8, IR36, IR54 and IR56 in wet (1983) and dry (1984) seasons.

Organism	Grains infected(%)[a]							
	Wet Season				Dry Season			
	IR8	IR36	IR54	IR56	IR8	IR36	IR54	IR56
Trichoconiella padwickii	15.0	26.0	40.0	17.8	5.5	7.5	40.5	13.0
Curvularia lunata	10.0	15.0	7.9	3.0	17.0	10.0	6.5	4.5
Drechslera oryzae	1.0	—	5.3	—	1.0	1.0	—	—
Fusarium spp.	11.2	17.8	5.6	36.4	40.0	35.5	17.5	14.0
Alternaria tenuis	1.0	—	—	0.5	—	0.5	—	1.5
Alternaria longissima	5.5	0.5	—	2.3	—	—	—	—
Phoma sp.	4.3	3.0	1.8	3.0	0.5	—	—	—
Sarocladium oryzae	4.5	—	0.5	0.8	—	2.0	9.5	4.5
Nigrospora sp.	—	—	0.5	0.7	0.5	0.5	2.5	0.5
Pithomyces	0.5	—	1.0	—	—	—	0.5	—
Gerlachia oryzae	1.0	—	1.0	—	—	—	—	—
Cladosporium sp.	0.5	—	0.8	0.5	—	0.5	9.0	2.0
Penicillium sp.	—	—	0.5	—	—	—	—	—
Aspergillus sp.	0.5	0.5	—	—	—	—	—	—
Nematode sp.	—	—	1.0	—	—	—	—	—

[a]Means of 8 replications with 200 seeds/variety.

house. The panicles were sprayed twice a day for 3 days.

In the experiment using a fixed number of rice bugs, 10 fifth instar rice bugs per 10 panicles were used. Two varieties, IR22 and IR36 were inoculated at early milk stage. IR22 was inoculated with *D. oryzae*, *C. lunata* and *Phoma* sp. whereas IR36 was inoculated with *D. oryzae*, *C. lunata* and *T. padwidckii*.

RESULTS AND DISCUSSION

The insect species associated with grain discoloration in IRRI farm fields were *Leptocorisa oratorius* Fabricius, *Menida varipennis* (Westwood), *Stollia ventralis* (Westwood), and *Nezara virudula* Linnaeus. *L. oratorius* was the most abundant pest species collected in the dry and wet seasons. Similar results were obtained by Gyawali(1981) showing that *L. oratorius* was the most predominant among the several species of rice bugs in the Philippines.

IR56 was most severely discolored by IR8, IR54 and IR36. The most common fungi found associated with discolored grains in both seasons were *T. padwickii*, *C. lunata*, *D. oryzae*, *Fusarium* spp., *Phoma* sp. and *S. oryzae* (Table 1). The same organisms associated with grain discoloration were isolated by Castaño in Colombia(1983). A survey at IRRI in 1976 and 1977 showed *T. Padwickii*, *Curvularia* spp. and *Fusarium* spp. on rice grains in both wet and dry seasons (Annual Report 1976 and 1977).

The results obtained in the pathogenicity experiments were similar to those of Castaño (1983). On IR22, the symptoms produced by *D. oryzae*, *S. oryzae*, *C. lunata* and *A. tenuis* were the most severe whereas on IR36, *D. oryzae* and *T. padwickii* were the most severe (Table 2). The most frequently isolated organisms from previously inoculated IR22 were *D. oryzae* followed by *A. tenuis*, *T. padwickii*, *F. solani* and *C. lunata* whereas on IR36 it was *C. lunata*, *D. oryzae*, *A. tenuis*, *F. solani* and *T. padwickii*. These results confirmed that these pathogens can cause grain discoloration. All the pathogens induced grain

Table 2. Degree of grain discoloration and percentage of organisms isolated from previously inoculated rice grains of IR22 and IR36.

Organism	Degree of discoloration[a]		Grains infected[b](%)	
	IR22	IR36	IR22	IR36
Drechslera oryzae	3.0a	3.0a	97.5	95.0
Curvularia lunata	2.5ab	2.8ab	24.7	96.0
Sarocladium oryzae	2.8a	2.8ab	1.5	7.5
Alternaria tenuis	2.3abc	2.0c	72.0	68.0
Trichoconiella padwickii	1.5cd	2.3bc	61.0	47.5
Fusarium solani	1.8bcd	1.8c	49.0	50.5
Phoma sp.	1.3d	1.0d	3.5	0.0
Control	0.3e	0.0e	0.0	0.0

[a]Severity of discoloration 0~3 : 0=not discolored; 1=slightly discolored; 2=moderately discolored; 3=severely discolored. Mean of 3 replications. Means followed by a common letter are not significantly different at the 5% level.

[b]Mean of 8 replications with 200 seeds each.

Table 3. Effect of rice bug densities an pathogen infection on the incidence of grain discoloration and unfilled grains of IR36[a].

Treatment	Discoloration incidence[b]	Unfilled grains (%)
Experiment 1		
20RB+*C. lunata*	8.5a	73.75a
14RB+*C. lunata*	6.5 b	72.50a
8RB+*C. lunata*	5.0 c	70.00a
20 rice bugs	4.5 c	74.75a
14rice bugs	3.0 de	75.00a
8 rice bugs	2.5 ef	55.00 b
C. lunata	4.0 cd	51.00 b
Control	1.5 f	18.50
Experiment 2		
20RB+*D. oryzae*	8.0a	50.12a
14RB+*D. oryzae*	7.0ab	37.90ab
8RB+*D. oryzae*	6.0 b	35.72ab
20 rice bugs	3.5 c	38.70ab
14 rice bugs	3.0 c	33.22ab
8 rice bugs	2.0 cd	31.67ab
D. oryzae	7.5ab	34.65ab
Control	0.5 d	24.00 b

[a]Mean of 4 replications. Means in a column followed by a common letter are not significantly different at the 5% level.

[b]Scoring scale: 0~9 where 0=no incidence; 1=less than 1% ; 3=1 to 5% ; 5=6 to 25% ; 7=26 to 50% ; 9=51 to 100%.

discoloration and the severity of symptoms depended on the pathogens used. *D. oryzae* produced the most severe symptoms among the pathogens tested.

In the test with different populations of rice bugs with *C. lunata*, the incidence of discoloration was significantly higher ($P>0.05$) in treatments where both the fungus and insect occurred together than when they occurred singly (Table 3). Although there were more discolored grains on panicles treated with *C. lunata*, there were generally less unfilled grains as compared with rice bug alone. With *D. oryzae*, similar results on grain discoloration were obtained, however, there was no significant difference ($P<0.05$) for unfilled grains between the fungus and rice bug alone (Table 3). This confirms the findings of Marchetti(1983) stating that *D. oryzae* has been associated with reduction on grain weight and yield of rice.

In the experiment with a fixed number of rice bugs combined with different pathogens, for IR22 the grain weight was lower in treatments where rice bugs were involved regardless of the presence or absence of the fungus, but on IR36, the effect of rice bug and the pathogen alone was not significantly different (Table 4). In the incidence of discoloration on IR22, similar results were obtained as in the experiment with different population densities of rice bugs. The discoloration incidence was higher when both pests were combined than when they occurred singly, but on IR36, there was no significant difference

Table 4. Effect of rice bug damage and pathogen infection on the 1000 grain weight, severity and incidence of grain discoloration and % unfilled grains on IR22 and IR36[a].

Treatment	1000 grain weight(g)		Discoloration severity[b]		Discoloration incidence		% unfilled grains	
	IR22	IR36	IR22	IR36	IR22	IR36	IR22	IR36
RB+*C. lunata*	13.05c	12.03bc	1.8b	2.0bc	2.5c	7.5ab	49.53a	52.55ab
RB+*D. oryzae*	13.10c	10.00c	3.0a	3.0a	9.0a	9.0a	43.68ab	60.70a
RB+*Phoma*	12.13c	—	1.0c	—	1.5cd	—	45.98ab	—
RB+*T. padwickii*	—	12.61b	—	1.2d	—	6.0b	—	47.37bc
Rice bugs	12.30c	13.57b	1.0c	2.2b	1.0de	4.5b	48.83a	51.07abc
C. lunata	18.23ab	13.55b	1.0c	1.5cd	1.5cd	5.5b	18.13c	29.84e
D. oryzae	16.45b	14.08b	3.0a	3.0a	7.5b	8.0a	20.38bc	41.05cd
Phoma sp.	19.30ab	—	1.0c	—	1.0de	—	20.15c	—
T. padwickii	—	19.28b	—	1.7bcd	—	6.0b	—	35.53de
Control	20.70a	17.22a	0.0d	0.2e	0.0e	0.2c	17.90c	31.24de

[a]Mean of 4 replications. Means in a column followed by a common letter are not significantly different at the 5% level.

[b]Severity scale: 0~3 where 0=not discolored; 1=slightly discolored; 2=moderately discolored; 3=severely discolored.

[c]Scoring scale: 0~9 where 0=no incidence; 1=less than 1%; 3=1 to 5%; 5=6 to 25% 7=26 to 50%; 9=51 to 100%.

between these treatments. The difference in results between these two varieties may be due to differences in their susceptility to the insects and pathogens. In the percentage of unfilled grains, treatments with rice bugs were signifcantly higher ($p>0.05$) than those without rice bugs for both IR22 and IR36 except for the treatment with pathogen *T. padwickii* on IR36. The severity of discoloration was hignest on treatments where the fungus *D. oryzae* was present for both varieties. The discoloration produced by *D. oryzae* was the most severe among the pathogens used.

In conclusion, the study showed that there are several disease organisms associated with rice grain discoloration in both the wet and dry seasons. Both pathogens and rice bugs caused discoloration. There appeared to be no differences among varieties in percentage of grains infected. The most common disease pathogen found on the field collected grains was *D. oryzae* and this pathogen caused the highest degree of grain discoloration in greenhouse tests. Further studies should be conducted to determine whether feeding by the rice bug predisposes the grains to a higher degree of pathogen infection than which are not exposed to rice bug damage.

摘 要

變色米 發生에 關與하는 病原菌과 害虫을 分類同定한 結果 害虫으로는 허리노린재科에 속하는 *Leptocorisa oratorius*가 優占種이었고 노린재科인 *Menida varipennis. Stollia ventralis* 및 *Nezara viridula* 등이 關與하였으며 病原菌으로는 *Drechslera oryzae. Curvularia lunata, Trichoniella padwickii, Sarocladium oryzae, Alternaria tenuis* 및 *Fusarium solani* 등이 關與하였다.

病原菌과 害虫의 複合發生時에 變色米發生이 더 심하였고 病原菌만의 發生時는 變色米 發生에 주로 影響을 미쳤으며 노린재류만의 發生時는 收量減收에 더 큰 影響을 주었다. 그리고 노린재류에 의한 벼 乳熟期間의 吸汁은 病原菌侵入을 助長하여 벼의 質的 變化와 量的 減少에 크게 影響하였다.

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