Relationship between Planthoppers (*Nilaparvata lugens* and *Sogatella furcifera*) and Rice Diseases[1]

S.C. LEE[2], D.M. MATIAS[3], T.W. MEW[3], J.S. SORINO[3]
AND E.A. HEINRICHS[4]

李升燦 · D.M. 마티아 · T.W. 뮤우 · J.S. 소리노 · E.A. 하인리크 : 멸구類 (벼멸구 및 흰등멸구)와 水稻病害의 複合發生被害에 關한 研究

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ABSTRACT The locational preference of the brown planthopper (BPH) *Nilaparvata lugens* (Stål) and the whitebacked planthopper (WBPH) *Sogatella furcifera* (Horvath) was studied on rice cultivars IR22 and IR36 as an integral part of subsequent research on insect-fungal pathogen relationships. The BPH was observed to stay consistently on the basal portion while the WBPH showed a general preference for the upper portion regardless of varieties, rice growth stages and insect population density levels. The habitat preference of both species (BPH and WBPH) was found not to be affected by the presence of the other species when both species are present on the same host plant.

Five rice cultivars with different reactions to BPH biotype 2 were used in the study on BPH-*Rhizoctonia solani* relationship: IR22 and TN1 (susceptible); Triveni and ASD7 (moderately resistant); and IR42 (resistant). Test plants were inoculated with R. *solani* (Kuhn) 3～4days after insect infestation. Sheath blight disease severity/incidence was significantly higher in the treatment where BPH+R. *solani* were together than in the treatment with only the pathogen. Symptom expression of the disease in the BPH-pathogen combination was faster and mycelial growth was more profuse inducing the formation of more infection structures. Regardless of varietal reaction to BPH biotype 2, the degree of hopperburn was significantly higher in the combination of the two pests as compared with that of BPH alone. There could be a synergistic relationship between the insect pest and the pathogen indicated by a positive interaction between the two species.

The brown planthopper (BPH) *Nilaparvata lugens* (Stål) and whitebacked planthopper (WBPH) *Sogatella furcifera* (Horvath) are major pests of rice, and they usually occur in a population complex as migratory insects on rice plants. The BPH prefers to occupy mostly the lower portion of rice plants and the WBPH the upper portion (Peraiah et al. 1979, Rao 1981, and Mochida 1982). Feeding and ovipositional punctures of the BPH seem to predispose the rice plants to various fungal and bacterial diseases (Narayanasamy et al. 1979). Chuke (1983) found that sheath rot disease of rice was greater when plants were artificially inoculated after BPH infestation.

It has been speculated that mechanical injuries by hoppers, stem borers, leaf folders and whorl maggots may intensify the infection of rice plants by several diseases. A positive correlation between BPH or stem borer population and stem rot disease incidence was noted by other researchers (Thri Murty et al. 1980, Kobari 1961), and Shieh (1966) reported the significance of wounds on stem rot infection. Devadath et al. (1975) observed in the field that plants damaged by stem borer also developed bacterial leaf blight infection in other leaves of the dead heart tiller and found that the insects mechanically help in the entry of the pathogen into the plant. Injuries on rice leaves caused by sucking and chewing insects were found to serve as portal of entry for the bacterial blight pathogen (Mohiuddin et al. 1976).

The role of insects in the fungal infection of rice plants is still underestimated and very limited research data are available. Sheath blight is generally

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[2] Present address: Department of Agricultural Biology, Chonnam National University. Kwangju 500, Korea (전남대학교 농과대학 농생물학과)

[3] International Rice Research Institute, P.O. Box 933. Manila, Phillippines.

[4] Present adresss: Department of Entomology, 402 Life Sciences Bldg., LSU Agricultural Center, Baton Rouge, Louisiana 70803-1710, U.S.A.

confined to the lower part of plants until the maximum tillering stage, while the disease progresses rapidly upward. Accordingly, insects which prefer to stay at the lower part of the plant are suspected to influence disease development before vertical growth and insects which prefer the upper portion might have something to do with vertical disease progress in the later stage of disease development. These studies were therefore initiated to verify the general observations on the habitat preference of the BPH-WBPH population complex on rice plants as an integral part of subsequent research on insect-fungal pathogen interactions.

MATERIALS AND METHODS

Habitat preference of individual species in a BPH-WBPH *population complex*

Two varieties, IR22 (susceptible to BPH biotype 2) and IR36 (resistant to BPH biotype 2 and susceptible in the seedling stage but moderately resistant to WBPH on an older plant) were used in the study. Seedlings of the varieties were transplanted in 12cm diameter clay pots and were later reduced to 7 tillers per pot when the plants reached the desired growth stage. To ensure insect-free plants, all the test plants were pre-caged for 10 days before infestation.

Infestation of the plants was done simultaneously with 3 rd instar nymphs of BPH biotype 2 alone, WBPH alone or a combination of both species at population densitites of 20, 40 and 80 insects per pot. Plants infested with the combination of BPH and WBPH consisted of 50% of each insect species at the given population density level. Each pot was enclosed separately in a mylar film cage before infestation and pots were arranged in a split-split-split plot design on metal water pan trays in the greenhouse.

Daily observations on the location of individual insect species on the rice plants were made every day at 0900 hours starting 3 days after infestation (DAI) to allow some time for the insects to naturally orient themselves. The observations were continued up to 6 DAI.

To standardize observations, the upper portion of the rice plant was designated as the region above the first node (first leaf axil counted from the bottom) to the tip of the uppermost leaf and the region below the first node the lower or basal portion.

Interaction between brown planthopper infestation and sheath blight pathogen infection on rice

The virulent lowland rice isolate of the sheath blight pathogen *R. solani* was isolated from naturally infected IR36 at the IRRI farm. The fungus was grown on an autoclaved rice grain/rice hull mixture (3 : 1, v/v). The isolate for the stock culture was maintained by growing the fungus on PDA slants and was stored in a cold room.

The rice cultivars used and their reaction to BPH biotype 2 were TN1(susceptible); IR42(susceptible); Triveni (moderately resistant), ASD7 (moderately resistant). The varieties which are susceptible to sheath blight were TN1, IR22 and IR42 while Triveni and ASD7 are moderately resistant.

The pots were fertilized at the rate of 90kg N/ha. At maximum tillering stage, the number of tillers was later reduced to 10/pot for all treatments.

The test varieties were infested with 100 4th-instar insects/pot. Three to five days after infestation the test plants were inoculated with a week old culture of *R. solani* by scattering the inoculum around the base of the test plants. A treatment was inoculated with *R. solani* and sprayed with honey dew one day after inoculation up to 5 days. An 8-hr day temperature of 30±3°C with relative humidity range of 60~80% during the day and 70~100% at night was maintained in the greenhouse throughout the duration of the study. Sheath blight symptom development and mycelial growth were observed daily in all treatments where the sheath blight pathogen was present. Infection cushions on the treatment where *R. solani* was present were also observed under the microscope. Seven and 14 days later, degree of disease severity and degree of hopperburn were evaluated respectively using the Standard Evaluation System(IRRI 1980) scoring scale.

RESULTS AND DISCUSSION

Locational preference of BPH and WBPH

Results from the study showed that the BPH populations prefer to stay dominantly on the lower portion of the rice plants regardless of crop growth stages, varieties, population densities, and single or mixed species. On the other hand, it was observed that the majority of the WBPH occupy the upper portion of the plants and this position was maintained even when mixed with BPH. However, statistical analysis showed that the WBPH preferred mostly the uppermost part of IR36 at maximum tillering and booting stages which influence the insect to move to a more suitable feeding site within the plant (Fig. 1). At seedling stage, the mean percentage of insect populations on the upper portion of IR22 and IR36 did not differ significantly ($p<0.05$).

At maximum tillering and booting stages of both varieties (IR22 and IR36) the mean WBPH population on the upper part of the rice plants was significantly higher from that of the seedling stage regardless of population density levels. Statistical analysis showed that the mean percentage of insect population on the upper portion of IR36 at maximum tillering and booting stages was significantly higher ($p>0.05$) than that on IR22 at the same crop growth stages. It is known that IR36 becomes resistant to WBPH at later growth stages which influences the insect to move to a more suitable feeding site within the plant.

BPH-sheath blight interaction

The development of sheath blight symtoms due to *R. solani* on all varieties tested was faster and earlier in the treatment where the BPH and the sheath blight pathogen were combined together as compared to the treatment where the sheath blight pathogen occurred singly. The results indicate that the presence of BPH predisposes the rice plants to more severe sheath blight infection. Carter (1973) stated that insects play an important role in fungal diseases by making wounds on plants through which fungi enter the plants.

Degree of disease severity was significantly higher ($p>0.05$) on plants with BPH+pathogen than on plants with only the pathogen(Table 1). It was further observed that disease incidence measured

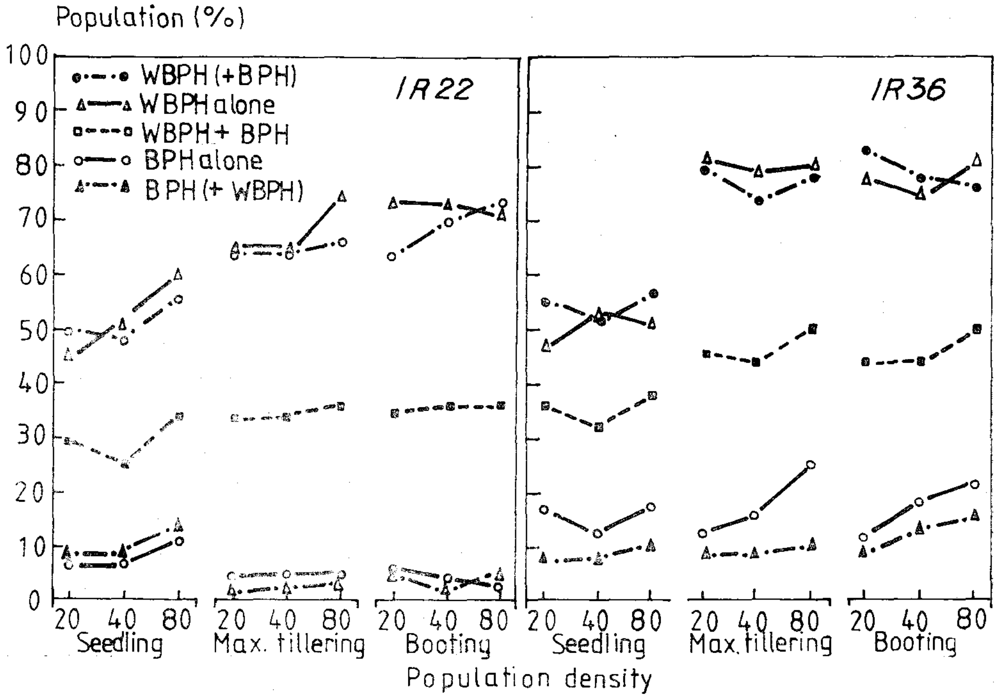

Fig. 1. Percent population of BPH and WBPH on upper portion of IR22 and IR36 at seedling, maximum tillering and booting stages.

Table 1. Effect of brown planthopper infestation and *R. solani* infection on disease severity on different varieties.

Treatment	Mean of disease severity[a]				
	IR22	TN1	IR42	ASD7	Triveni
BPH+*R. solani*	7.0a	7.0a	7.2a	6.5a	7.0a
BPH alone	0.0c	0.0c	0.0c	0.0c	0.0c
R. solani alone	3.5b	3.2b	3.5b	2.8b	4.0b
Control	0.0c	0.0c	0.0c	0.0c	0.0c

[a] Disease severity: 0~9. 0=no incidence; 1=lesions limited to lower 1/4 of leaf sheath area; 3=lesions present on lower 1/2 of leaf sheath area. Slight infection on lower (3rd or 4th) leaves; 7=lesions present on more than 3/4 of leaf sheath. Severe infection on upper leaves (flag & 2nd leaf); 9=lesions reaching top of tillers, severe infection on all leaves & some plants killed. Mean of 4 replications. Means followed by a common letter are not significantly different at the 5% level.

in terms of the number of tillers infected was significantly higher ($p>0.05$) in the BPH-sheath blight pathogen combination as compared to that of the sheath blight pathogen alone (Table 2).

Table 2. Effect of brown planthopper infestation and *R. solani* infection on disease incidence on different varieties.

Treatment	Mean tillers infected (%)[a]				
	IR22	TN1	IR42	ASD7	Triveni
BPH+*R. solani*	95a	88a	97a	82a	97a
BPH only	0c	0c	0c	0c	0c
R. solani	73b	43b	75b	45b	62b
Control	0c	0c	0c	0c	0c

[a] Derived from number of tillers infected over the total number of tillers. Mean of 4 replications. Means followed by a common letter are not significantly different at the 5% level.

Table 3. Degree of mycelial growth of *R. solani* on different treatments on IR22, TN1 and IR50.

Treatmens	Variety and mycelial growth[a]		
	IR22	TN1	IR50
BHP+*R. solani*	⧻	⧻	⧻
BPH only	—	—	—
R. solani only	+	+	+
R. solani+honey dew	⧺	⧺	⧺
Control	—	—	—

[a] ⧻=very abundant
⧺=abundant
+=sparse
—=none

Mycelial growth was most abundant in the BPH+sheath blight pathogen followed by sheath blight+honey dew combinations in contrast to that of the pathogen alone (Table 3). The profuse mycelial growth might have produced more infection structures such as infection cushions and lobate appresoria. Marshall and Rush (1980) reported that the number of infection structures were highly correlated with disease severity.

The greater disease severity and incidence in the BPH-sheath blight pathogen combination compared to that of sheath blight pathogen alone was facilitated perhaps by: the physical/physiological changes of rice plants brought about by insect damage which predisposed the plants to more sheath blight infection; wounds created by BPH upon feeding which served as ports of entry for the pathogen; and/or insect excretion (honey dew) which served as good supplemental medium for the profuse growth of the pathogen increasing the inoculum potential. Injuries caused by insects weaken the plants and make them more susceptible to fungal attacks by pathogens (Christensen & Schneider 1950, Chez et al. 1977). Christensen (1953), Summers (1952), Porter and Smith (1974) and James et al. (1977) reported that root infections by fungi are facilitated by insects feeding on plant roots which create ports of entry for the fungal pathogens, and in addition, weaken the plants and predispose them to fungal attacks. Further, Christensen & Wilcoxon (1966) reported that insect excretions deposited on leaf sheaths of corn plants provided an excellent medium for rapid growth of many parasites and saprophytes which then invade living tissues.

Furthermore, the degree of hopperburn observed in all the cutlivars was significantly higher ($p>0.05$) in the BPH+sheath blight pathogen combination as compared to that of BPH alone (Table 4). Regardless of varietal reaction to BPH biotype 2, the occurrence of complete hopperburn (i.e. all plants dried) was earlier in the combination of the pathogen and the insect as compared with the treatment wherein only the insect occurred.

As a result, we conclude, that sheath blight infection and hopperburn were significantly more severe in the combination of BPH+*R. solani* than

Table 4. Effect of brown planthopper infestation and *R. solani* infection on degree of hopperburn on different varieties.

	Mean degree of hopperburn[a]				
Treatment	IR22	TN1	IR42	ASD7	Triveni
BPH+*R. solani*	7.8a	7.2a	4.5a	7.0a	6.5a
BPH alone	5.7b	4.6b	2.0b	3.5b	3.4b
R. solani alone	0.0c	0.0c	0.0c	0.0c	0.0c
Control	0.0c	0.0c	0.0c	0.0c	0.0c

[a] Degree of hopperburn: 0~9. 0=no damage; 1=very slight damage; 3=1st and 2nd leaves of most plants partially yellowing; 5=pronounced yellowing and stunting or about half of the plants wilting or dead; 7=more than half of the plants wilting or dead and remaining plants severely stunted or dying; 9=all plants dead. Mean of 4 replications. Means followed by a common letter are not significantly different at the 5% level.

in the treatment with either pest alone. BPH excretion and wounding causing physical/physiological changes in plants may be the major factors responsible for greater sheath blight infection. These findings indicate that there could be a synergistic interaction between the two pests.

摘 要

水稻 病害虫의 同時發生 被害에 관한 研究를 위한 基礎試驗으로 벼멸구와 흰등멸구의 複合發生에 따른 棲息處選好性을 確認코저 感受性 品種인 IR22와 抵抗性인 IR36(分蘖最盛期부터 흰등멸구에도 抵抗性임)을 供試하여 調査한 結果 벼品種別, 生育時期別 및 發生密度에 따라 多少 差異는 있으나 一般的으로 흰등멸구는 大部分 벼 윗部分에 棲息하였고 벼멸구는 아래部分에 棲息함을 알 수 있었다. 두 種의 複合發生時의 棲息選好性은 相對種의 發生에 影響을 받지 않았고 각각 一定한 棲息處를 選好하는 傾向이었다.

벼멸구의 生態型 2에 對하여 反應이 다른 다섯가지 品種(IR22 및 TN1 : 感受性, Triveni 및 ASD7 : 中程度抵抗性, IR42 : 抵抗性)을 供試하여 紋枯病과 벼멸구의 同時發生에 의한 被害를 調査한 結果 病害虫의 同時發生 被害는 病原菌이 單獨發生했을 때 보다 紋枯病의 發病을 顯著히 助長시켰으며 病症의 發現速度도 빨랐고 菌系生長도 旺盛하여 感染器(infection structure)의 形成도 豊富하였다.

벼멸구의 生態型 2에 對한 品種 反應과는 상관없이 벼멸구와 紋枯病과의 同時發生은 벼멸구 單獨發生에 比하여 더 심한 枯死現象(hopperburn)을 일으켰다. 즉 紋枯病 病原菌과 벼멸구의 同時發生은 相乘的 被害가 나타남을 確認하였다.

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