

Virus diseases of rice and their control

D. V. W. ABEYGUNAWARDENA, C. M. BANDARANAYAKA AND
C. B. KARANDAWELA

Central Agricultural Research Institute, Peradeniya

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INTRODUCTION

Virus diseases constitute a serious threat to increased rice production in South-East Asian countries. In Ceylon, viruslike symptoms were first reported from Bibile in 1965 (1). Since then, virus diseases have been increasingly recognized in most rice-growing districts and they could develop into epidemic proportions, particularly under conditions of high fertilization, cultivation of susceptible varieties, multiple cropping and haphazard cultural practice.

Three virus diseases, namely Yellow Dwarf, Orange Leaf and Grassy Stunt have been characterized in Ceylon on the basis of their symptoms, vector transmission and virus-vector relationships. This paper reviews experimental work on virus characterization and also discusses complex problems associated with their control in Ceylon.

YELLOW DWARF

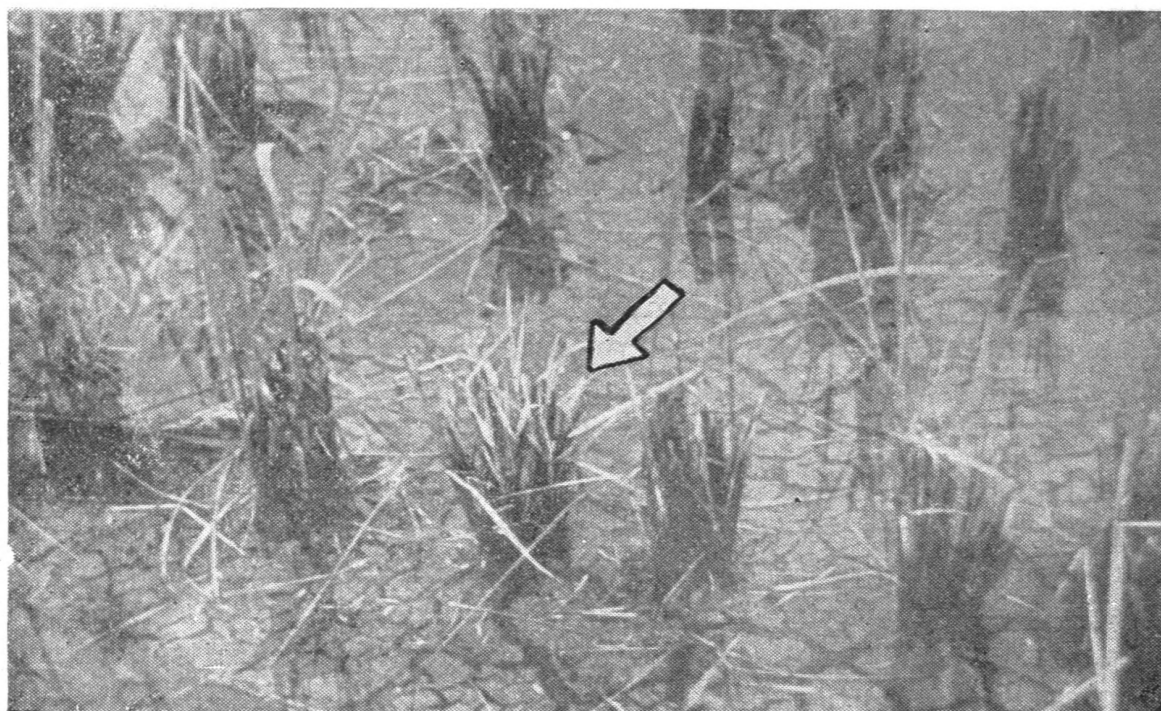
Although Yellow Dwarf disease of rice was first reported in Japan in 1919, its presence in tropical Asia has been recognized only during the last decade. In Ceylon, the disease was observed in 1966, and since then, has been found to occur in most rice-growing districts. At the present moment, its distribution in the field is highly sporadic but estimates of infection on ratoon growth, for instance at Peradeniya, have shown up to 20 per cent of infected hills. The crop loss from Yellow Dwarf at this stage could be considered to be insignificant but the disease may assume epidemic importance with extensive cultivation of susceptible and high productive varieties. In Japan, for example, 50,000 acres are known to be severely affected with this disease resulting in an estimated yield loss of about 10,000 tons (2).

The disease is known to be transmitted by three species of green leafhopper, namely *Nephotettix cincticeps* Uhler, *N. impicticeps* Ishihara and *N. apicalis* Motsch (2). Among them, the predominant vectors in tropical Asia are thought to be *N. impicticeps* and *N. apicalis*. In Japan, the disease is reported to be transmitted principally by *N. cincticeps* (2).



Fig. 1. Natural Infection of Rice with Yellow Dwarf Disease.

Fig. 2. Secondary growth from Rice Stubble infected with Yellow Dwarf Disease.



Symptoms. As illustrated in Figure 1, Yellow Dwarf disease of rice is characterized by general chlorosis of the plant, severe stunting and profuse tillering. Chlorotic symptoms appear initially on new emerging leaves, and chlorosis spreads thereafter to succeeding leaves as well as to tillers and the main stem. When young plants are infected chlorosis becomes pronounced followed by leaves turning whitish brown from tip downward. The leaftips lose turgidity and finally acquire a dirty brown colour. Panicles, if produced, show retarded emergence and the grain is often spotted, defective and remain only partly filled.

Symptoms of Yellow Dwarf are also frequently seen on secondary growth from rice stubbles, and the affected hills can be readily distinguished from a distance. Given in Figure 2 are infected secondary growth from rice stubbles with characteristic symptoms of pronounced yellowing, and profuse tillering. Infected ratoons have smaller leaves than those of healthy hills.

Transmission. Four leaf and planthopper species commonly found to colonize rice in Ceylon were experimentally tested for their ability to transmit Yellow Dwarf. They were *N. apicalis*, *N. impicticeps*, *Inazuima dorsalis* Motsch and *Nilaparavata lugens* Stal. Among them, only green leafhoppers *N. apicalis* and *N. impicticeps* (Figure 3) were determined to be active transmitters.

Shinkai, working in Japan, experimentally demonstrated the transmitting ability of *N. apicalis* to be lower than that of either *N. impicticeps* or *N. cincticeps*. In the present investigation, however, no differential transmitting ability of either *N. apicalis* or *N. impicticeps* was observed. Both species were equally efficient and gave 60 percent positive transmission of the disease.

Virus-vector relationships. In experiments to determine the optimum number of vectors required to produce highest transmission, no substantial difference in the transmitting ability between a single vector, or groups of 2 or 3 vectors was observed.

The incubation period of the virus when determined by the appearance first visual symptoms in the rice variety Taichung (Native) I varied from 25-90 days. On the other hand, its incubation period in the vector (*N. impicticeps*) was found to vary from 20-55 days. Illustrated in Figure 4 is the effect of the period of incubation of the virus on the transmitting ability of the vector. The transmitting ability of the

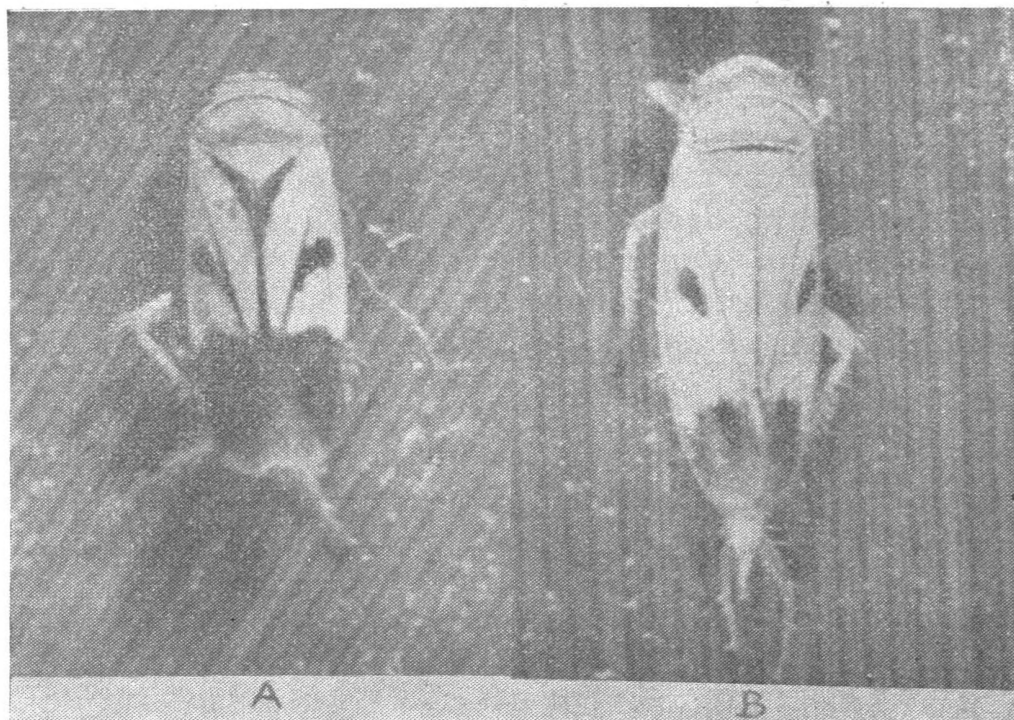


Fig. 3. Vectors of Yellow Dwarf Disease.

A—*Nephotettix apicalis*.

B—*Nephotettix impicticeps*.

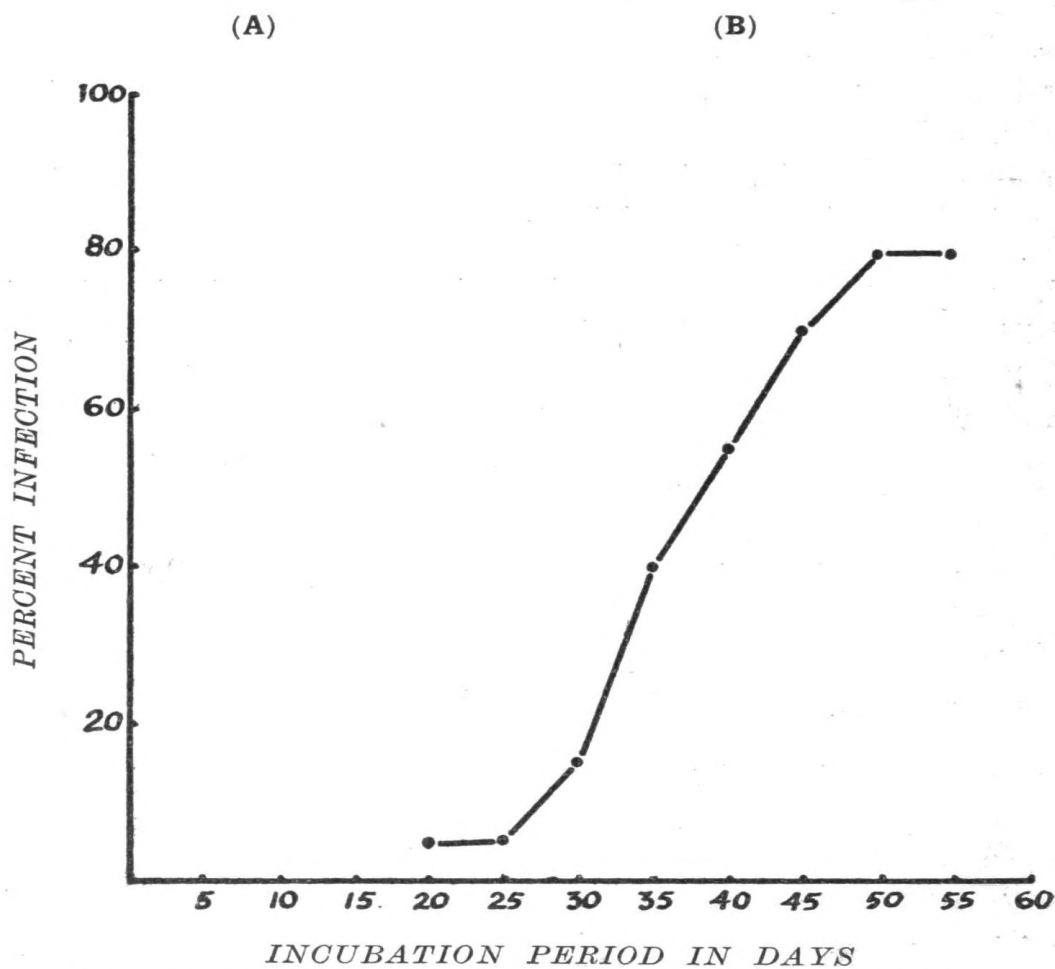


Fig. 4. Effect of incubation period of Yellow Dwarf Virus in *Nephotettix impicticeps* on transmission.

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vector increased with the increase in incubation period from 20-55 days. Disease transmission was highest when insects were given a 45-50 day incubation period of the virus.

The basic relationship of virus-vector has been established to be persistent. Early instar larvae of *N. impicticeps* were fed on a virus source and given an incubation period of 35 days prior to serial transfer to test plants. Shown graphically in Figure 5 are results of a typical experiment on serial transmission of the disease. It will be noted that a single viruliferous leafhopper was able to transmit the disease to more than 10 plants in succession, and that its transmitting ability increased up to the seventh successive transfer. The observed increase in transmitting ability could, therefore, be attributed to the extended incubation of the virus, thus confirming that an optimum incubation period of 40-50 days was required to give maximum vector efficiency.

The results of experiments described on virus-vector relationships and on transmission of Yellow Dwarf thus revealed that (1) a single vector was sufficient to obtain maximum infection, (2) an incubation period of 45-50 days of the virus in its vector was required for maximum transmission, (3) a single vector was able to infect more than 10 plants serially without having to feed on a fresh virus source, or without any substantial loss in its transmitting ability, and finally (4) both *N. impicticeps* and *N. apicalis* possess an equal transmitting ability of Yellow Dwarf disease. It follows, therefore, that the above improvements for effective transmission of Yellow Dwarf could be profitably applied in a mass screening of rice varieties for disease resistance.

Tests on varietal resistance. A series of tests on resistance or susceptibility of rice varieties to Yellow Dwarf were undertaken employing improved methods of disease transmission. Reported in Table 1 are the results of the first varietal evaluation involving 8 indigenous and introduced rice varieties.

Test seedlings placed in glass tubes were inoculated at 2-3 leaf stage, 25 seedlings per variety. Seedlings thus inoculated were grown in 6" clay pots and disease estimates taken on the basis of visual expression of symptoms of yellowing, profuse tillering and stunting of plants.

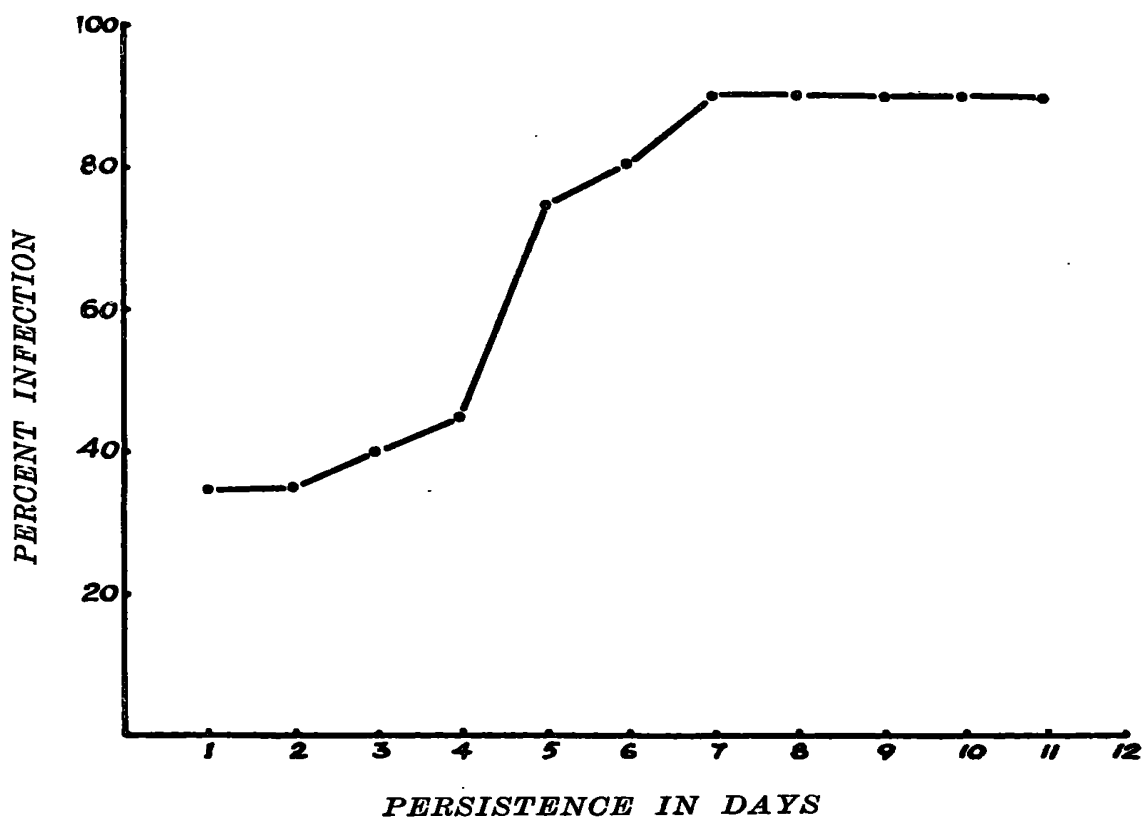


Fig. 5. Persistence of Yellow Dwarf virus *Nephopettix impicticeps*

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TABLE 1
Relative Resistance of Rice Varieties to Yellow Dwarf

<i>Variety</i>	<i>Percent Infection</i>
H 4	20
H 102	40
Chianung 242	60
Taichung (Native) I	75
IR 8	80
Remadja	90
H 6	100
Heenati 309	100

No differential reactions were observed among the rice varieties, nevertheless the degree of infection varied considerably. Based on the latter, H4 emerged as most resistant, H 102 and Chianung 242 showed moderate infection while IR 8, Remadja, H6 and Heenati 309 exhibited susceptibility.

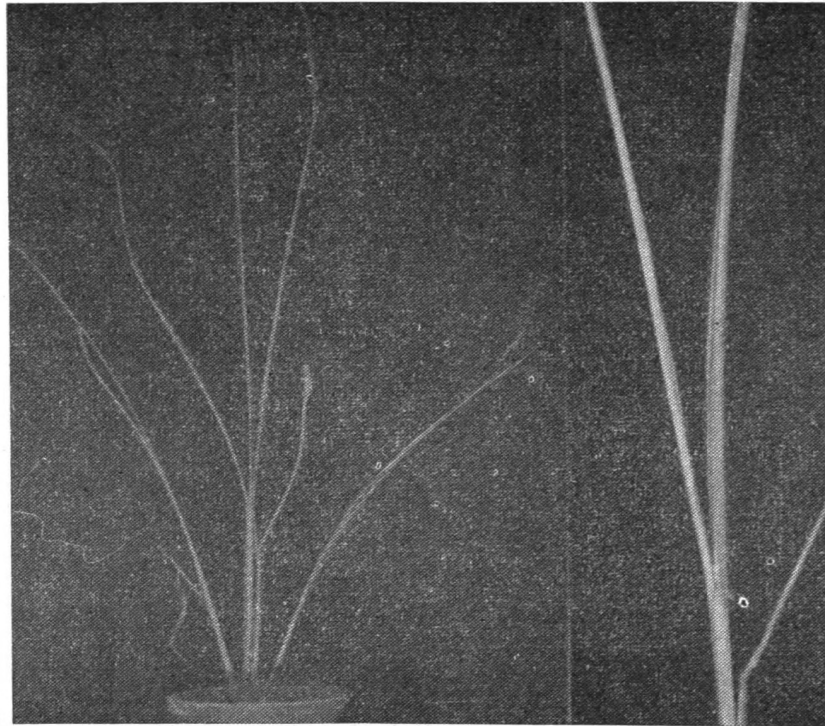
ORANGE LEAF

Orange Leaf virus disease of rice was first reported from northern Thailand in 1960 (4). It has since been found to occur in the Philippines and Ceylon (5, 1). The disease is now widely distributed in the country but its occurrence is highly sporadic and shows a scatter distribution in the field. In fields at Peradeniya, secondary growth from rice stubbles showed up to 5.6 per cent of infected hills (1).

Symptoms. The characteristic symptoms of the disease is the appearance of conspicuous bright orange colour in the leaves of the rice plant. The orange colour appears as streaks running from leaftip downward, and in certain cases, these streaks are confined to only one side of the leafblade. Leaf margins roll inward commencing at the leaftip and progresses downward (Figure 6). Infected plants show reduced tillering, and in a great majority of infections, the plants are finally killed. Panicles show retarded exertion, and the grain becomes discoloured and partly filled. When 2-3 leaf seedlings are infected, they are rapidly killed.

Transmission. Experimental inoculation studies revealed that the disease is transmitted by the zig-zag leafhopper *Inazuma dorsalis* Motsch (Figure 7). No positive transmission was obtained with other species of rice leaf and planthoppers viz. *Nephotettix apicalis*, *N. impicticeps* and *Nilaparvata lugens*. This partly confirms the findings of Rivera *et al* on insect transmission of the Orange Leaf disease (5).

Virus-vector relationships. Vector efficiency in transmitting the Orange Leaf disease was improved by an increase in the number of insects per test plant. Experiments revealed that an insect group of 3 was superior to either a group of 2, or a single insect. A further increase in the number of insects from 3 to 8 per group per test



(A)

(B)

Fig. 6. Orange Leaf Disease.
A—Severely infected plant.
B—Inward Rolling of Leaves.

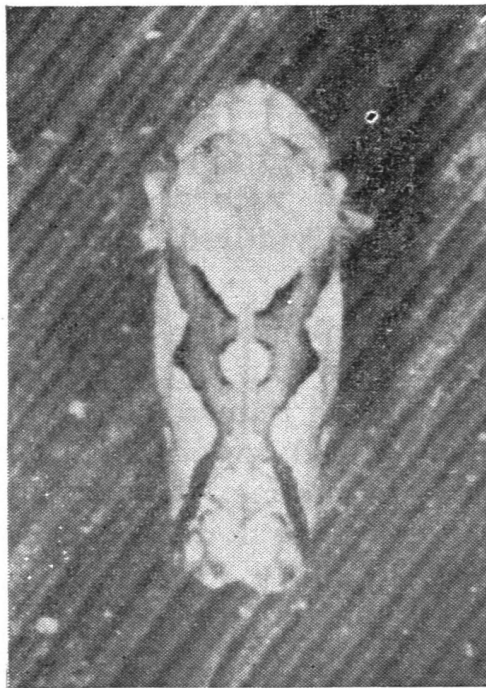


Fig. 7. Vector of Orange Leaf Disease Inazuma dorsalis.

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seedling did not result in increased transmission of the disease. The relationship of virus-vector was determined as persistent. In serial transmission studies, a single viruliferous vector was found to be capable of infecting over 4 plants in succession without having to feed on a fresh virus source.

Tests on varietal resistance. Thirty two indigenous, hybrid and introduced rice varieties were experimentally inoculated to determine their resistance or susceptibility to Orange Leaf disease. In this investigation, viruliferous vectors were transferred to 2-3 leaf seedlings contained in test tubes and given an inoculation feeding period of 24 hours. Seedlings, thus inoculated, were planted in clay pots and disease appearance and severity data taken at regular intervals. Illustrated in Table 2 is the percent infection and symptoms exhibited by each test variety.

TABLE 2
Varietal Reaction of Rice to Orange Leaf Disease

Variety	Per cent. infection	Symptoms observed
Pachchaiperumal	100	Orange colour of leaves, pronounced leaf rolling and death of seedlings
Murunga 307	100	do.
H-106	100	do.
H-105	90	do.
Murungakayan 303	80	do.
Murungakayan 304	80	do.
Murungakayan 104	80	do.
Heratwi	80	do.
Vellai Illankalayan	80	do.
Hal Suduwi	80	do.
Murunga 308	80	do.
Dahanala	80	do.
Pokkali	80	do.
Vellaiperunel	80	do.
H 4	80	do.
H 501	80	do.
Pinulot	80	do.
Mas 24	80	do.
IR 8	80	Orange colour of leaves, leaf rolling not pronounced
IR 5	70	do.
Murungakayan 302	70	Orange colour of leaves, pronounced leaf rolling and death of seedlings
Dewaradderi	70	do.
Tadukan	70	Brown colour of leaves, leaf rolling not pronounced
Ratuwi	60	Orange colour of leaves, pronounced leaf rolling and death of seedlings
Dickwi	60	do.
Ptb 16	60	do.
H 7	50	do.
H 102	50	do.
Bengawan	50	do.
Elwee	50	Orange colour of leaves, no rolling of leaves
Podiwi-a8	40	Orange colour of leaves, pronounced leaf rolling and death of seedlings
Kalu Dahanala	20	Yellowing of leaves, no leaf rolling or death of seedlings

All rice varieties tested developed systemic infection and no recognizable differences existed in the severity of disease reaction in a population of plants in any single variety. However, varieties investigated showed conspicuous differences both in the severity of infection as well as their reaction to disease. Thus, differentiation of varieties as susceptible, resistant or tolerant was possible.

The cultivated varieties H4, H7, H105, H501, Pachchaiperumal, Murungakayan 302, Pokkali and Podiwi-a8 were susceptible and showed a severe reaction to disease which included the development of intense orange colour followed by inward rolling of leaves, and finally death of seedlings. Varieties such as IR 8, IR 5 and Elwee showed a high degree of infection but did not react violently with leaf rolling symptoms. Kalu Dahanala reacted with mild symptoms of leaf yellowing but the disease neither caused rolling of leaves nor death of seedlings. Hence, it could be categorized as a tolerant variety, and has potential importance as a genetic source in breeding for resistance or tolerance to Orange Leaf.

GRASSY STUNT

Grassy Stunt disease was first reported in the Philippines in 1963 (6). In Ceylon, it is highly sporadic in occurrence and has been commonly found to affect the variety IR 8.

Symptoms. The disease at a glance resembles Yellow Dwarf. The virus causes severe stunting, profuse tillering, and the leaves are generally tufted and erect (Figure 8). On older leaves, rusty brown specks appear. Panicle exertion is often retarded and the grain becomes spotted and generally unfilled or half-filled.

Transmission. The disease was experimentally transmitted with the brown planthopper *Nilaparvata lugens* Stal (Figure 9). The incubation period in the rice plant was determined as 10-14 weeks.

CONTROL OF RICE VIRUS DISEASES

Until broad-based resistant or tolerant varieties are developed by rice breeding, control of virus diseases must be accomplished by integration of field sanitation, management practice and elimination of vectors.

Virus diseases persist between *maha* and *yala* cropping seasons in secondary growth from rice stubbles which thus serve as sources of initial infection. In ill-drained fields, particularly in the wet zone, the

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Fig. 8. Natural Infection of Rice with Grassy Stunt Disease.

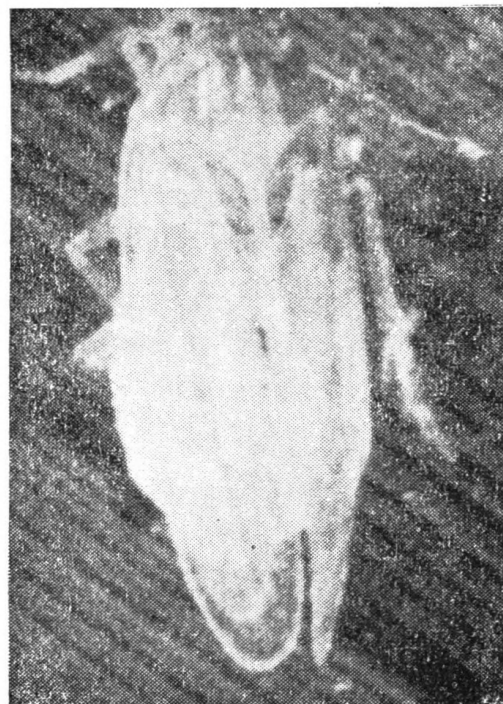


Fig. 9. Vector of Grassy Stunt Disease Nilaparvata lugens.

prevalance of secondary growth from uncontrolled rice stubbles poses special problems in virus control. In such situations, good field hygiene and post-harvest eradication of virus reservoirs are of the utmost importance.

Management practice aimed at virus control must necessarily include attention in many details such as avoidance of staggered planting, elimination of haphazard and mixed cultivation of varieties of different age classes, and finally, eradication of all potential sources of infection. Best results from above practices could be achieved by their integrated and combined application on a contiguous *yaya* or area basis rather than on scattered farmer's fields.

In localities where virus diseases are endemic, good management practice and field hygiene should necessarily be combined with vector control. Leafhopper and planthopper vectors of rice virus diseases could be eliminated by insecticide application. This method is particularly useful for vector control in nurseries. Spraying of nurseries will result in elimination of early infections that are generally responsible for heavy crop losses. Indirect control of rice virus diseases could also be accomplished by breeding and development of rice varieties with resistance to vector infestation.

SUMMARY

The identity of three virus diseases of rice *viz* Yellow Dwarf, Orange Leaf and Grassy Stunt has been established on the basis of symptoms, transmission and virus-vector relationships.

Yellow Dwarf was transmitted by green leafhoppers *N. apicalis* and *N. impicticeps*, and both species exhibited equal transmitting ability. Experiments have demonstrated that a single vector was sufficient to obtain maximum transmission, an incubation period of 45-50 days in the vector was necessary for maximum transmission and that the virus is persistent.

An evaluation of resistance or tolerance of indigenous, hybrid and introduced rice varieties revealed that H4 was highly resistant whereas IR 8, Remadja, H6, and Heenati 309 showed extreme susceptibility.

Orange Leaf was transmitted by the zig-zag leafhopper *I. dorsalis*. The transmitting ability of a group of 3 insects was superior to that of a group of 2, or a single insect. A single viruliferous vector was able to infect over 4 plants in succession without having access to a fresh virus source.

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Thirty-two rice varieties were evaluated for resistance to Orange Leaf. Widely cultivated varieties such as H4 and Pachchaiperumal were highly susceptible. IR 8, IR 5 and Elwee did not react violently, while Kalu Dahanala was tolerant and exhibited only leaf yellowing symptoms.

Grassy Stunt was transmitted by the brown planthopper *N. lugens*. The incubation period of the virus in the host was found to be 10-14 weeks.

Control of rice virus diseases is discussed with special reference to an integrated approach through field sanitation, management practice and vector elimination.

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