7. RICE WAIKA, A NEW VIRUS DISEASE, FOUND IN KYUSHU, JAPAN

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In 1971, a new virus disease rice waika was discovered in Kyushu in the southern part of Japan. The disease spread rapidly in several years and caused serious damage. In the meanwhile, causal factor was not yet enlightened. It had been called "stunting phenomenon of rice" as the causal factor was unknown.

In order to find out the cause of the abnormal state of rice, cooperative investigation was started in 1972 by the Kyushu National Agricultural Experiment Station and seven Prefectural Agricultural Experiment Stations.

Two years after the investigation started, 1974, the cause of this disease was attributed to the insect-borne virus and the common name "rice waika" disease was proposed.

From 1975, the Institute for Plant Virus Research, University of Tokyo, and the Kyushu National Agricultural Experiment Station have been jointly proceeding with the work. The items of the project under study include the virological and the ecological studies of rice waika, and breeding of resistant varieties to the disease.

This paper introduces both the brief history on occurrence of the disease and some experimental results conducted in Kyushu.

History and Distribution

Two hectares of paddy field in Saga Prefecture were presumed as the first outbreak of the disease in 1967. But at the present time, it cannot be identified as rice waika due to lack of detailed informatiin. In 1971, four years after the presumed first outbreak, the diseased paddy covered an area of 1,647 ha. Next year, 1972, it increased to 11,924 ha and was limited to the coastal area surrounding Ariake, Shimabara and Yatsushiro Bays.

Yearly, rice waika spread rapidly from affected to adjacent areas. In 1973, it increased to 24,825 ha covering seven percent of the paddy area of Kyushu, and loss of yield was estimated to be 10,000 tons. Previously, waika was only observed in the coastal plains but later was also seen in the elevated areas of about 200 meters above sea level.

Green rice leafhopper *Nephotettix cincticeps* Uhler was proved experimentally to be the vector of rice waika by Yokoyama and Sakai[12] in 1973. And successively small spherical virus particles were found by Nishi et al.[9]

The cooperative investigation committee confirmed the above mentioned results and the principle of controlling the disease was decided as follows: intensive chemical control of vector insects and replacement of varieties to resistant ones. Subsequently these counter-measures were put into practice from the current season of 1974. This year, the area of diseased paddy decreased suddenly to 612 ha. In 1975, the area decreased to only 24 ha.

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Symptoms and Losses

In naturally infected fields, the first visible symptoms appear on the rice plant 70 days after sowing. Discoloration of leaves due to lack of nitrogen and shortening of plant height are the chief characteristics. Diseased hills usually distribute in a circular shape several meters in diameter.

In late August during the culm elongation stage of rice, shortening of plant height appears remarkably, and in early September at heading stage the infected plants were singled out from the healthy ones. But by the inoculation tests, primary symptoms as obscure rusty spots on leaf, drooping leaves and rolling inward of leaves develop on plants about one month after inoculation.

These symptoms are not always distinguishable and do not last long but also disappear with the developing of new leaves and shortly afterwards reappear in a healthy condition. At present, infected plant may be identified practically only by shortening of plant height at the heading stage of rice. To establish early diagnosing, technique must be one of the important objects.

The rates of shortening of infected plants are 20% in culm and 10% in panicle length and are accompanied with decreasing in numbers and lowering in quality of rice grain.[3, 4]

Pathogen Virus

Small spherical virus particles, 30 nm in diameter, were found in infected rice plants collected in Fukuoka Prefecture by Nishi et al.[1, 9] The same virus particles were observed from infected rice plants which had been inoculated with *Nephotettix cincticepts*.[9]

Vectors and Transmission

Up to the present time three species of insects are known as vectors of rice waika —green rice leafhopper *Nephotettix cincti*ceps Uhler, Oriental green rice leafhopper *Nephotettix virescens* (Distant) and tropical green rice leafhopper *Nephotettix nigropictus* (Stål)

In 1973, Yokoyama and Sakai[12] succeeded in transmitting the causal virus of rice waika from diseased rice plants to healthy ones with *N. cincticeps*. Researchers in the cooperative investigation committee also obtained the same result experimentally.[2, 9] *N. virescens*[5] and *N. nigropictus*[10] were tested and proved as a vector. *Recilia dorsalis* Motschulsky showed no positive results.[11] *N. cincticeps* distribute widely in Japan, especially high population in Kyushu. *N. virescens* and *N. nigropictus* are merely found in southern Kyushu.

N. cincticeps can transmit the rice waika virus just after acquisition feeding. Transmissible periods are usually one day, and two days in very few cases after 24 hours of the acquisition feeding.[11] Transmission pattern of *N. virescens* is same as *N. cincticeps* except the retention period is sometimes 2–3 days in the former.[5]

The general characteristics in leafhopper-borne virus are that the vector transmits the virus persistently and there is a long incubation period in insect. The transmission pattern may be rather peculiar to rice waika. Rice waika in Japan is similar to the tungro in Southeast Asia in two points, namely, 1) non-persistent transmission and 2) vector insect.

Rice plants are able to supply a source of virus for insect transmission seven days after inoculation feeding although the plants do not show any symptoms at the time.[8]

The transmission pattern may suggest that when the primary infection is established even on a small scale, the following developments of the disease are continued and

hastened by increasing of vector population.

Host Range

Inoculation tests were carried out repeatedly on about 30 species of gramineous plants which inhabit around the paddy fields infected with rice waika but the virus could not be recovered from all of these gramineous plants.

Varietal Resistance of Rice Plant

Varietal reactions to natural infection of the rice waika were investigated in fields. The varieties of rice were classified as follows:

Susceptible : Reiho, Saikai No. 132, Saikai No. 134, Nankai No. 57, Hiyokumochi, etc.
Medium : Toyotama, Mineyutaka, Asominori, etc.
Resistant : Nihonbara, Norin No. 22, Koganenishiki, Tsukushibare, etc.

Some of the indica varieties were also tested by artificial inoculation.[6] Among them, Taichung Native I which is susceptible to tungro was also susceptible to waika and showed the same infection rate as a susceptible check, Reiho. But neither yellowing of leaves nor distinct shortening of culm as in tungro was observed.

Control

At the present time, practical measures to control the rice waika are applications of insecticides and utilization of resistant varieties of rice.

In the lowland province alongside the coast of Ariake Bay, where waika was prevalent, transplanting time of rice is late June and heading time is early September.

The disease becomes distinguishable in the culm elongation period of the rice plant in late August. The effecitve infection periods in fields are closely correlated to the growth stages of rice plants and the generations of the vector insects. Therefore, the application time of insecticides is most important in controlling the disease.

Green rice leafhopper has four generations a year in this area. Adults of overwintered generation emerge at the end of March and survive until early May in gramineous weeds. Adults of the first generation emerge from the middle of June to early July and migrate into nursery bed and paddy field. The second and the third generation adults emerge in the paddy field in late July and late August respectively.

In 1975, Maejima et al.[7] transplanted only one hill of the rice plant infected by waika as the infection source in the center of a healthy rice field. The developments of vectors were surveyed and their active transmission was tested. Reappearance of the feature prevalence in 1973 was successful in the field.

The adults of the first generation, nymphs and adults of the second generation transmitted the waika from the infection source, only one hill, to almost all hills of the field. And in a plot, where the vectors of these generations were controlled, diseased plants were scarcely found. From these results it seems that rice waika is mainly transmitted by the adults of the first generation and nymph and adult of the successive generations in the early rice stage. The application time of insecticide must be decided according to the interaction between vectors and rice culture in each locality.

Regarding the utilization of varietal resistant of rice, the susceptible variety, Reiho, was cultivated in an area of 150,000 ha encompassing about 50% of Kyushu in 1973 and was replaced rapidly by resistant variety, Tsukushibare, from 1974.

The source of primary infection is essential to conclude the infection chains of a disease. But in rice waika, another host plant which may be the overwintering host, has not yet been found. Some researchers in the cooperative committee are now devoting their time to this subject.

The reasons why occurence of the rice waika was limited in Kyushu cannot be clarified. Susceptible variety, Reiho, and high population of vector may be the factors but they are not sufficient to give full explanation. Further investigation is required from an epidemiological standpoint.

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Discussions

K. Sogawa, Japan: What are the main factors induced the outbreak of waika virus disease in Kyushu, Japan?

Answer: The main factor induced waika virus disease is not clear. But the following two factors are considered to to be closely related. (1) Variety "Reiho" have been widely cultivated since 1970 and the variety is susceptible to the waika virus disease. (2) In 1971 to 1973, the policy to decrease rice production forced to increase uncultivated fields, where vector leafhoppers multiplied. Thus, vector population was high from early stage of rice cultivation. I think these two backgrounds induced severe infection of waika virus disease in Kyushu.

E. Shimura, Japan (Comment): Besides above two backgrounds, there is another important factor, a change in an agricultural practice, mechanical transplanting. The mechanical transplanting has been introduced since 1970 or so. This means they need to protect rice plants from the attack of insects in paddy field for wider scale than the case in the nursery, but most farmers were not used to do so. Actually in the past, entomologists adviced farmers not to transplant seedlings before middle of June

because of high density of viruliferous insects. After the outbreak of rice waika disease, agronomists have adviced farmers to make transplanting later than June 20.

K. C. Ling, IRRI: Does waika diseased plant produce symptoms on the regenerated growth?

Answer: I did not test experimentally to get symptoms on ratoons by cutting the young diseased plants.

I. N. Oka, Indonesia: Is there any possibility that the waika disease will spread to the north of the island?

Answer: Rice variety "Reiho", susceptible to the waika virus disease, is cultivated only in Kyushu, and not in northern part. And so, vector leafhopper population in northern part is not so high as in Kyushu. Therefore, the possibility seems to be rather limited.

Y. Nagai, Japan: Which is more important to successfully control waika disease in Kyushu, chemical control or resistant varieties?

Answer: Susceptible variety "Reiho" was replaced by resistant variety "Tsukushibare". Vector leafhoppers were controlled, especially at early stage of rice cultivation. These two were considered to be important.

T. Iida, Japan: Where and how does this virus overwinter?

Answer: It is not clear yet.