VIRUS DISEASES OF RICE IN INDIA

A. Anjaneyulu*

ABSTRACT

Rice is affected by four virus diseases in India. Of these, tungro is very widespread and reported from 11 states of India. Next to tungro disease, grassy stunt is important. But it is confined to South India only.

Recently a new strain of grassy stunt, GSV_4 has been reported from South India. The two other virus diseases, ragged stunt and necrotic mosaic are of minor importance and reported only from experimental farms. The significant contributions to tungro in India are on perpetuation of the virus and vectors, epidemiology and control of the disease. Tungro perpetuates on rice stubbles, wild rice species and a few grassy weeds. Artificial simulation of tungro epiphytotic conditions in experimental farms has been developed in India and a large number of rice germplasm has been screened.

Several resistance sources have been identified. A greater progress has been made on vector control. A synthetic pyrethroid, cypermethrin has been reported for effective control of the vector and prevention of tungro disease. Sources of resistance to grassy stunt have been identified. The rice cultivar IR32 and a non cultivated rice species *Oryza minuta* have been reported to be resistant to grassy stunt.

Introduction

Rice is affected by four virus diseases i.e. tungro, grassy stunt, ragged stunt, and necrotic mosaic in India. Of these, tungro is widespread and occurred in epidemic form in several states of India. Grassy stunt is next in importance and it is confined only to South India. Recently, a new strain of grassy stunt has been reported from Tamil Nadu in South India. Ragged stunt and necrotic mosaic are of minor importance in India and are reported only from experimental farms. A brief account of Indian literature on tungro and grassy stunt is given in this paper.

Tungro

1 History, geographical distribution and importance

Leaf yellowing transmitted by *Nephotettix virescens* was first reported by Raychaudhuri *et al.* (1967) as a virus disease of rice in India. One year later, John (1968) confirmed it as tungro. Subsequently, this disease has been referred to as tungro in the literature. It occurred in an epidemic form in the states of Bihar and Uttar Pradesh during the wet season of 1969. Rice cultivar Padma was particularly susceptible to the virus and was most seriously affected. Tungro epidemics occurred in the north-eastern region during 1973 and in Kerala during 1974. The epidemics in the north-eastern region continued to occur at 3 or 4 years intervals i.e. 1980 and 1984 destroying rice over several millions of hectares. Of late, this disease has spread to the southern states of India and it is a threat to rice production in Tamil Nadu and Andhra Pradesh. Now, this disease is fairly widespread in India and its occurrence has been reported from the states of Andhra Pradesh, Assam, Bihar, Karnataka, Kerala, Manipur, Orissa, Tamil Nadu, Tripura, Uttar Pradesh, and West Bengal. Tungro is a very serious disease and yield losses up to 100% were reported.

* Plant Pathologist, Division of Plant Pathology, Central Rice Research Institute, Cuttack 753006, Orissa, India.

2 Disease symptoms

Tungro causes distinct stunting of plants, discoloration of leaves and reduction in tiller number. Tungro-diseased leaves are yellow or orange, slightly rolled outwards and somewhat spirally twisted. The leaf discoloration usually starts from the tip of the leaves and may extend to the lower part of the leaf blade. Young leaves may have a mottled appearance and old leaves show rusty color specks of various sizes. The leaf discoloration in tolerant cultivars may gradually disappear at later stages with the formation of new foliage which is dark green in color. Stunting and leaf discoloration persist throughout the plant growth in susceptible rice cultivars. Infected plants may die, but usually they live until maturity. The diseased plants of susceptible cultivars may not flower at all, whereas plants of tolerant cultivars may suffer due to abnormal delay in flowering in comparison to healthy ones. The panicles are often small and not completely exserted. The grains may be sterile sometimes and their quality is greatly affected.

3 The causal agent

Tungro disease of rice is caused by two types of virus particles i.e. tungro spherical form virus and tungro bacilliform virus (Singh *et al.,* 1984). The size of the spherical virus is about 28 nm in diameter and of the bacilliform virus 33 nm in diameter and 175 nm in length. The presence of both virus particles is associated with severe symptoms of tungro.

4 The strains

Anjaneyulu and John (1972) identified four distinct strains designated as RTV 1, RTV 2A, RTV 2B and RTV 3 based on pathogenicity studies. RTV 1 produced mild symptoms on Taichung (Native) 1 and did not infect any of the six differential cultivars tested. RTV 2A and RTV 2B were undistinguishable on Taichung (Native) 1, on which they produced severe symptoms. RTV 2A infected Pankhari 203, Kamod 253, Ambemohar 159, and Ambemohar 102 and produced severe symptoms. RTV 2B infected Latisail, Pankhari 203 and Ambemohar 159 and produced mild symptoms. Kamod 253 and Ambemohar 102 were susceptible to RTV 2A, but resistant to RTV 2B. RTV 3 produced severe symptoms on Taichung (Native) 1 in the initial stages, but the infected plants soon recovered and produced green leaves. This strain also infected five out of six differential cultivars. Kataribhog was resistant to all the four strains.

5 Transmission and virus-vector relationships

Attempts made to transmit this disease by mechanical means or through seed were negative. Tungro viruses are transmitted exclusively by *Nephotettix virescens* and *N. nigropictus.* The former species was more efficient in transmission than the latter species. Studies on virus-vector relationships revealed that the minimum acquisition feeding period was less than one hour; the minimum inoculation feeding period was 10 minutes; the virus did not have any incubation period in the vector; the virus did not persist for more than five days in the adults and three days in the nymphs; the vector gradually lost its transmission efficiency during post-acquisition starvation up to eight hours and the vector was capable of re-acquiring the virus after cessation of transmission. The infective nymphs failed to transmit the virus after moulting. The virus-vector relathionships of tungro virus are unique and a rare example among leafhopper-transmitted viruses.

6 Epidemiology

1) Perpetuation

Anjaneyulu *et al.* (1982a) conducted a study on the possibilities of rice cultivars and their stubbles acting as sources of reservoir hosts for tungro virus. Out of 15 commercially grown high-yielding semi-dwarf rice cultivars indexed for the presence of virus through non viruliferous *N. virescens,* Taichung (Native) 1, IR 8, Padma, Bala, and Krishna served as better sources of virus inoculum in standing crop as well as in stubbles than others. Due to intensive cultivation of high-yielding rice cultivars, it has been a common practice especially in states like West Bengal and Tamil Nadu, to overlap two crops of rice cultivars. Under such circumstances, tungro virus might survive and propagate in the principal host itself.

Next to principal hosts, wild rice species might act as link hosts between crops. Rao and Anjaneyulu (1978) reported that out of 13 wild rice species tested, *Oryza glaberrima, O. nivara, O. perennis,* and *O. barthii* were susceptible in artificial inoculation. The virus was recovered from these species through non-viruliferous *N. virescens.* The former two species served as better sources of virus inoculum than the latter two species. While confirming the susceptibility of the above wild rice species, Anjaneyulu *et al.* (1982a) found that *O. australiensis, O. brachyantha, O. eichingeri* and *O. punctata* were additional susceptible wild rice species.

The possibilities of certain weed species acting as reservoir hosts were also investigated in India. Five grass species, *Eleusine indica, Hemarthria compressa, Polypogon monspeliensis, Sorghum halepense,* and *Sporobolus tremulus* were found to harbor tungro virus in nature as symptomless carriers (Mishra *et al.,* 1973). In artificial inoculation, Prasada Rao and John (1974) reported the susceptibility of two weed species i.e. *Paspalum distichum* and *Echinochloa colonum.* The species did not show any symptoms, but served as virus carrier hosts. However, at Cuttack, it was found that tungro virus did not infect any of the 20 weed species and six cereal food crops tested by artificial inoculation. These species showed neither visible symptoms nor acted as symptomless carriers (Rao and Anjaneyulu, 1978).

Regarding the host range of the vector, although it preferred rice plants, *N. virescens* could complete its life cycle on *Echinochloa colonum* and *Paspalum arbiculare* (Anjaneyulu *et al.,* 1982a). On the contrary, *N. nigropictus* preferred weed plants (*Leersia hexandra*) than rice for its multiplication. The other susceptible weed species for *N. nigropictus* were *E. colonum, Ischaemum indicum* and *P. orbiculare* (Anjaneyulu *et al.,* 1982a).

2) Disease spread

Several factors such as rice cultivars, virus inoculum, vector population, and cultural practices influence the rate of tungro disease spread under field conditions. Kondaiah *et al.* (1976) reported that rice cultivars, proximity of virus inoculum and seasonal factors especially humidity interact in the spread of tungro disease by the vector *N. virescens.* Shukla and Anjaneyulu (1981a) found that the age of the plant has a profound influence on the disease spread. The spread was faster in 35, 45, and 55-day old crops of Taichung (Native) a and 35 and 45-day olf crops of Pankaj and Ratna rice cultivars than in older plants. The number of leafhoppers per plant and amount and source of virus inoculum have also a remarkable influence on the disease spread (Shukla and Anjaneyulu, 1982). The rate of tungro infection increased with the increase in leafhopper number from 0.1 to 5.0 leafhoppers per plant. It was found that even three leafhoppers per plant could spread the disease very fast and this number of leafhoppers was considered as the threshold level for tungro disease spread. The disease spread was very rapid even with 1.2% virus inoculum. The rice cultivars Taichung (Native) 1 and Jaya served as good sources of virus inoculum while Ratna and particularly IR 20 served as poor sources for disease spread.

Cultural practices such as time of planting (Shukla and Anjaneyulu, 1981b) and plant spacing (Shukla and Anjaneyulu, 1981c) also influence the rate of disease spread. Tungro disease incidence was greater in September, October, November, and December plantings, while it was either absent or negligible in January, February, June and July plantings at Cuttack. The rate of disease spread was slower under closer spacings than under wider spacings.

3) Disease epidemics

Tungro occurs in epidemic form in a cyclical pattern. Quick and efficient transmission of the virus by the vector *N. virescens,* stylet-borne nature of the virus in the vector, the occurrence of the vector in vast proportions, easy and rapid build-up of the vector under favorable conditions, quick movement and long distance migration of the vector, and susceptibility of newly introduced high-yielding cultivars appear to be greatly responsible for the occurrence of this disease in an epidemic form. For tungro epidemic, there should be a coincidence of vector population, virus inoculum, young stage of crop growth and susceptibility of rice cultivar. Delinking of any of these factors can eliminate the danger of tungro epidemic. Thus these factors coincide only in certain years and in such years tungro occurs in epidemic form. So far, no effective method of forecasting system has been developed in India. However, early rains in monsoon season might lead to tungro epidemic because the vectors will multiply early in the season and there will be a good amount of vector population during the young growth stage of the crop. Under these circumstances, an epidemic is likely to occur provided the virus inoculum is available.

7 Prevention and control

Rice varieties show wide variations in their tungro virus reaction. Excellent sources of resistance have been identified. By using field screening techniques developed at the Central Rice Research Institute, Cuttack, Anjaneyulu *et al.* (1982b) screened 5,560 germplasm collections and identified 78 tungro resistant donors, of which 43 did not show any visual symptoms, while susceptible Taichung (Native) 1 showed 100% infection. The highly resistant donors were Kataribhog, Habiganj DW 8, Ptb 18, ARC 7125, ARC 7140, ARC 10342, ARC 13560, ARC 13820, ARC 13901, and ARC 13959. Among the commercially released high-yielding rice cultivars, Annapurna, IR 20, IR 30, Pragati, Pusa 2-21, Pusa 33, Sugdass and Triveni were resistant. They have also identified 38 experimental cultures which have a high degree of resistance. Thus, tungro can easily be suppressed by growing resistant cultivars.

The alternative method of preventing tungro disease is by controlling tungro vectors through insecticides. To prevent tungro disease, an effective insecticide should possess quick knockdown effect in order to prevent virus infection and long persistence. Powerful repellents with strong fumigation action can also keep away the vectors from the plants. With these objectives in mind, extensive search has been made at the Central Rice Research Institute, Cuttack and as a result of this program several insecticides have been identified to prevent tungro disease. The most effective insecticides were carbofuran, a systemic granular insecticide (Shukla and Anjaneyulu, 1980), and cypermethrin, a synthetic pyrethroid (Satapathy and Anjaneyulu, 1984), which has a powerful repellent action. They have been identified as the best insecticides to prevent tungro disease by controlling the vectors. Some other insecticides reported to be effective in controlling the vector and reducing the disease incidence were FMC 35001, phosphomidon, oxydemeton-methyl, and bendiocarb (Satapathy and Anjaneyulu, 1983).

Grassy stunt

The Mundakan and Punja rice crops of Trichur and Kuttanad in Kerala state were severely damaged by an outbreak of brown planthopper and grassy stunt virus disease during 1973–74 (Anjaneyulu, 1974). Approximately 15,000 ha of rice were affected by grassy stunt virus disease in Kerala during 1973–74. There were no outbreaks of this virus disease thereafter.

1 Symptoms

The infected plants were severely stunted and bore an excessive number of tillers. The leaves were short, narrow, erect and pale green or yellow in color. Young leaves sometimes exhibited interveinal chlorotic mottling or stripes. Most of the old leaves had numerous characteristic dark brown spots of various dimensions. The diseased plants generally did not produce any panicles. Sometimes, a few worthless panicles with dark brown grains emerged from the diseased plants.

2 Transmission and virus-vector relationships

This disease was transmitted by the brown planthopper, *Nilaparvata lugens*. The incubation period of the virus ranged from 10 to 18 days in the vector and 6 to 10 days in the plant. The viruliferous hoppers after the incubation period could transmit the virus until their death

(Anjaneyulu, 1974).

Ghosh *et al.* (1979) tested the transmission efficiency of different forms of *Nilaparvata lugens*. Brachypterous males and females, macropeterous males, and nymphs transmitted the virus. Different forms of the vector differed in their transmission efficiency. The maximum percentage of transmission by *N. lugens* colony was 46. The pattern of transmission by nymphs and the male form brachypterous and macropterous insects was almost identical.

3 Varietal reaction

Rice cultivars IR 28, IR 34, IR 36 which were reported to be resistant to grassy stunt in the Philippines were susceptible in India (Ghosh *et al.,* 1979). IR 32 was resistant. A non cultivated rice species, *Oryza minuta* was also resistant to grassy stunt virus.

4 A new strain of grassy stunt

Mariappan *et al.* (1984) reported a new strain of grassy stunt virus in India. It is similar to grassy stunt virus, strain 2 in the Philippines. The identification of this strain was based on symptoms, serological tests and pathogenicity studies. *Oryza nivara* which was resistant to the original strain is susceptible to grassy stunt strain 2. The symptoms on *O. sativa* differed from those of the original strain. The symptoms resembled tungro. Plants showed mild stunting and increased tillering. The infected leaves exhibited a yellow-orange discoloration like tungro. A latex test indicated a positive reaction between the new strain in India and the grassy stunt strain of the Philippines.

References

1) Anjaneyulu, A. and John, V.T. (1972): Strains of rice tungro virus. Phytopathology, 62, 1116-1119.
2) Anjaneyulu, A. (1974): Identification of grassy stunt, a new virus disease of rice in India. Curr. Sci., 43, 416-417.
3) Anjaneyulu, A., Shukla, V.D., Rao, G.M. and Singh, S.K. (1982a): Experimental host range of rice tungro virus and its vectors. Plant Dis., 66, 54-56.
4) Anjaneyulu, A., Singh, S.K. and Shenoi, M.M. (1982b): Evaluation of rice varieties for tungro resistance by field screening techniques. Trop. Pest Managm., 28, 147-155.
5) Ghosh, A., John, V.T. and Rao, J.R.K. (1979): Studies on grassy stunt disease of rice in India. Plant Dis. Reptr., 63, 523-525.
6) John, V.T. (1968): Identification and characterization of tungro, a virus disease of rice in India. Plant Dis. Reptr., 52, 871-875.
7) Kondaiah, A., Rao, A.V. and Sreenivasan, T.E. (1976): Factors favouring spread of rice tungro disease under field conditions. Plant Dis. Reptr., 60, 803-806.
8) Mariappan, V., Hibino, H. and Shanmugam, N. (1984): A new rice virus disease in India. Int. Rice Res. Newslett., 9(6), 9-10.
9) Mishra, M.D., Ghosh, A., Niazi, F.R., Basu, A.N. and Raychaudhuri, S.P. (1973): The role of graminaceous weeds in the perpetuation of rice tungro virus. J. Indian Bot. Soc., 52, 176-183.
10) Prasauda Rao, R.D.V.J. and John, V.T. (1974): Alternate hosts of rice tungro virus and its vector. Plant Dis. Reptr., 60, 23-25.
11) Rao, G.M. and Anjaneyulu, A. (1978): Host range of rice tungro virus. Plant Dis. Reptr., 62, 955-957.
12) Raychaudhuri, S.P., Mishra, M.D. and Ghosh, A. (1967): Preliminary note on transmission of a virus disease resembling tungro of rice in India and other virus-like symptoms. Plant Dis. Reptr., 51, 300-301.
13) Satapathy, M.K. and Anjaneyulu, A. (1983): Evaluation of emulsifiable concentrate and wettable powder insecticides for control of rice tungro virus disease and its vector. J. Pl. Dis. Protect., 90, 269-277.

14) Satapathy, M.K. and Anjaneyulu, A. (1984): Use of cypermethrin, a synthetic pyrethroid, in the control of rice tungro virus disease and its vector. Trop. Pest Managm., 30, 170-178.
15) Singh, S.K., Bhaktavatsalam, G., Lapierre, H. and Anjaneyulu, A. (1984): Association of two types of virus particles in an isolate of rice tungro disease. Int. Rice Res. Newslett., 9 (2), 15.
16) Shukla, V.D. and Anjaneyulu, A. (1980): Evaluation of systemic insecticides for control of rice tungro. Plant Dis., 64, 790-792.
17) Shukla, V.D. and Anjaneyulu, A. (1981a): Spread of tungro virus diseases in different ages of rice crop. J. Pl. Dis. Protect., 88, 614-620.
18) Shukla, V.D. and Anjaneyulu, A. (1981b): Adjustment of planting date to reduce rice tungro disease. Plant Dis., 65, 409-411.
19) Shukla, V.D. and Anjaneyulu, A. (1981c): Plant spacing to reduce rice tungro incidence. Plant Dis., 65, 584-586.
20) Shukla, V.D. and Anjaneyulu, A. (1982): Effect of number of leafhoppers and amount and source of virus inoculum on the spread of rice tungro. J. Pl. Dis. Protect., 89, 325-331.

Discussion

Tantera, D.M. (Indonesia): What is the extent of the total area infected with tungro in farmers' fields in India?

Answer: I can not give you a precise estimate. Indeed tungro is an important disease in India which occurs every three to four years.

Hibino, H. (IRRI): In Cuttack, IR20 and IR30 which harbor resistance genes to tungro from TKM-6 are resistant whereas IR28 and IR29 which have resistance genes from Gampai are susceptible. I was informed that in South India in 1984, IR20 was severely infected with tungro while IR50 and IR56 which harbor Gampai genes were resistant. Do you know why the reaction of these varieties was different in Cuttack and in South India? Were IR28 and IR29 susceptible at the time they were introduced? How was the performance of IR20 and IR30 against tungro in South India at the time they were introduced?

Answer: This is an interesting question. Unfortunately I can not answer for the time being. I would like to mention that the cultivation of IR50 is not popular among the farmers as IR50 is highly susceptible to blast.

Ishikura, H. (Japan): Your presentation on the efficacy of cypermethrin and carbofuran to control tungro is most informative as in Japan the control of rice virus diseases is dependent on the use of pesticides to suppress the vector population. I would like to know how many applications of either cypermethrin or carbofuran you made to obtain the results you reported.

Answer: We applied carbofuran twice at 15-day interval. Cypermethrin persists in the plant for about 10 days and 2-3 applications are sufficient. Cypermethrin acts as a repellent and the insect is killed immediately (knockdown effect) before it transmits the virus to the plant (10 min duration is enough for the vector to inoculate the tungro virus to the plant).

Rossel, H.W. (IITA): I would like to emphasize that not only the knockdown aspect but also the persistency in the plant seems to make an insecticide suitable (effective) as a chemical control agent of persistently transmitted viruses like groundnut rosette, a disease which we studied in North Nigeria several years ago.