Green Leafhopper (GLH), *Nephotettix Virescens* (Distant) and Rice Tungro Disease (RTD)

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Abstract

The rice green leafhoppers (GLH) are one of the most devastating rice pests throughout the rice growing areas of Asia. Both nymphs and adults of the green leafhopper feed on rice by sucking the plant sap and plugging the vascular bundles with stylet sheaths. The onset of the tungro disease depends on the presence of a susceptible host, a virus source, and the vector. It is associated with two viruses—rice tungro bacilliform virus (RTBV) and rice tungro spherical virus (RTSV). Both viruses are transmitted by the green leafhopper (GLH) *Nephotettix virescens* (Distant). A direct correlation between vector population and disease incidence has been observed at different locations.

Keywords: Rice tungro disease (RTD), green leafhopper (GLH), *Nephotettix virescens* (Distant), transmission

1. Introduction

Disease spectrum and intensity are continuously changing because of the dynamic nature of crop systems, pests and pathogens. Thus, disease management has become the major functional component of the crop production systems. Over 800 species of insects in rice ecosystems have been reported worldwide. Out of these, 100 species attack rice while the rest are considered as friendly insects[1]. Almost 20 insects are considered as rice pests of economic importance that include stem borers, gall midge, defoliators and vectors like leafhoppers and plant hoppers that cause direct damages and transmit various diseases[2].

2. The Green leafhopper (GLH)

The green leafhopper, *Nephotettix virescens* (Distant), coming under the subfamily Deltocephalinae of the family Cicadellidae, is considered as a serious pest of rice in many rice growing countries. Among the reported *Nephotettix* species, six are known to Asian regions and two in Africa. In *Nephotettix virescens* the vertex is unmarked with distinctive furrows which is longer in the middle than next to eyes and is pointed in most specimens. In some males usually head, pronotum and scutellum are green in colour but some have black marking nearer to ocelli. The colour of subgenital plate of the male genitalia is off-white and is partly black. Male pygofer is rounded with one long and four small spines. The middle of the shaft of the aedeagus bears 3–5 pairs of spines[3]. The number of spines on the male aedeagus is a distinctive character of the *Nephotettix virescens* which separates it from other *Nephotettix* species[4].

The rice green leafhoppers (GLH), are one of the most devastating rice pests throughout the rice growing areas of Asia[5,6]. The insect feeds mainly on the adaxial surface of the leaf blade and rarely on the leaf sheath[7]. The insect causes direct damage to the rice plant by sucking the sap from vascular tissues and reduces the vigour, number of tillers and yield of rice[8]. Both nymphs and adults of the green leafhopper feed on rice by sucking the plant sap and plugging the vascular bundles with stylet sheaths. They cause damage to the rice crop by either directly sucking the sap or indirectly by transmitting virus diseases such as dwarf, transitory yellowing, tungro, yellow dwarf and yellow-orange leaf [9].

The population densities and abundance of *Nephotettix* sp is varied due to the flight activity of *Nephotettix* which is influenced by seasonal and meteorological factors and their relationship varies depending upon the location too[10]. The emergence of GLH into a major pest has been commonly attributed to the introduction of high yielding rice cultivars and the accompanying high N application[11].

3. Rice Tungro Disease

Rice tungro disease (RTD) accounts for $1.5 billion annual loss in rice production worldwide[12]. The epidemics of tungro disease in the last century caused famines and great loss of human life[13]. So insects cause millions of dollars' worth of losses annually to food crops and other plants all over the world. A majority of cereal viruses are disseminated among

plants by insect vectors. Exploitation of natural resistance genes against cereal viruses is one of the most practical ways to manage cereal viruses in fields. However, the sources of natural resistance genes are very limited or lacking for many viruses and the durability of some natural resistance genes is often questionable[14].

The onset of the disease depends on the presence of a susceptible host, a virus source, and the vector. The availability of virus inoculum, a high population of GLH, and early growth stage of the crop are responsible for a disease outbreak[15]. It was observed that adult GLH plays an active role in introducing primary inoculum to the field, whereas both nymphs and adults help in further secondary spread[16]. A direct correlation between vector population and disease incidence has been observed at different locations[17,18]. High vector populations[19] and a large proportion of viruliferous vectors[20] also play an important role in disease outbreaks. The presence of viruliferous GLH is one of the most important factors that cause RTD incidence

4. Tungro Disease in India

The disease attracted the public attention for the first time following an epidemic outbreak in the eastern parts of Uttar Pradesh and Bihar as early as in 1968[21,22]. In India three major epidemics in farmers' fields during 1984, 1988 and 1990 caused severe quantitative and monetary losses. In 1981 the disease incident ranged 40-100% in Bihar and 60-100% in West Bengal[23]. Now this disease is fairly wide spread in rice growing areas of India. An epidemic outbreak of tungro during 2001 in three districts of West Bengal caused an unmilled rice production loss of 0.5 mt valued at Rs 2911 million[24]. At early stage the infection may result 100% yield loss[25].

5. Symptoms in Rice Plants due to Tungro

Plants infected with rice tungro virus showed marked stunting, yellow to yellow-orange leaf discolouration and reduced ear-bearing tillers. The panicles in diseased plants are often small, sterile and incompletely exerted. Grains in such panicles are covered with dark blotches, and show reduced weight[26]. Also it is reported to reduce the number of panicles and spikelets, and decrease grain-filling, grain-weight yield and starch content in the grains[27,28].

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6. Transmission of the Rice Tungro Disease

Rice Tungro disease (RTD) spreads very fast during the early growth stage of the crop[18]. Hence, it is essential that rice seedlings be adequately protected from tungro infection. This

can be achieved by applying insecticides in seedbeds to kill immigrant vectors to prevent virus transmission. A seedbed protection trial was therefore conducted to study the effect of nursery protection on the incidence of GLH and RTD.

Rice virus diseases are considered as the most serious threat to rice yields. Most rice viruses are transmitted by hemipteran insects such as planthoppers and leafhoppers. The leafhopper transmitted tungro virus results in one of the most economically important and wide spread viral disease of rice. As the most devastating viral disease of rice in South and Southeast Asia, rice tungro disease is one of the significant fears to sustainable annual rice productions in the world[29].

Rice tungro disease (RTD) caused by the co-infection of rice tungro bacilliform virus (RTBV) and rice tungro spherical virus (RTSV) is a devastating viral disease of rice prevalent in Southeast Asia with outbreaks affecting thousands of hectares[30,31]. The virus is transmitted mainly by green leafhopper (GLH) *Nephotettix virescens* (Distant) and *Nephotettix nigropictus* (Stal)[32,33]. *Nephotettix virescens* Distant is the most efficient vector of tungro virus with transmission ability of 80% approximately[17]. RTD is caused by *Rice tungro bacilliform virus* (RTBV) and *Rice tungro spherical virus* (RTSV). Both RTSV and RTBV are transmitted by green leafhoppers (GLH) in a semi-persistent manner[34]. RTSV is independently transmitted by GLH, whereas RTBV can be transmitted by GLH only in the presence of RTSV[35,36,34].

RTBV is a double stranded (ds) DNA genome virus and a member of the Tungrovirus genus in the Caulimoviridae family with particles sizes of 100-300 nm in length and 30-35 nm in width. On the other hand, RTSV is a single-stranded (ss) RNA virus and a member in the genus of Waikavirus (Sequiviridae). Virus particles are polyhedral and about 30 nm in diameter[37]. The virus infection results a drastic reduction in chlorophyll, amount of sugar increase whereas starch decrease in the grain. There are 5 strains RTV1, RTV 2A, RTV 2B, RTV 3 and RTV 4 of the virus. Electron Microscope reveals that the virus occurs independently or in aggregation inside the phloem tissue[38].

7. Recent Methods of Tungro Disease Control

Host plant resistance is the most economically and environmentally sound pest management strategy[39,40,41,42]. It is compatible with other management strategies like biological control. Different rice varieties show different reactions to tungro infection[43]. Reviews of tungro

disease management strategies employed in India, Indonesia, Malaysia and the Philippines emphasized the increasing importance attached to preventive measures such as varietal resistance and cultural control. Diversity analysis for resistance to rice Tungro disease (RTD) among some advanced breeding lines and cultivars of rice (*Oryza sativa* L.) using mass screening and forced inoculation methods with the insect vector, green leafhopper (GLH), showed considerable variation among the rice genotypes[44]. Pathogen-derived resistance against RTD was reported as being only partially effective[45]. Studies involving an RNAi construct are encouraging[46,47]. Recent studies indicated that transgenic rice plants carrying an inverted repeat of 500-bp fragments encoding various proteins of RTSV can produce small interfering RNA from the hairpin RNA transcribed from that transgene. Compared to other contemporary studies with other viruses, it is possible that some of these transgenic rice lines might be resistant to RTSV[48].

8. Conclusion

Several studies and reviews suggest that more research is needed to elucidate the interaction components between the host, virus and vector that can be used to engineer tungro disease resistance.[35,49,50,33,42] . Collaboration between entomologists and plant breeders in the screening of rice varieties for resistance to rice tungro disease (RTD) as well as documenting the interaction with the insect pest, green leafhopper (GLH) *Nephotettix virescens* (Distant) must be strong. The continued RTD surveillance over the years will ensure close monitoring of the disease development and minimization of crop lose by taking appropriate eradication actions[51].

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