

## Introduction

There are five key species of plant and leaf hoppers which are known to be important pests of rice in Asia and Australasia.

They belong to two families, the Delphacidae and Cicadellidae. Delphacidae includes the brown planthopper (*Nilaparvata lugens*), small brown planthopper (*Laodelphax striatellus*) and whitebacked planthopper (*Sogatella furcifera*) which tend to inhabit the base of the plant, whilst the green paddy leafhopper (*Nephotettix virescens*) and rice green leafhopper (*Nephotettix cincticeps*) from the Cicadellidae family tend to inhabit the upper parts of the plant.

Both families are economically important pests of rice, when favourable conditions allow them to reach high infestation levels. All the species feed by the insertion of stylet mouth parts into the plant phloem tissue and damage is caused by either direct sap loss or through the injection of toxic saliva. The distinctive browning and wilting of rice plants, which is caused by hopper infestation is commonly known as 'hopper burn'. Plant and leafhoppers are also known to transmit various plant viruses such as grassy stunt and rice-stripe cereal mosaic.

Treatment with insecticides has been the primary control option for growers, with systemic insecticides more favoured in recent years. However the selection of resistant plant varieties and use of biological control agents are also important control method for these pests.



## Insecticide Resistance

Insecticide Resistance has been recorded in rice hopper species since the early 1960's, when organophosphates, carbamate and cyclodiene organochlorine insecticides were the main methods of chemical control. Although further insecticide chemistry has been introduced to control hoppers, the importance of rice as a staple food crop and the reliance on insecticides for the control of insect pests has seen the continued evolution of insecticide resistance. The most recent developments have seen populations of *Nilaparvata lugens*, *Laodelphax striatellus* and *Sogatella furcifera* independently develop resistance to neonicotinoid and phenylpyrazole insecticides. At the time of writing there is no evidence of a common cross-resistance between chemical classes of insecticide across these species, however there is evidence that individual hoppers may exhibit multiple mechanisms of resistance to one or more insecticide modes of action.

**Table 1: Insecticide modes of action to which field collected rice hoppers have been reported in literature as being (1960-2010).**

Insecticide Chemistry	Mode of Action	<i>Nilaparvata lugens</i>	<i>Laodelphax striatellus</i>	<i>Sogatella furcifera</i>	<i>Nephotettix virescens</i>	<i>Nephotettix cincticeps</i>
Carbamates	1A	X	X	X	X	X
Organophosphates	1B	X	X	X	X	X
Cyclodiene organochlorines	2A	X	X			
Phenylpyrazoles (Fiproles)	2B	X	X	X		
Pyrethroids	3A	X	X	X		
Neonicotinoids	4A	X	X	X		
Selective Feeding Blockers	9B & 9C					
Chitin Biosynthesis Inhibitor	16	X	X	X		

The information presented in this table is based on peer-reviewed published reports of field collected populations of rice hoppers being isolated at a specific time and location before being tested for insecticide susceptibility. Insecticide resistance is a dynamic process, and therefore, the information provided does not reflect the current status of insecticide resistance in all countries or locations.

## Distribution & Migration

**Table 2: Recorded regional range of different rice hoppers.**

The regional range of each of the five key species of rice hoppers varies and in many cases over-lap. Many of the species are migratory in nature and therefore each species may not reach pest status in all of its range every year.

The brown planthopper (*Nilaparvata lugens*) for example is recorded as being an immigrant pest in China, Japan and Korea after migrations from tropical and sub-tropical regions of S.E. Asia. Infestation levels in these countries are often dependant on environmental conditions throughout the region.

	<i>N. lugens</i>	<i>L. striatellus</i>	<i>S. furcifera</i>	<i>N. virescens</i>	<i>N. cincticeps</i>
Japan	X	X	X	X	X
Korea	X	X	X		X
Taiwan	X	X	X	X	X
China	X	X	X	X	X
Philippines	X	X	X	X	
Vietnam	X	X	X	X	
Laos	X	X	X	X	
Cambodia	X	X	X	X	
Thailand	X	X	X	X	
Myanmar	X	X	X	X	
Malaysia	X	X	X	X	
Indonesia	X	X	X	X	
Australia	X	X			
India	X	X	X	X	
Pakistan	X	X			
Pacific Islands	X	X			

## Resistance Management

As there is no evidence of cross-resistance amongst the groups insecticides used for rice hopper control, it is recommended that the rotation of effective insecticides with different modes of action are used to provide insect control, whilst at the same time reducing the risk of insecticide resistance from developing. The following should be considered when designing an insect control program for rice hoppers:

- Plan ahead. Determine when in a typical season insecticides applications are likely to be needed and plan for the rotation of insecticides with different modes of action, avoiding the consecutive use of products belonging to the same mode of action group. Plan for contingencies in case extra applications are needed due to untypical pest infestations. Consider the presence of other insect pests of rice (e.g. stem borers or leaf folders) and required treatments.
- Determine which insecticides are most effective for controlling each rice pest during each application timing. If the presence of other rice pests over-lap with rice hoppers, consider using pest specific insecticides rather than broad spectrum insecticides, which may increase unnecessary resistance selection pressure for either or both pests.
- Evaluate the current insecticide resistance situation in the area (consult local crop advisors and experts). Avoid using insecticides already affected by resistance where possible.
- Consider the impact of the insecticides on non-target insects and natural predators, especially during early season applications, where maintaining natural predators can reduce the need for later sprays.
- Consider the use of insect-resistant rice varieties and the use of biological control agents.
- Always follow insecticide label instructions for application timings, volumes and concentrations.

## Susceptibility Monitoring

The topical application of insecticides using a syringe, as described by multiple researchers has proved to be a useful bioassay in determining the susceptibility of insecticides, which have strong contact activity against rice hoppers. Extensive monitoring programs have been conducted across the host range of these pests with neonicotinoid, carbamate, phenylpyrazole and buprofezin insecticides.

Alternatively leaf dip assays, as described in the IRAC approved method No. 005, provide a method of assessing the activity of all insecticides which are utilised for the control of planthoppers, including pymetrozine, which primarily acts by reducing feeding and egg lay. A video of this method is available via the IRAC web-site.