Insecticide Resistance Action Committee

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Introduction

There are five key species of plant and leafhoppers 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. 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 planthopper infestation is commonly known as `hopper burn`. Plant and leafhoppers are also known to transmit various plant viruses such as rice ragged stunt, rice grassy stunt, southern rice black-streaked dwarf, rice tungro bacilliform, and rice-stripe virus.

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

Insecticide Resistance

Insecticide Resistance has been recorded in rice hopper species since the early 1960's, when organophosphate, carbamate and cyclodiene organochlorine insecticides were the primary chemical classes used. The importance of rice as a staple food crop has continued the reliance of insecticides for the control of hopper pests and resulted in the evolution of insecticide resistance, in spite of new insecticide class introductions. The most recent development of resistance has been of populations of *Nilaparvata lugens, Laodelphax striatellus* and *Sogatella furcifera* independently to neonicotinoid and phenylpyrazole insecticides. At the time of writing there is no evidence of cross-resistance 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 which are registered for the control of rice planthoppers and leafhoppers and reports in literature of resistance from field collected insects (1960-2019).

IRAC Mode of Action Group	Insecticide Chemistry	Mode of Action	*Nilaparvata lugens*	*Laodelphax striatellus*	*Sogatella furcifera*	*Nephotettix virescens*	*Nephotettix cincticeps*
Group 1: Acetylcholinesterase (AChE) inhibitors	Carbamates	1A	X	X	X	X	X
	Organo-phosphates	1B	X	X	X	X	X
Group 2: GABA-gated chloride channel blockers	Cyclodiene organochlorines	2A	X	X			
	Phenylpyrazoles (Fiproles)	2B	X	X	X		
Group 3: Sodium channel modulators	Pyrethroids	3A	X	X	X		
Group 4: Nicotinic acetylcholine receptor (nAChR) competitive modulators	Neonicotinoids	4A	X	X	X		
	Sulfoximines	4C					
	Mesoionics	4E					
Group 9: Chordotonal organ TRPV channel modulators	Pyridine azomethine derivatives	9B					
Group 16: Inhibitors of chitin biosynthesis, type 1	Buprofezin	16	X	X	X		
Group 28: Ryanodine receptor modulators	Diamides (cyantraniliprole)	28					
Group 29: Chordotonal organ modulators – undefined target site	Flonicamid	29					

Distribution & Migration

The regional range of each of the five key species of rice hoppers varies and often overlap. Many of the species are migratory in nature and therefore each species may not reach pests 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 Southeast Asia. Infestation levels in these countries are often dependant on environmental conditions through-out the region.

Table 2: Recorded regional range of different rice hoppers.

	N.Lugens	*L.striatellus*	*S.furcifera*	*N.virescens*	*N.cincticeps*
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

There is no evidence of cross-resistance among the groups of insecticides used for rice hopper control, thus it is recommended to rotate effective insecticides of different modes of action. Effective rotation of mode of action groups will reduce the risk of insecticide resistance from developing. Rotation of insecticides between sub-groups should be left in the case that no effective partners exist between mode of action groups. 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. Stemborers or leaffolders) 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 overlap 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

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, especially those with 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 any insecticide, regardless of the primary mechanism of exposure. Leaf dip is a common assay for pymetrozine, which primarily acts by reducing feeding and egg lay. A video of this method is available on the IRAC web-site.

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