Conclusion

There is no doubt that pesticides are to be the last input in the agricultural process but are also important for the present sustainable production of rice. Despite the fact that they are hazardous, we have to handle them very carefully to harness maximum good out of it. But at the same time, the present world has recognized the immense value of human health which is bonded with environment and food. The world is moving towards an insecticide-free rice with safest crop protection strategy. It is only possible when the exact alternative of these compounds will be worked out. So, continuous effort should be in progress to develop eco-friendly control methods such as insect resistant/tolerant varieties packaged with other safe control measures.

Good Practices of Pesticide Use for Managing Rice Pest

NRRI Technology Bulletin - 133

Editing and layout : GAK Kumar and Sandhyarani Dalal
Photography: Guru P. Pandi and M. Jena

BSCIC NABCB QM 030 ISO 9001 REGISTERED BN10448/9364:0914

Laser typeset at the National Rice Research Institute, Indian Council of Agricultural Research, Cuttack (Odisha) 753 006, India and printed at Printech offset, BBSR. Published by the Director, for the National Rice Research Institute, Cuttack (Odisha) 753 006.

Good Practices of Pesticide Use for Managing Rice Pest

Totan Adak, Mayabini Jena, PC Rath, Guru P Pandi, Basana Gowda G, NKB Patil, Annamalai M and P Golive

Pests and pesticides are two important aspects bothering rice farmers, researchers, policy makers and even pesticide industry today. In this era of high yielding rice varieties, also is visible inside the country a yearn for traditionally grown rice and a rising demand for pesticide-free rice. The silhouetted picture of a bowl of rice grown with naturopathy has started taking a form of green rice or organic rice and is still waiting to pave its way to a larger form. Grand maa's story about "A grain as big as a hen's egg" and "grandfather healthier than grandson", which was based on safe agriculture with ecological balance is now no more a story for small children but has become a demanding aspiration of the whole world. The robust insecticidal technology for crop pest control, particularly in rice, has definitely contributed towards increasing the food grain production of the country. But in turn, it has entered to the core of agricultural system as an Octopus engulfing the entire pest control strategy and entangling the ecology with poisonous effects. No matter how much has been said on the role of chemical pesticides for increased food production and safe limits of use but the real scenario is scary as far as the general public is concerned. The voice of Rachel Carson in 'Silent Spring' raised in the western part of the world during 1962, is not silent till today. Rather, it's voice has become louder and louder day by day in each direction. And today, it is ringing a bell in our ears. Why is it so?

If we look back and analyse, the past history of human civilization was also not devoid of chemicals. It dates back to 4,500 years, when the Sumerians used sulfur compounds as insecticides. The Rig Veda, which is about 4,000 years old, also mentions the use of poisonous plants for pest control. Ancient Chinese and Egyptian cultures are known to have used chemicals to control their pests. The pre-world war era was characterized by first generation pesticides of natural chemicals from plants and other living organisms. The pesticidal property of different plants is reported in Arthasashtra (Kautilya's period) and Ayurveda (Sushruta, 1000A.D.). Some of the potential botanical products during the pre-world war period were nicotine from ***Nicotiana tabacum***, rotenone from ***Derris elliptica***, and pyrethrin from ***Crysanthemum cineraraefolium***. The only aim at that time was to control the destructive insects. But the period is also marked for insufficient food grain production. There was a clearcut difference between 'have's and 'have not's.

Invention of DDT during the year 1939 opened up a new vista for pest management in different crops including rice. It started the era for second generation pesticides and has transformed the post-world war era into a period of pesticides. Synthetic chemical pesticides made their entry to rice farming in different forms and figures. Many commercially available chemical insecticides flooded the market. They were made easily available and were reliable for emergency action. The adoption for those insecticides spread to every agricultural sector and their contribution for bringing green revolution to the country was greatly acknowledged. In India, insecticides have the largest share in domestic consumption followed by fungicides and herbicides mainly because India's tropical climate is conducive for growth and multiplication of insects. Out of total pesticides consumed in agriculture, rice has the share of about 23%. According to the experts, about 10 - 30% food grain losses can be saved by the use of insecticides.

Present status of insecticide usage

If we analyse the present status of insecticide availability in India, there are 282 pesticides registered for use, and their production has increased to approximately 82,185 metric tonnes (CIB & RC, 2013). Out of these pesticides, about 43 insecticides including bio-pesticides are recommended for rice in different formulations and doses (Table 1).

Table 1. Insecticides recommended for rice insect pests & field rodents.

Insecticide name	LD 50 (oral) (mg/kg body)	Colour code	Recommended against rice pests
Acephate	945	Blue	Stem borer, Leaf folder, Plant hoppers, GLH
Acetamiprid	146	Yellow	YSB, BPH, LF
Aluminum phosphide	8.7	Red	Rice weevil, Rice Moth
Azadirachtin (neem products)	4241	Blue	Thrips, Stem borer, BPH
Benfuracarb	205	Yellow	Stem borer, Leaf folder, BPH
Bifenthrin	54.5	Yellow	Stem borer, LF, GLH
Bromadiolone	>0.56	Red	Field rats, Large bandicota, Indian house rat
Buprofezin	>2198	Blue	BPH, GLH, WBPH
Carbaryl	614	Blue	LF, BPH, Blue jassid, Case worm
Carbosulfan	101	Yellow	Stem borer, Gall midge, GLH, LF
Cartap hydrochloride	325	Yellow	Stem borer, Leaf folder, Whorl maggot
Chlorantra-niliprole	>5000	Green	Stem borer and Leaf folder
Chlorpyrifos	66	Yellow	Stem borer, Leaf roller, Gall midge, Hispa, Whorl maggot, GLH, BPH, Grasshopper
Chromafenozide	>5000	Green	LF, Stem borer
Clothianidin	>500	Blue	BPH, GLH, WBPH
Deltamethrin	87	Yellow	Stem borer, LF, Whorl maggot, Rice weevil, Rice moth, Red flour beetle
Dichlorvos	80	Yellow	BPH
Dinotefuran	>2000	Blue	BPH
Ethofenoprox	42800	Green	BPH, Stem borer, LF, Gall midge, Whorl maggot, GLH, WBPH

Fenobucarb	620	Blue	BPH, GLH, WBPH
Fipronil	92	Yellow	Stem borer, BPH, GLH, Gall midge, Whorl Maggot
Flonicamid	884	Blue	BPH, WBPH, GLH
Flubendiamide	>2000	Blue	Stem borer, Leaf borer
Imidaclopride	131	Yellow	BPH, WBPH, plant hoppers, thrips, GLH, Stem borer
Indoxacarb	179	Yellow	Leaf Folder, Piller, Green semilooper, Stem fly
Lambda-cyhalothrin	56	Yellow	Stem borer, Leaf folder, GLH, Gall midge, Hispa, Thrips
Malathion	1778	Blue	Hispa
Methyl bromide	214	Yellow	Rice weevil, Red Flour Beetle, Khapra beetle
Methyl parathion	18-50	Red	Ear head caterpillar, Ear head bug, Leaf roller, Gall midge, GLH, Hispa, Leaf roller, Stem borer, Whorl maggot
Monocrotophos	14	Red	BPH, GLH, Leaf roller/ folder, YSB
Oxydemeton methyl	48	Red	Blue leaf hopper, White leaf hopper
Phenthoate	249	Yellow	case worm
Phorate	2	Red	Gall fly, Hispa, Leafhopper, Plant hopper, Stem borer, Root weevil
Phosphamidon	7	Red	Stem borer, Leaf borer, GLH, BPH, WBPH
Pymetrozine	5820	Green	BPH
Quinalphos	71	Yellow	BPH, Leaf roller, Stem borer, Hispa, Gall midge, GLH
Thiacloprid	444	Yellow	Stem borer
Thiocyclam hydrogen oxalate	399	Yellow	Stem borer, Leaf folder
Thiamethoxam	>1563	Blue	Thrips, GLH, BPH, Stem borer, Gall midge, WBPH
Triazophos	66	Yellow	Stem borer, Leaf folder, Hispa, BPH, WBPH

Pesticide mixtures

Pesticide mixtures	Effective against
Acetamiprid 0.4%+ Chlorpyriphos 20% EC	Stem borer, Brown Plant Hopper(BPH), White Backed Plant Hopper (WBPH)
Buprofezin 9%+Acephate 24% w/w WP	Brown Plant Hopper
Buprofezin 15% + Acephate 35% w/w WP	BPH, WBPH
Buprofezin 20% + Acephate 50% w/w WP	Stem Borer, Leaf Folder & Brown Plant Hopper
Buprofezin 22% + Fipronil 3% SC	Brown Plant Hopper
Chlorpyrifos 50% + Cypermethrin 5% EC	Stemborer, Leaffolder
Deltamethrin 0.72% w/w+ Buprofezin 5.65% w/w EC	Brown Plant Hopper, Leaffolder
Ethiprole 40 + Imidacloprid 40% WG	BPH, WBPH
Fenobucarb 20% + Buprofezin 5% w/w SE	Yellow stem borer, Leaf Folder, BPH
Flubendiamide 3.5% + Hexaconazole 5% w/w WG	Stem borer, Leaf folder
Fipronil 4% + Thiamethoxam 4% w/w SC	Brown Plant Hopper, Green Leaf Hopper & White Backed Plant Hopper
Imidacloprid 6% + Lambdacyhalothrin 4% SL	Stem borer, Hispa, Plant Hopper & Gundhi Bug
Phosphamidon 40% + Imidacloprid 2% SP	Brownplant hopper, Greenleaf hopper, Stemborer
Acetamiprid 0.4%+ Chlorpyriphos 20% EC	Stem Borer, BPH & WBPH
Chlorantraniliprole 0.5% w/w + Thiamethoxam 1.0 % w/w GR:	Stem borer, Leaf Folder, Brown Plant Hopper, Green Leaf Hopper

Source : CIB and RC, 2013

As far as highly toxic insecticides are concerned, the organochlorines comprising of chlorinated hydrocarbons and cyclodienes as well as their functionally related groups such as DDT, HCH, methoxychlor, aldrin, dieldrin, endrin, heptachlor, endosulfan, toxaphene, mirex, strobane are highly persistent both in the environment and biological systems and help in developing insecticide resistance. Among organophosphate insecticides, which includes phosphates, phosphorothionates, phosphorothiolates, phosphonates, phosphorodithioates and others such as trithioates, amidates, anhydrides, etc. are equally or even more toxic to parasitoids and predators than to insect pests. Therefore, pest resurgence and outbreak of secondary pests is more frequent. Insecticide resistance is also quite common with this group. Carbamates (Methyl carbamates and Oximes) have the major limitation of high toxicity to parasitoids and predators. The limitation of early photodegradable analogues (Allethrin, resmethrin, tetramethrin, prothrin) and new photostable analogues of synthetic pyrethroids (Phenothrin, permethrin, cypermethrin, deltamethrin, fenvalerate, fluvalinate, fenpropathrin, flucythrinate, fenfluthrin, tralocythrin, ethofenprox) are also many. Their repeated use results in outbreak of mites, aphids, white flies etc. Rapid development of insecticide resistance in insect pests is probably due to their low mortality. Margin of safety to plants is less. Therefore, repeated applications may also result in phytotoxicity. The other groups evolved afterwards like amidines (Chlordimeform, Amitraz), Neonicotinoids (Imidacloprid, Clothianidin, Diamide group), Phenylpyrazole (Oxadiazine group, Fipronil) are still in the process of public use and their limitations are being scrutinized in the long run. New research pointed out neonicotinoids as potential toxic chemicals against honeybees and other beneficial insects. Generally, most of the pesticides considered hazardous are already banned and some of the commonly used broad spectrum insecticides are under severe restriction.

In India, around 40 per cent of the total cultivated area is treated with the pesticides. Approximately, 65-70 per cent of the cultivated area treated with pesticides is irrigated. The production of pesticides started in India in 1952 and at present, India is the fourth largest global producer of agrochemicals after US, Japan and China.

These pesticide industries had a value of USD 4.4 billion in financial year 2015 and are expected to grow at 7.5% per annum to reach USD 6.3 billion by financial year 2020 (FICCI report 2016). If we compare the quantity of insecticide-use in India with other countries, the scenario is quite safe. Far less pesticide is used in India (about 0.48 Kg/ha) in comparison to other countries like Taiwan, Japan, China, Holland, South Korea, France, USA, Thailand and Pakistan. But still, the question arises that when the quantity of pesticides used in India is very low as compared to other developed countries and the hazardous insecticides are already banned or restricted, why we have much higher pesticide residues in the food of our country? Have we increased our pesticide application now? If not, then what are the factors contributing to such hazardous situation?

Constraints in pesticide use

A critical examination on these aspects in relation to rice brings about certain facts. They are-

a) **Changed insecticide market:** The most important drawback in the present insecticide-market scenario is that most of the commonly used insecticides such as carbaryl, quinalphos, monocrotophos, carbofuran, methyl parathion etc. are either banned, restricted or are in the verge of fading away from the market. New compounds like imidacloprid, ethofenprox, thiamethoxam, fipronil etc. have been prescribed to rice pest management system. But they are not able to reach every corner of rice growing areas due to their availability in the market and high price. So they are becoming practically unavailable to farmers compelling them to use available but un-prescribed pesticides.

b) **Ignorance of users:** Though many insecticides are banned or restricted, which were existing in the market and farmers' use for a long period, farmers of rural and tribal areas of the country are unaware of the situation. Insecticides with the same name are still available with local insecticide dealers and are also used by the farmers. Such unauthorized spurious insecticides are posing more damage to human health and environment in the interior hilly and tribal areas during the recent years.

Most of the available chemicals are either synthetic pyrethroids or combination of synthetic pyrethroids with organophosphate insecticides and with alluring names such as 'Ustad', 'Toofan', Rocket etc. These products are not effective against major rice pests even after repeated applications and Ustad is very often used by the youth of tribal and rural areas for fish-catch which is of serious concern.

c) **Excessive use of granules:** Granular formulation of insecticides are being widely used now by the farmers due to its easy application method. As they are applied to soil directly, they are reported to leach down to the groundwater pollution. Again, selection within granules is always for a cost-effective product such as phorate, which, though highly toxic to target pest, also is equally toxic to non-target organisms like fish, crab, water snake, frog, earthworm etc. As a result, the ecological balance is altered increasing the risk to rice ecology along with adding substantially to ground water pollution. Once ground water is polluted with toxic chemicals, it may take many years for the contamination to dissipate or be cleaned up. Cleanup may also be very costly and complex, if not impossible.

d) **Destruction of beneficial organisms:** In the process of crop protection, beneficial organisms in rice ecosystem, particularly the predators and parasites of rice insect pests, are being reduced or destroyed by chemical insecticides. It was observed that application of phorate granule drastically reduces earthworm population in rice field whereas repeated foliar spray of chlorpyrifos causes fish mortality in the nearby ponds or water pits of the village. Those contaminated fish are either consumed by the local people or are in sale in the nearby market leading to health hazards.

e) **Development of tolerance by insect pests:** The most subject of concern is that due to prolonged use of these chemicals, tolerance is being developed by insects to certain pesticides gradually necessitating frequent increase in dose and number of application which is further adding to pollution of the environment.

Regulation in pesticide usage

a) **Regular verification of toxicity:** An Expert Committee was formed on 8th July, 2013 to examine the continuous use of or otherwise of neonicotinoid pesticides registered in India. The mandate of the Committee, on 19th August, 2013, was further expanded to review 66 pesticides which are banned or restricted or withdrawn in other countries but continue to be registered for domestic use in India. The committee after detailed examination, submitted its report to the Central Government on the 9th December, 2015 basing on which government has banned 12 pesticides with immediate effect (from August 9, 2018) and ban on another six will be implemented from December 31, 2020. The ban applies to registration, import, manufacture, formulation, transport, sale and use of all these pesticides. Similar set up should be there to evaluate all the pesticides in every 10 years after its release. New science and chronic effect will come into play for its right use.

b) **Implementing the regulation:** India's regulation (Insecticide Act' 1968 or Rule or draft of Pesticide Management Bill' 2017) is very strict in paper but very weak in implementation. Few of the regulations are not followed till date. For example, pesticides should be used in the crops which have label claim to that particular crop. But at farm level, there is no such mechanism to regulate this issue which aggravates the problem like residue at global level. One of the major reason of pesticide residues in food products is due to use of non-recommended pesticides.

c) **Regulating pesticide retailers:** Another biggest flaw in pesticide usage is due to the pesticide retailers who remain at the bottom of pyramid and interact with farmers on daily basis. There should be some stringent action to regulate the pesticide retailers who themselves recommend the pesticides to the farmers. Proper training should be imparted to the personnels involved in this business before actually granting the license. Another important aspect to check the retailers selling non-recommended and spurious pesticides is to digitalize the entire process of sale.

d) Identification of non-pesticide areas: Since rice is also cultivated in unfavorable lowland situation with stagnant water during wet season, pesticide application becomes less effective for insect pests but more hazardous for users. Likewise, tribal farmers show reluctance to use pesticides in their rice crop. Perhaps that is also a reason that in India, the trend shows maximum pesticide use in some of the northern states whereas it is very less in north-eastern and other tribal dominated region. Those areas may become the target for insecticide hazard as they misuse it as a bait for fish or bird killing.

Strategies to manage pesticides for better use

The overall picture gives us an indication of ignorance, poor economy of farmers which leads to less use, over use and misuse of insecticides. But, it is also not possible to dispense pesticides immediately or in near future unless we have appropriate alternatives for pest control. So, our pesticide application method should be regulated with proper procedure and be complemented with other control measures to achieve the purpose for judicious use of pesticides. Some important steps to be taken are-

a) Bridging the knowledge gap: The insecticide market has gone through a vast change during 1960 - 2019. The commonly used 2nd generation pesticides, which were dominating for about 3 decades, has got replaced by 3rd and 4th and newer generation pesticides so quickly that this change of insecticide group perhaps formed a gap of it's knowledge for proper use among the farmers. This gap should be filled up by dissemination of knowledge through training, demonstration, popular articles, news, media etc.

b) Access to quality pesticides: Non-availability of quality products in rural or interior areas is a major problem for over use of pesticides or mis-use. There should be enough provision in different government programmes to demonstrate quality pesticides in their proper time of application with proper formulation and dose.

c) Pesticides for pest complex: The eco-friendly pesticides and low dose-high efficacy products introduced to the insecticide market at present are mostly specific target oriented products and they are weak in addressing the complex pest situation occurring in paddy. Some broad spectrum insecticides should be selected for this purpose.

d) Spurious Chemicals: Spurious chemicals are reported very often which are floating in the market as well as in interior rural areas. They are to be identified and strongly dealt with stringent action.

e) Pesticide application with pest scenario: The change of pest scenario in rice is also a factor in changing the application pattern of insecticides and their efficacy. The interference of climatic hazards like drought and erratic rainfall during the crop period requires in-depth study of persistent toxicity of insecticides on crop as well as against the target pests. Emphasis is to be given on selection of proper pesticides, their dose, time, and mode of application, their effect on earthworms as well as beneficial soil fauna and residues they leave in food chain.

f) Pesticide application in IPM: Experiments conducted for several years proved that judicious use of insecticides has always brought pest population to a level below the economic injury. When practiced as a part of IPM with other management methods, it will be a boon to farmers to manage rice pests and subsequent increase on yield.

g) Cost effectiveness: The high cost of present chemicals and distress sale of paddy are also creating a barrier for adoption of quality pesticides. Farmers should get the price of paddy according to their good quality investment. Synthetic pesticides should not be encouraged in tribal or rural areas where bio-intensive pest control is farmers' favourite with their local resources.