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Insecticide Resistance Management

(*Geeta Devi, Lomash Kumar and Rahul Saini)
Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana, India
*Corresponding Author's email: geetbishnoi0029@hau.ac.in

Insecticide resistance is a growing issue for people who depend on pesticides to effectively control agricultural, veterinary, and medical insect pests. In many insects, the problem extends to all major groups of pesticides. The first instance of DDT resistance was reported in the year 1947. According to estimates, there are at least 447 species of arthropods that are resistant to pesticides in existence today. Many insects have evolved resistance to novel pesticides with diverse modes of action from the primary four classes. The adaptation of the insect population targeted by a pesticide that results in diminished susceptibility to that chemical is known as pesticide resistance. As a result of natural selection, pests become resistant to a chemical; the most resistant organisms survive and pass on their genetic features to their progeny. Pests that were once huge hazards to human health and agriculture but were eradicated by pesticides are now making a comeback. Nowadays, mosquitoes that can spread malaria are resistant to almost all insecticides that are used to control them. The fact that the organisms that cause malaria have developed a resistance to the medications used to treat the sickness in people only makes the issue worse. The corn earworm is a pest that infects a variety of agricultural crops around the world, including cotton, tomatoes, tobacco and peanuts. Insecticides are used in the fields of agriculture, veterinary medicine, and public health to control the population of insects that damage crops or spread disease. Due to the fact that many populations of insects have evolved a tolerance to the poisonous effects of the chemicals, insecticides are not always successful in suppressing insect populations. Resistance is the hereditary capacity to withstand an insecticide dose that would be fatal to the vast majority of people in a typical wild population of the same species. To combat the invasion of a seemingly limitless variety of insects, insecticides are frequently used in agriculture, houseplant populations, gardens, and other living environments. To keep populations under control, insecticides are utilised, but over time, insects may develop a tolerance to the poisons. The term for this is pesticide resistance. When a population ceases reacting to pesticide applications or does not respond as well, insecticide resistance is evident. Many resistance mechanisms have been discovered recently, and resistance detection techniques have been developed. These mechanisms can be categorised into four groups: a) increased metabolism to non-toxic compounds, b) reduced target site sensitivity, c) lower rates of pesticide penetration, and d) higher rates of insecticide excretion. There are various ways to ascertain whether the processes are present in a given population. These tests allow us to see the structure of the resistance mechanisms.

There are thousands of insect species in the globe that are particularly bothersome to people because they either spread severe and crippling diseases or ruin crops. A growing issue for those who depend on insecticides to effectively control agricultural, veterinary, and medical insect pests is insecticide resistance. The first case of pesticide resistance was documented in 1914 by A. L. Melander. At Washington, he investigated the efficiency of lime sulphur, an inorganic insecticide, against the San Jose scale (*Quadraspidiotus* *perniciousus*), an orchard pest. In conventional orchards, a treatment with lime sulphur eliminated all scales in one week, but in an orchard with resistant scales, 90% survived after two weeks. Although there weren't many instances of pesticide resistance before 1940, as DDT and other synthetic organic insecticides became widely used, the number of cases exponentially increased. Thirteen orders of insects have resistance, although more than 90% of the arthropod species with resistant populations are either Diptera (35%), Lepidoptera (15%), Coleoptera (14%), Hemiptera (14% in the broad sense) and mites (14%).

The excessively large population of resistant Diptera is a result of the widespread use of insecticides to combat disease-carrying mosquitoes. Pests in the medical and veterinary fields make up 41% of dangerous resistant species, while agricultural pests make up 59%. Each resistant population of a variety of species is resistant to a wide range of insecticides. According to statistical research, crop pests that feed either by gnawing or sucking on plant cell contents and have an intermediate number of generations per year (four to ten) are most likely to evolve resistance.

Pesticide resistance mechanism in insect

Insects can develop resistance to crop protection chemicals in a variety of ways, and pests frequently display multiple resistance mechanisms at once.

Behavioural resistance: Insects that are resistant to toxins may be able to sense or recognise a threat and avoid it. For various types of insecticides, including organochlorines, organophosphates, carbamates, and pyrethroids, this route of resistance has been documented. If certain insecticides are present, insects may simply cease feeding, or they may flee the area where spraying took place (for example, they may migrate to the underside of a sprayed leaf, move farther into the crop canopy, or fly away from the target area).

Penetration resistance: This occurs when the insect's outer cuticle develops barriers that can slow the absorption of the chemicals into their bodies. Penetration resistance can protect insects from a variety of insecticides. Penetration resistance is frequently present along with other forms of resistance, and reduced penetration intensifies the effects of those other mechanisms.

Metabolic resistance: Insects that are resistant to toxins may be able to eliminate them from their bodies more quickly than insects that are susceptible to them. The most frequent mechanism and most difficult obstacle is metabolic resistance. Insects break down pesticides using their own internal enzyme systems. These enzymes may be present in greater quantities or in more effective forms in resistant strains. These enzyme systems may be more versatile and more effective than others, able to break down a wide variety of pesticides.

Altered target-site resistance: Modification of the location where the toxin typically binds to the insect to lessen the effects of the insecticide. This is the second most typical resistance mechanism.

Management of insecticides resistance

The effectiveness of one insecticide should no longer be tested as part of a resistance monitoring programme with the goal of switching to a different chemical when resistance levels exceed the level that compromises disease control. Early problem diagnosis and quick assimilation of data on the resistant insect population are essential for effective resistance management since they allow for the selection of appropriate pesticides.

How can you control a pest species once it becomes resistant to a certain pesticide?
Using a new pesticide, particularly one from a different chemical class or family of pesticides with a different mechanism of action against the insect, is one way to deal with the problem. Of course, the availability of a sufficient supply of pesticides with various modes of action is

essential for the ability to utilise other pesticides to prevent or postpone the emergence of resistance in insect populations. Although it may not be the optimum approach, this technique enables pest control while alternative management techniques are being developed and applied to the problem. Pesticides are frequently utilised in these tactics, however they are used less frequently and occasionally at reduced application rates.

Delaying the evolution of resistance in pests is the aim of resistance management. The greatest strategy for doing this is to use less insecticides. Consequently, resistance management is a part of integrated pest management, which mixes chemical and non-chemical measures in an effort to provide safe, cost-effective, and long-term pest population control. Predators, parasitoids, and diseases all function biologically to control insects as alternatives to insecticides. Cultural controls (crop rotation, changing planting dates to reduce pest exposure, and using cultivars resistant to pest damage) and mechanical controls (exclusion through barriers and trapping) are also beneficial.

Modelling has been crucial in developing strategies for managing resistance because large-scale resistance tests are costly, time-consuming, and may exacerbate resistance issues. Despite the fact that models have revealed a number of measures that have the ability to postpone resistance, in practise, managing resistance has been most successful by limiting the number of pesticide treatments and diversifying the types of insecticides used. For instance, initiatives in Australia, Israel, and the United States have restricted the frequency and duration of usage of specific insecticides against cotton pests.

More efficient methods for spotting resistance in its early phases of development are needed for resistance management. By lessening the selection pressure that a pesticide exerts on the insect population, pest resistance to that pesticide can be controlled. In other words, it's best to avoid situations when a certain chemical kills all insects but the ones that are the most resilient. By eliminating needless pesticide applications, adopting non-chemical control methods, and allowing untreated refuges where vulnerable pests can live, this can be accomplished. Using the integrated pest management (IPM) strategy typically aids in managing resistance.

Pesticide rotation is a typical strategy for managing resistance when pesticides are the sole or primary source of pest control. To prevent or postpone the development of pest resistance, several kinds of pesticides with various mechanisms of action must be used alternately. The impact of several pesticide classes on a pest may vary. Different classifications of fungicides, herbicides, and insecticides are designated by the U.S. Environmental Protection Agency (EPA or USEPA). Manufacturers of pesticides may stipulate on the product labelling that no more than a certain number of applications of one pesticide class in a row must be made before switching to a different pesticide class. Tank mixing pesticides combines two or more pesticides with distinct modes of action to enhance the effectiveness of each individual pesticide application and prevent or postpone the development of insect resistance.