Lecture (5)

Pesticide Resistance

What is a pesticide resistance?

There are many definitions of insecticide resistance – however the one promoted by the Insecticide Resistance Action Committee (IRAC), they define resistance as the selection of a heritable characteristic in an insect population that results in the repeated failure of an insecticide product to provide the intended level of control when used as recommended. According to this definition, differences in susceptibility apparent in laboratory bioassays may not necessarily constitute resistance if the difference does not result in a change in the field performance of the insecticide.

A population of pests in a crop production field can be made up of different biotypes of the pest organism. A biotype of an organism is the same species, but has genetic variances. For example, dogs are a single type of organism, but there are many different types of dogs. This is due to genetic variation within the dog species.

This natural genetic difference within a pest species can allow some members of the species to survive a pesticide application. Pesticides damage or prevent specific processes in an organism that are required for life and a genetic difference may protect the organism from damage due to the pesticide. The surviving members of that population are **resistant** to the pesticide.

Thus, pesticide resistance is the natural ability of a biotype of an organism to survive exposure to a pesticide that would normally kill an individual of that species. This occurs with insects, fungi, weed, and other pests.

How Resistance occur?

Pesticide resistance at a population level, as opposed to just a few individual pests within a species, can occur after repeated exposure to a single type of pesticide. This is because only the resistant organisms are left to reproduce with other resistant organisms. The new resistant biotype (with the natural ability to survive a pesticide exposure) then becomes the dominant biotype of the pest population.

This is why planting a refuge of susceptible corn along with Bt corn is important: so that some biotypes of the susceptible pest survive and mate with the resistant organisms, delaying the ability of the pest to develop a resistant population.

When a resistant population occurs, the pesticide is no longer useful for managing that specific pest and other management options must be sought out.

However, if pest resistance is managed effectively, a pesticide can remain useful for growers to continue using into the future.

How resistance works?

Using one type of pesticide over and over again can produce resistance in a population of insects, fungi, weeds, or other organisms. For example, a corn field that is infested with green worms feeding on the corn plants:

•First, the grower decides to spray a certain chemical to get rid of those worms.

•The pesticide will kill the majority of green worms, but there may be some part of the population that is not affected by the chemical, just as in humans some chemicals may affect certain people whereas those same chemicals may not affect other people. These unaffected worms are represented above in red.

•Let's say that out of thousands and thousands of green worms a few have the genetic ability to survive the pesticide application. These worms keep on eating corn plants and can eat as much as they want because most of the competition they had in the field is now dead and the insecticide has not killed them.

•The surviving worms are not killed by a subsequent application of the same chemical and reproduce. Offspring have the same genetic composition as their parents and are able to withstand the insecticide.

•The insecticide is no longer useable as a viable method of pest management for this organism since the surviving biotype is now resistant to the pesticide.

•Even though this example is greatly sped up from what occurs in real life, it illustrates how pest organisms can overcome pesticides.

Insecticide resistance:

Insecticides are used to control insect pests. Insect resistance to the synthetic insecticide DDT was documented in 1947 and since that time, key pest organisms have been found with resistance to new insecticides within 2-20 years of release. When a pest becomes resistant, the insecticide is used more frequently and the insecticide must ultimately be replaced as insect control diminishes. Even "in-plant" types of insecticides such as the insecticidal protein Bt can be overcome by insects! Simply put, rotation of management practices is essential to keeping current pest control tools useable.

How insects become resistance:

There are several ways that insects can become resistant to the effects of pesticides. The first is called metabolic. Metabolic resistance occurs when the insect can clear it's body of a toxin, or break a toxin down more quickly than the other insects of its species. Target-site resistance occurs when the insecticide can no longer connect at it's target-site at a molecular level in the insect. Penetration resistance is when the insects shell more slowly absorbs an insecticide. And when certain insects can sense or steer clear of insecticide dangers, it is called Behavioral resistance.

Manage pesticide resistance:

There are many ways to manage or delay pesticide resistant organisms from becoming established.

The first way is to scout your fields to determine if the pest is present at high enough numbers to cause a problem. Then, spray pesticides only if needed. If a field is sprayed when pest numbers are lower than a determined threshold, it can be unprofitable. Be sure to follow the label when applying a pesticide. The label is, in effect, the law.

Make sure to rotate to different types of pesticides throughout the season and from season to season. When choosing pesticides to rotate, be sure the products work in different ways and do not just differ in name only. Pesticides can control the same organism, but may work in different ways. Using pesticides that work in different ways makes it difficult for an organism with resistance to one of the those ways to survive.

Using pesticide alternatives to manage pests is also an option. These alternatives include tillage, natural enemies, crop resistance, and crop rotation. Keep in mind that pest resistance can also develop to non-pesticide management options. So be sure to use multiple tactics when managing pest organisms in crop production fields.

Rotating pesticides:

Rotating pesticides with other chemicals or management tools is an important part of avoiding resistance.

•This time, instead of applying more of the same insecticide, the grower decides to use an insecticide with a different chemistry, one that will still control the worms, but does so in a different way.

•After this application, the remaining worms not killed by the first chemical are controlled. Their genetics are not allowed to become dominant.

•Rotating chemicals and management tools reduces the chances that a genetic variation will emerge and become the dominant pest.

Resistance of major groups of pesticides:

Resistance

Insect resistance is dependent on the volume and frequency of applications of insecticides and the inherent characteristics of the insect species. Resistance to pyrethroids comes in two forms: (1) non-metabolic resistance through the decreased sensitivity or reduction in the number of voltage-gated sodium channels, and (2) metabolic resistance via detoxifying enzymes, oxidases and decreased cuticle penetration. There are four mechanisms by which resistance is expressed: (1) decreased sensitivity of the sodium channels due to altered structure, (2) decreased sensitivity to pyrethroids through a change in the kinetics of the channel, (3) reduced number of channels available for pyrethroids to bind, and (4) altered lipid membrane around the nerve.

The detoxification of insecticides through the action of CYP is one of the more important resistance mechanisms. Metabolic resistance can be reduced through the use of a synergist, but non-metabolic resistance cannot.