# MICROBIAL-CHEMICAL INSECTICIDE MIXTURES

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For a long time, pest control in the cotton industry has depended on a narrow range of broad-spectrum insecticides. However, because of increasing insecticide resistance, the future is uncertain and alternatives are urgently required. There is a need to conserve natural control in the crop, principally parasites and predators, and exploit other biological control agents where possible. Unfortunately, most of these are vulnerable to chemicals and attempts to integrate them with chemical control are likely to be only partially successful. However, microbial insecticides in the form of microbial-chemical mixtures can have a role in delaying the development of resistance.

## Microbial insecticides

Microbial insecticides are based on pathogenic microorganisms, in practice usually bacteria or viruses. Unlike other forms of biological control, they are compatible with chemical insecticides, as well as being safe to humans and highly selective and non-destructive to natural control agents. Consequently, their use avoids the problem of the rapid reinvasion of the crop by pest species following insecticide use. This particularly applies to mites, which develop to enormous populations following the destruction of their predators.

Microbial insecticides which have been available commercially have been based on the bacterium, *Bacillus thuringiensis* (Bt), which is active against caterpillar species, or a heliothis NPV, a virus which is specific for heliothis species. These have shown limited efficacy at currently recommended rates, particularly when the level of heliothis pressure is high. The recommended use of *B. thuringiensis*-based products, such as "Dipel", "Thuricide" or Javelin", is in combination with chemicals, preferably ovicides (Cameron, 1988). The virus has not been available commercially since 1984.

Mixture selection

In selecting mixtures, the first thing to establish is that there is no "antagonism" between the two components. This involves determining the potency of each of the components by bioassay, and then determining the potency of one or more mixtures. Antagonism is indicated if the potencies of the mixtures are less than that expected from the potencies of the components. The relationship is said to be "additive" if the potency of the mixture is equivalent to the potencies of the two added together. In some instances, the potency of the mixture is greater than that expected. In other words, there is "potentiation" or "synergism".

The first microbial plus chemical insecticide mixture which was successfully used was *B. thuringiensis* plus chlordimeform. Chlordimeform has both ovicidal and larvicidal activity and is also a miticide. Early evidence suggested that the two were synergistic. Unfortunately chlordimeform has been withdrawn from the market because it constitutes a possible health hazard.

A suitable replacement for chlordimeform is being sought. A number of chemical insecticides, some commonly used on cotton and some experimental, have been tested for ovicidal activity (Teakle et al, 1988), and a number of mixtures assessed in the laboratory for interaction, ie. antagonistic, additive or synergistic. *H. armigera* larvae of ages 0 days (unfed) or 4 days and 7 days (starved the previous 24 hours) have been tested for their responses to the mixtures. The microbial insecticides need to be ingested to be effective against larvae, whereas chemical insecticides are usually active by contact as well. To allow both ingestion and contact to occur, we sprayed the insecticide mixtures onto the larvae on flat dishes. The starved or unfed insects drank from the droplets containing the insecticides. The amount consumed was apparently uniform for each larval age group, because regular dose-mortality responses were obtained.

The results showed that mixtures of *B. thuringiensis* or heliothis NPV with

endosulfan, fenvalerate, lambda-cyhalothrin, methomyl, methyl parathion, or profenofos displayed additive potencies. While this confirms their compatibility, the additional advantage of synergism has not been found for these mixtures.

Resistance selection

In mixtures of microbial and chemical insecticides, low doses of each are normally used. There has been considerable debate on the desirability of this. It is feared that these may constitute "discriminating doses", which kill only the susceptible larvae and spare resistant ones, actually increasing the rate of resistance selection. There is no way of avoiding discriminating doses unless extremely high doses are used. This is because the larvae on the crop are not of uniform age and therefore differ in susceptibility, uniform coverage is not achievable, and the insecticide concentration will decline progressively through plant growth and weathering. With mixtures, what is probably more relevant is that larvae which may be resistant to one of the components still have to survive the other component(s), to which they are unlikely to have resistance. This should reduce the rate of selection for resistance.

Modifying feeding behaviour

Another possibility is that of modifying the feeding behaviour of heliothis with sublethal doses of chemical insecticides to make them more likely to ingest microbial insecticides. Dosed larvae suffering disorientation or incoordination could tend to remain on the surface of the plant instead of burrowing into squares or bolls. They would therefore be more likely to ingest any microbial insecticides applied at the same time. Flowering cotton was sprayed with low insecticide doses and newly-hatched larvae observed for failure to migrate toward the reproductive parts of the plant. The results have not been encouraging, but this study is continuing.

To become commercially accepted, mixtures of microbial and chemical insecticides need to achieve a satisfactory level of control at acceptable expense. In

addition, they will work best if they minimise the problems associated with the use of each. As well as conserving natural control, a reduced rate of selection for resistance could be a valuable bonus. All available pest control strategies need to be considered in cotton, particularly those which complement each other.

References

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