RESISTANCE TO THIODICARB IN *HELICOVERPA ARMIGERA*

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Chemical insecticides are currently essential for the control of *H. armigera* on cotton and are likely to remain an important component of control strategies for the foreseeable future. However, insecticide resistance is a major threat to the economic production of cotton in Australia. The development of resistance had been delayed by the insecticide resistance management strategy for *H. armigera* but levels of pyrethroid and endosulfan resistance have gradually increased over recent years. Thiodicarb (LARVIN ^{R})plays a vital part in management of resistant *H. armigera*, it has larvicidal and ovicidal qualities on *H. armigera*, which are very valuable. As resistance to pyrethroids and endosulfan increases, however, so does the use of alternative chemicals such as thiodicarb. It is essential that the use of this chemical is carefully managed to avoid or delay resistance. This can only be achieved by effective resistance detection and monitoring techniques and understanding underlying resistance mechanisms.

Resistance to some carbamate insecticides (methomyl and carbaryl) in *H. armigera* is has been known since 1983. But at that time no resistance to thiodicarb (also a carbamate) was identified. However, in early 1993, there were severe *H. armigera* control problems with thiodicarb in sweet corn and maize crops. These failures were widely distributed across New South Wales and Queensland. Testing at Tamworth showed that these populations were resistant to thiodicarb (approximately 30 fold). In some, the resistance frequency was as high as 80%. Thiodicarb resistance conferred cross resistance to other carbamates (such as methomyl). While thiodicarb resistant *H. armigera* were largely confined to the maize and sweetcorn populations, a resistance survey on cotton in early 1993 indicated that a low frequency (~10%) of thiodicarb resistant individuals were also present in the cotton areas of NSW and Queensland.

During the 1993/94 cotton season, we conducted a comprehensive survey of the distribution of thiodicarb resistant *H. armigera* in NSW and Queensland. In cotton areas, throughout the season, the frequency of resistant individuals was very low , averaging ~ 2%. However, higher resistance frequencies (ranging from 10 - 48%) were found in *H. armigera* collected from a few sweet corn and maize crops which had been sprayed heavily with both methomyl and thiodicarb.

Resistance monitoring data from the past two season shows that very heavy use of both thiodicarb and methomyl on maize and sweet corn encourages thiodicarb resistance build-up in *H. armigera* . Sweet corn, vegetable cropgrowers are being altered to this danger. Prevailing patterns of thiodicarb use on cotton do not appear to be contributing to resistance build-up at the moment. Consequently, other than to suggest that thiodicarb not be used as the last spray of the season, the 1994/95 *H. armigera* resistance management strategy has not placed any restrictions on thiodicarb use on cotton. Nevertheless, to ensure that thiodicarb remains effective against *H. armigera.*, cotton growers must avoid the dangers of overuse.

To help identify the best resistance management strategy for future thiodicarb use on cotton we investigated the mechanisms of *H. armigera* resistance to thiodicarb. Carbamates normally kill *H. armigera* by interfering with the nervous system. They block/inhibit the neuro transmitter enzyme acetylcholine esterase and thus prevent the insect nervous system from functioning properly. The thiodicarb resistant *H. armigera* were found, however, to possess a form of this enzyme which was partially insensitive to attack by either thiodicarb or methomyl (Fig. 1). This is a new new resistance mechanism for *H. armigera.* Target site insensitivity, such as this, is normally a very difficult resistance mechanism to overcome.

Studies, so far, indicate that thiodicarb and methomyl use on sweet corn and maize selects for thiodicarb resistance in *H. armigera.* While thiodicarb use on cotton seems not to have contributed to the resistance problem, cotton growers should be aware that *H. armigera* are very mobile. Resistant moths originating from other crops can and will invade cotton and growers will need to use thiodicarb very carefully if *H. armigera* susceptibility is to be preserved. Overuse would undoubtedly exacerbate the resistance situation.

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Figure 1.
The effects of methomyl on acetylcholine esterase activity in thiodicarb resistant and susceptible *H. armigera*. The susceptible enzyme is rapidly and totally inhibited by methomyl. The resistant enzyme is much less sensitive to inhibition, remaining active at higher insecticide concentrations (>100fold).