

Diamondback Moth in South Texas: A Technique for Resistance Monitoring in the Field

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Abstract

Laboratory bioassays were conducted to determine the response of larvae of a susceptible strain of diamondback moth *Plutella xylostella* (L.) from the Rio Grande Valley of south Texas to five classes of insecticides. Test insecticides were permethrin, methamidophos, endosulfan, methomyl and *Bacillus thuringiensis*. Three monitoring techniques were developed and tested as methods of determining the extent of insecticide resistance in the field. The most efficient technique involved a disposable cup assay in which larvae were exposed to discriminating doses of insecticide representing LC₉₀ doses for a susceptible strain. Monitoring tests confirmed resistance to permethrin and methamidophos in one field population. Tests with a second field population showed methomyl was the most effective insecticide available. Field data substantiated the results of the monitoring test. The applicability of resistance monitoring methodology developed with *Heliothis* in U.S. cotton to problems of resistance management in diamondback moth are presented.

Introduction

The diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae), is a cosmopolitan pest of cruciferous crops and a key pest of cabbage in the Rio Grande Valley of south Texas where there is extensive production of these crops from fall through spring each year. Resistance to insecticides has been slower to appear in DBM of the United States mainland compared to elsewhere in the world. First reports of control difficulties in the Rio Grande Valley led to confirmation of resistance in DBM populations in 1987 and 1988 (Magaro and Edelson 1990). In this paper we will briefly describe the development of resistance and our responses to the situation. The aim of the research was to confirm the presence of resistance and to provide growers with a rapid and easy-to-use method for determining which class of insecticides would provide control in a field situation where the presence of resistance was suspected. The development of techniques to do this was influenced by parallel studies performed in 1986 and 1987 for determining the presence of resistance to pyrethroid insecticides in the tobacco budworm (TBW), *Heliothis virescens* (F.), in Texas and other southern states (Leonard et al. 1987; Luttrell et al. 1987; Plapp et al. 1987).

Methods

When resistance appeared in the Rio Grande Valley, the first problem was to develop a rapid method to monitor for it. Three different techniques were developed and tested. These included a leaf dip assay, a treated vial assay and finally, a disposable cup assay. The latter has proven to be the most useful under field conditions.

The initial problem with the assays was to decide between the use of a dose-mortality response and the use of a discriminating dose assay. The former can tell the investigator the resistance of the average insect in the population; the latter tells what proportion of the population is resistant. Earlier work with the TBW had led to the development and wide use of a discriminating dose assay which provides information on the proportion of the population resistant to an insecticide. Data over several years of tests with this technique and approximately 60,000 field-collected TBW males have been reported (Plapp et al. 1990). The advantages of using a discriminating dose technique have been described by Roush and Miller (1986) and include greatly simplified assays and much more efficient statistical treatment of the data. As we will show below, the use of this assay is very useful in determining the types of insecticides that may be useful for DBM control in situations where resistance is present.

The initial assay method used by Magaro and Edelson (1990) was a leaf dip assay. First, tests were done at a dose designed to be equivalent to field rates of permethrin, esfenvalerate, methomyl, carbaryl, methamidophos, methyl parathion, and endosulfan. These insecticides are representative of four different chemical classes of insecticides and three different modes of action, e.g., sodium channel agents, cholinesterase inhibitors and a GABA agent. The results showed resistance was present to all compounds and highest to the cholinesterase-inhibiting organophosphorus and carbamate insecticides.

The next step was to determine dose-mortality lines for susceptible DBM with the same insecticides. This was done with permethrin, endosulfan, methamidophos, methomyl and also *B. thuringiensis*. From this work, the authors were able to determine the LC₉₀ doses for each insecticide to a susceptible strain. It is this determination which is critical to developing discriminating dose assays.

Tests were done using the glass vial technique at LC₉₀ doses based on extrapolations from the previously described assay. The method worked well, but proved less useful than the method described below.

The technique finally decided on was defined as a Disposable Cup Bioassay. This technique is very close in theory and practice to the leaf dip assay. For this technique discriminating dose concentrations of several insecticides were poured into 29.6 ml plastic cups, swirled around and the excess poured out. DBM larvae were then placed in the cups and response determinations made 4 hours later.

The different techniques were tested on laboratory-reared DBM larvae and the results were found to be comparable with each method. Because of ease of use and lower costs, the disposable cup assay was finally adopted as the technique of choice.

Two series of tests were performed in which DBM larvae were collected from fields where resistance was suspected. Larvae were tested with several potential control agents and the decision as to which insecticide to use was based on the results obtained. In one test endosulfan proved to be the insecticide of choice. In a second test, methomyl was chosen. Assays of the results proved that the method was effective in predicting if a particular insecticide would yield satisfactory control.

Nature of DBM Resistance

An important point to be considered in dealing with insecticide resistance is to determine its cause in a pest population. There are two main mechanisms of resistance in most pest species. These are changes at target sites and increases in ability to detoxify insecticides (metabolic resistance). The latter type is most prevalent in polyphagous insects while the former type is more prevalent in monophagous or oligophagous pests. The DBM is clearly an example of the former type. Evidence that resistance to DDT and pyrethroids is target site has been reported (Liu et al 1982b) and evidence for insensitive acetylcholinesterase (target site) resistance to organophosphates has also been reported (Noppun et al. 1987). Resistance associated with each type usually yields populations with 10-100-fold resistance. When higher levels are present,

the cause is usually interaction of both factors. In the DBM, there is evidence in a number of cases of greater levels of resistance. An excellent example is the high level of resistance to pyrethroids in the Ban-chau strain (Liu et al. 1982a).

Available data from the Rio Grande Valley research as well as from many previous studies suggests that target site resistance is present in almost all resistant DBM populations. Metabolic resistance, when present, seems to be an additional factor. Indeed, both types of factors are almost always present in cases of high resistance levels.

An easy way is available to determine which type of resistance is present in a field population. The assay is based on the understanding that high levels of metabolic resistance to insecticides occur only in actively feeding life stages, e.g. large larvae. Target site resistance, on the other hand, will be present in all life stages. Therefore, determination of resistance levels in adults and neonate larvae as well as in larger larvae can be used to determine the type of resistance present.

From work with *Heliothis* we know there are biological costs to insects associated with both metabolic and target site resistance to insecticides. Target site resistance to pyrethroids is clearly associated with decreased reproductive success and decreases in mating competitiveness. Metabolic resistance in the tobacco budworm is associated with decreases in fecundity including increases in generation time and decreases in egg production per female (Campanhola et al. 1991).

Management of Resistance in DBM

As discussed above, an understanding of the mechanisms of resistance is crucial for developing adequate resistance management strategies. In the case of the tobacco budworm, pyrethroid resistance is usually associated with target site changes. Successful management has been obtained by restricting pyrethroid use to one generation per year and using alternate types of insecticides if control is necessary for other generations. It seems likely that the same principle can be applied to insecticide control of the DBM.

Metabolic resistance, if present instead of or in addition to target site resistance, can be managed by using mixtures of insecticides. Examples include use of insecticide: synergist mixtures and also use of insecticides composed of mixed isomers. Examples of the latter include \pm isomer organophosphorus compounds such as methamidophos and oxime carbamates such as methomyl. Attempts to utilize either approach in managing resistance have not been successful, providing strong evidence that target site resistance is the major factor present in most resistant DBM populations.

In practice, determining the mechanism of resistance is secondary to determining if resistance of any sort is present. Monitoring techniques as described by Magaro and Edelson (1990) and reviewed here provide a way to resolve this problem. If growers can use these techniques to make appropriate control decisions, pest management can be improved and selection for insecticide resistance may be decreased. Overall, monitoring can play an important role in the successful implementation of IPM programs for the DBM.

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