INSECTICIDE RESISTANCE IN DIAMONDBACK MOTH

(*Plutella xylostella*) (Lepidoptera: Plutellidae)

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ABSTRACT

Diamondback moth is a cosmopolitan species of considerable importance as a pest of cruciferous plants. It is capable of rapid growth in numbers and has a high potential for the development of insecticide resistance. By 1986 resistance had been confirmed to 23 insecticides in 16 countries.

A susceptible population was identified from a forage brassica crop on a Massey University farm. Insects collected were used to establish a susceptible laboratory colony. Full dose mortality curves for a range of insecticides were constructed for this colony using leaf dip bioassays. The LD_{95} values were determined for each of the 7 insecticides tested and used as diagnostic doses to screen field populations for resistance.

Field populations regularly exposed to insecticides were sampled at five locations in intensive market garden areas in the North Island. Larvae and pupae collected from these sites were reared to the F1 generation in the laboratory. Third instar larvae were then tested for resistance using leaf dip bioassays treated with the diagnostic doses. Some insecticide resistance was detected at each of the five sites. Insect survival for the site showing the highest resistance levels ranged from 82% to 16% when exposed to the diagnostic dose (LD_{95} for the

susceptible population). Only one site showed resistance to all of the insecticides screened and there seemed to be no pattern to the cross resistance spectra encountered on each site. All five sites had different histories of pesticide usage. Two of the five sites were in close proximity but they were geographically isolated from the remaining 3 sites which were isolated from each other.

High levels of parasitism by *Diadegma semiclausum* was evident in all of the field populations tested. The impact that this is having on the development of resistance is unknown but warrants further study.

Even though resistant insects were found, their numbers were low and the crop loss too small to be of concern to the growers. However in the light of experience in South East Asia it would be prudent to formulate resistance management tactics for New Zealand conditions.

I suggest that a number of reccomendations should be made to growers with respect to their diamondback moth control programmes. Pyrethroid use should be restricted to one application per brassica crop. The use of control action threasholds should be encouraged as should the use of less persistent insecticides such as dichlorvos and mevinphos. Urgent attention should be given to the development of an efficient grower operated monitoring programme. The feasibility of operating an integrated pest management programme should also be investigated.

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CHAPTER ONE

INSECTICIDE RESISTANCE.

There is considerable complexity and even controversy over the concept of insecticide resistance. However in practical crop protection, resistance is inevitably connected to the expected result of a pesticide application and manifests itself as insect control failures (Brattsten 1989). Insecticide resistance was first recorded between 1911 and 1916 when San Jose scale resistance to lime sulphur and Californian red scale resistance to hydrogen cyanide was detected (Long 1982). To date, insects have developed resistance to nearly every type of insecticide in common usage (Brown and Payne 1988) with over 447 economically important insect species showing resistance to one or more insecticides (Wilson 1988, Brattsten 1989).

Resistant strains develop through the survival and reproduction of individuals carrying a genome that allows them to withstand exposure to doses of an insecticide that would have otherwise proven fatal (Brattsten et al 1986). The process by which insect populations become resistant is one of evolutionary change, where the organism is changing to meet changes in its environment. In this case the changes are the addition of toxic chemicals to their habitat by man. However this type of selection pressure is not new to phytophagous insects, as many plants produce toxic compounds as part of their defence system against insects. Some insects, in response to such selection pressure imposed on them by plants. have evolved methods of escaping the effects of these natural toxins. The host range of any given phytophagous insect species is in fact limited not so much by the nutritive value of the plants available as food but rather by its ability to tolerate the allelochemics of the potential host plants.

In those cases where the methods of escape from these plant toxins have been elucidated it appears that the insect has not one defence against the toxic plant chemicals but several or even many. Tobbacco hornworm for example appears to have six or seven built in mechanisms which enable it to avoid poisoning by nicotine (Brattsten 1989). If such multiple defence systems are the end point of the development of insect resistance to allelochemics then perhaps the same will prove true of the development of resistance to synthetic insecticides. Thus for example Sun et al (1986) observed that both metabolic and non metabolic mechanisms could be responsible for pyrethroid resistance in DBM. Liu et al (1981) claim that enhanced microsomal oxidation is a major factor in fenvalerate and permethrin resistance in DBM and that enhanced esterase hydrolysis was an additional minor contributor to permethrin resistance. The main mechanism for organophosphate and carbamate resistance in DBM seems to be acetylcholinesterase insensitivity (Liu et al 1981, Chen and Sun 1986, Miyata et al 1986, Sun etal 1986).

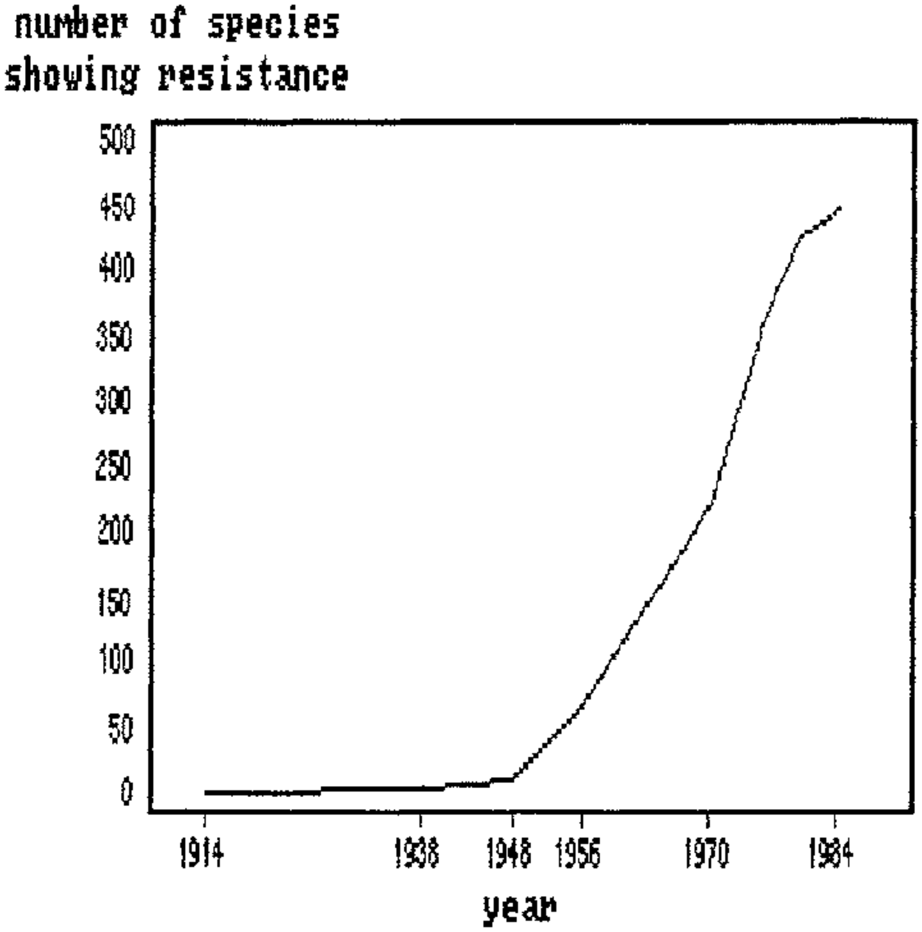
Insecticide resistance seems to be an inevitable and unavoidable consequence of persistent selection pressure. The only uncertainty is the time taken for the resistant strain to become predominant.

In contrast to the presumably slow evolution of resistance to natural toxins, resistance to synthetic insecticides has developed extremely rapidly. Brattsten et al (1986) suggest that this is probably due in part to some of the mechanisms that have evolved as a defence to plant allelochemicals being also an appropriate defence against synthetic insecticides. Figure 1. shows that the number of insect species showing resistance to one or more insecticides has increased dramatically in the last two decades. This is a phenomenon which in retrospect should not have been entirely unexpected and further development of resistance may be expected to continue at an increasing rate, unless we change the way in which we manipulate the insect's environment.

Brattsten (1989) claims that the concept of resistance as commonly used is a little artificial. For many years we have considered resistance as if it were a unique problem that happens to interfere with the chemical control of harmful insect species. However, in reality resistance is a case of biotype evolution. This is a natural process that occurs in response to any form of selection pressure. Modern agricultural and horticultural practices with their heavy reliance on pesticides have increased the selection pressure on insect pests.

Fig 1: The Development of Insecticide Resistance.

(Metcalf 1980)



This may mean that field populations in areas regularly treated with pesticides are likely to have acquired some degree of resistance, inferring that the genetic constitution has been changed in practically all insects that inhabit areas exposed to pesticides. This has a number of important implications when it comes to measuring insecticide resistance.

The diamondback moth is a cosmopolitan insect species of considerable importance as a pest of cruciferous plants. Diamondback moth (*Plutella xylostella* Lepidoptera: Plutellidae) has 14-28 generations per year in Malaysia, 15-20 in Taiwan, 5-12 in Japan and 6-7 in New Zealand, with overlapping of all development stages (Miyata et al 1986; Valentine 1975). This means that the species is capable of rapid growth in numbers and has a high potential for the development of insecticide resistance. Since 1953 numerous cases of insecticide resistance by diamondback moth to various types of insecticide have been reported from around the globe. By 1986 resistance to 23 insecticides in 16 countries had been confirmed (Georghiou 1981; Sun et al 1986). The highest levels of resistance have been found in the Ban Chau strain in Taiwan where the resistance ratios (LD_{50} of the resistant population/LD_{50} of a susceptible population) range from 2 for *Bacillus thuringiensis* to 50,000 for cyanofenphos, with intermediate values for eleven other insecticides (Sun et al 1986). In 1987 the newly formed New Zealand Committee on Pesticide Resistance identified diamondback moth as a potential resistance problem in this country (Elliot et al 1987).

The aim of this work was to establish whether or not diamondback moth was developing resistance to insecticides in New Zealand and to propose a set of management strategies that would either minimise the impact of resistance or reduce the likelihood of its development.