New Ecologically-Based Control Strategies for Diamondback Moth in Vegetable Brassicas

D.M. Suckling, T.C. Bourner and J.M. Daly

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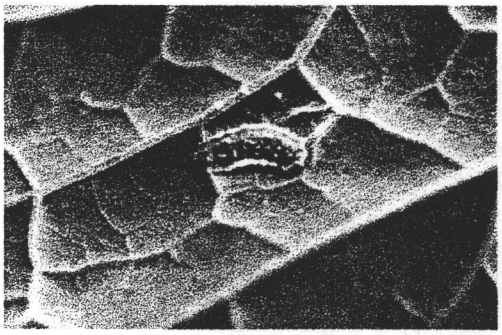

Closeup of diamondback moth cadaver collected in March 1998, in a kale crop near Blackball. The fungal rhizoids can be seen attaching the insect to the leaf. The disease outbreak in the insect population was locally common in the area. (Photo: HortResearch, Lincoln).

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HEAD OFFICE
The Horticulture & Food Research Institute of New Zealand Ltd
Private Bag 11 030
Palmerston North
Telephone 06 356 8080
Facsimile 06 354 0075

HortResearch
Canterbury Agriculture and Science Centre
P O Box 51
Lincoln
Telephone 03 325 6609
Facsimile 03 325 2946

This report has been prepared by the Horticulture and Food Research Institute of New Zealand Ltd (HortResearch) which has its Head Office at Batchelor Research Centre, Private Bag 11 030, Palmerston North and has been approved by:

DM Sutherland

Research Scientist

Date: 12/5/98

Science Manager

Date: 12/5/98

Project Objective

To develop a new selective and cost-effective control tactic for diamondback moth (DBM), compatible with organic production.

Executive Summary

The project has been successful in the first year, achieving several aims. A large part of the project has focussed on the lure-and-infect project against diamondback moth (DBM). This is a pheromone-based strategy for spreading insect diseases, which can be used as naturally occurring biological control agents. Male moths are lured to a station which contains actively sporulating fungus, where they become contaminated with the infectve spores. The moths then depart and die as the fungus produces more spores which are windborne and can infect other adults or larvae of DBM in the vicinity. During the first year of the project, insect and fungus cultures were obtained, methods have been learned for fungus culture, and effective pheromone lures obtained. Specifically:

- Twenty isolates have been obtained from natural populations of the fungus, which only occurs with the insect as the host. We found the fungus to be locally common in the Greymouth area, where outbreaks of DBM were found on unsprayed kale. This is a very promising result.
- An overseas isolate was obtained, and methods for working with it were learned during the visit of Dr. Judy Pell, (IACR-Rothamsted, UK) (funded by a C. Alma Baker Fellowship).
- A culture of DBM was established at Lincoln, used for supply of insects for our research.
- A Lincoln University student, J.M. Daly, has started to work towards his MSc with us on Lure and Kill against DBM.
- Pheromone traps were set up in Canterbury and Pukekohe (with FruitFed Supplies Ltd.). However, initial pheromone trapping results were disappointing, and the problem was traced to the lures, which were not as attractive as virgin female moths. Much more attractive pheromone lures have now been identified. We will continue to develop the most attractive lures possible, to maximise moth visits to the fungus stations/insecticide droplets.

A second part of the project investigated the lure and sterilize strategy, for possible combination with other tactics. The lure and sterilize component has been dropped after negative results. Eggs laid by females mated with males that had been treated with fenoxycarb showed no effects from the treatment, despite the reports overseas of an effect being found in codling moth, and this approach being developed against it.

Introduction

The fresh vegetable industry currently relies heavily on spraying broad-spectrum insecticides to achieve economic production of these food crops. However, this intensive practice is facing serious challenges from people - and the pest insects. Excessive pesticide use is undoubtedly one of the most important issues faced by the vegetable sector. Increasing scrutiny of farmer practices is occurring under the Resource Management Act (1991). Growers need to reduce their reliance on broad-specrum insecticides in order to meet the requirements of this legislation, and to meet increasing consumer demand for food free from pesticide residues, grown using cleaner production systems. Failure to change will jeopardise other industries, but there are clear advantages for New Zealand if we can implement such strategies.

Insecticide resistance is a rapidly increasing problem for the NZ vegetable industry, and resistance in DBM has been reported overseas to all major classes of insecticides, including Bt. There are currently very few alternative tactics, and the importation of new biological control agents will be increasingly difficult under the Environmental Risk Management Authority. The use of biological control is established in vegetable pest management, but is generally inadequate to maintain populations below the economic threshold, so most growers spray routinely. Vegfed specifically called for help with both DBM control and organic production (Research Priorities 1997). New initiatives are urgently being sought by the fresh vegetable industry. This project is one such iniative.

Overseas Visitor and Related Funding

The original proposal to Vegfed requested funding for the visit to Lincoln of Dr. J.K. Pell (IACR-Rothamsted, UK), but it was suggested by Vegfed that other sources be approached. The relevant MORST scheme was approached, but it was already fully subscribed. An application was made to the Lottery Board, without succcess. The British Council was also approached without success. However, a prestigeous **C. Alma Baker Fellowship** (£5000, ca. **$12,500**) was received for the collaboration. Dr. Pell visited us in March to teach us fungus culturing techniques and plan future collaborative work. This visit was very successful, as noted below.

A high quality FRST bid was prepared and submitted, with supporting letters from Vegfed, Novartis, and an organic brassica grower (Tony Mallard). Subcontractors were Rothamsted and AgResearch. Crop & Food Research declined to participate as a subcontractor for field surveys of diseased insects. The programme covered both longer and shorter term research aspects of new ecologically-based pest management approaches. The reviews and overall rating for quality and excellence were high. Unfortunately, the reduction in government funding for science meant that there were essentially **no new initiatives** funded in FRST Output 4 (fruit, vegetables, ornamentals, etc.). NSOF (Non-specific Output Funding, an internal CRI process) was also sought from HortResearch but this was not obtained.

Lure and Kill

Novartis has granted our team the NZ development license for their "Sirene" lure and kill product against various insects, including DBM. This initiative has led us to begin the development of a lure and kill formulation against leafrollers on pipfruit with ENZA support.

A Lincoln University Summer Scholarship was obtained ($4,000), and a student worked with the HortResearch team over the summer. He is now registered for an MSc. thesis on lure and kill aspects of this project against DBM, aiming to investigate alternatives to pyrethroid insecticide formulations (J.M. Daly). Alternatives are needed because of pyrethroid resistance. Work in this area is the subject of our proposal to VegFed for 1998/99.

Lure and Sterilize

Several experiments were conducted, but only a brief summary of the most pertinent results are presented because of the failure of the experiments to show a useful line for further development.

Phenoxycarb treatment by direct physical contact

Male and female DBM were exposed to fenoxycarb by confining them in a plastic pot (55mm tall by 42mm diameter) for 24 hours. The inside of the pot and lid was sprayed with a suspension of Insegar (fenoxycarb) in distilled water using an air brush sprayer and allowed to dry. The concentration of the spray used gave 0.165$\mu g.cm^{-2}$ of active ingredient (cf 0.2$\mu g.cm^{-2}$ succesfully used by Charmillot and Pasquier (1992). Moffitt et al. (1983) had also achieved an effect with related compounds, dosed directly on the insects. Our preliminary experiment using ca. 2 $\mu g.cm^{-2}$ (10x the published concentration of fenoxycarb) had shown significant mortality of the adult DBM, during the first 24 hours of exposure, but for those which survived, egg laying and hatching appeared to be normal. Three treatments were used: treated males, treated females and controls where neither sex was treated. For each treatment there were 6 replicates with five pairs of DBM to each replicate.

These tests of the juvenoid fenoxycarb against male or female diamondback moths showed no evidence of the effect reported for codling moth (treatment of males leading to eggs failing to hatch). The absence of any effect on the number of eggs laid and their rate of successful hatch was unfortunately confirmed for DBM using contact (Fig. 1) and ingestion methods (data not shown) by both males and females. The focus then shifted to trapping and the pathogen for the lure and kill system.

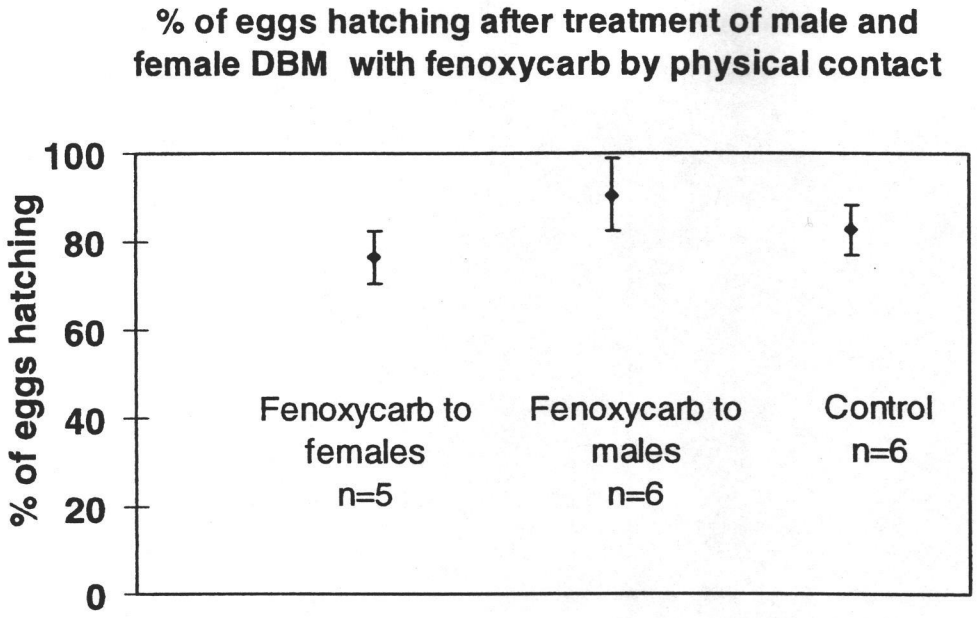

Fig. 1. The lack of effect of contact with fenoxycarb residues on the hatching of eggs laid by female DBM, after either male or female exposure. Values plotted are means from groups of five pairs of moths, with the bars indicating standard errors. A similar experiment had been reported to be successful against codling moth, by preventing egg hatch.

Lure and Infect

A colony of DBM was established, and rearing procedures were developed. Surveys were undertaken for the naturally-occurring fungus in Canterbury during Spring 1997, but were unsuccessful at finding the disease. The dry seasonal climate this year would not have been conducive to fungal disease outbreaks (epizootics), and no infected larvae were found, despite the report from one grower that he has seen the symptoms of fungal infection in DBM larvae in previous years. Outbreaks of the fungus in DBM populations was also reported from Canterbury by Kelsey (1965).

A visit to the West Coast with Dr. J. Pell in order to survey for fungus-infected caterpillars found them to be locally abundant in two kale crops, which had not been sprayed against DBM. Approximately 20 isolates were cultured in the laboratory and these are being stored in liquid nitrogen at Lincoln and Rothamsted (UK). A site was identified for initial tests of the isolates, and general outlines of suitable trial plans were made. A prototype trapping system based on the UK system was constructed at Lincoln for delivery of insect pathogens to DBM.

Importation of the Rothamsted strain was also undertaken, and bioassays performed with it in the laboratory. The lack of public good science funding or NSOF funding means that these cultures will have to await further funding for evaluation and development.

Access to an excellent computer model of DBM (currently under development) may be obtained from CSIRO, which should permit evaluation and aid development of new

pest management tactics. This initiative could eventually lead to the availability of a grower-friendly system.

Overseas Contacts on DBM Research

Contacts were made in Australia and elsewhere on DBM research. A visit was made to the research and extension scientists at the Victorian Dept. of Ag. (Knoxfield) (coincident with funding from another project). New products for DBM likely to be registered there include Fipronil (phenyl pyrazole, "Regent" from Rohm and Haas), Emamectin benzoate (Merck) and Spinosad (a Dow Elanco fermentation product). These products are unlikely to be "silver bullets". The focus of the Victorian work is DBM resistance, and resistance management of these products will be crucial to their longevity.

Pheromone Trap Results

Powerful pheromone lures are essential to the success of all three strategies (lure and kill, lure and sterilise, lure and infect). Initial trapping of DBM with pheromone traps using lures from HortResearch (Mt. Albert) indicated catches far below our expectations, in both Canterbury and Pukekohe. It was suspected that the low catches were due to problems of chemical purity, because for some insects related isomers of pheromones are repellent (to ensure that species don't cross-mate).

We were able to test other lures, and although catches in the final experiment were still below catches made in traps baited with three virgin female moths, a five-fold improvement was made (Fig. 2). Lures from the UK caught no moths at all. Recently developed so called "super lures" from CSIRO (Australia) were no better than the normal Australian lures, despite the CSIRO report that these lures should have been 4-10 X better. This type of variation is not uncommon, in that many species of insects have "pheromone types" which use different ratios or components in different areas of the world. It should be possible to improve the current "best" lures (#2, Fig. 2) further. Unfortunately high purity lure ingredients arrived too late to undertake further trapping to test the pure compounds at different rates and ratios.

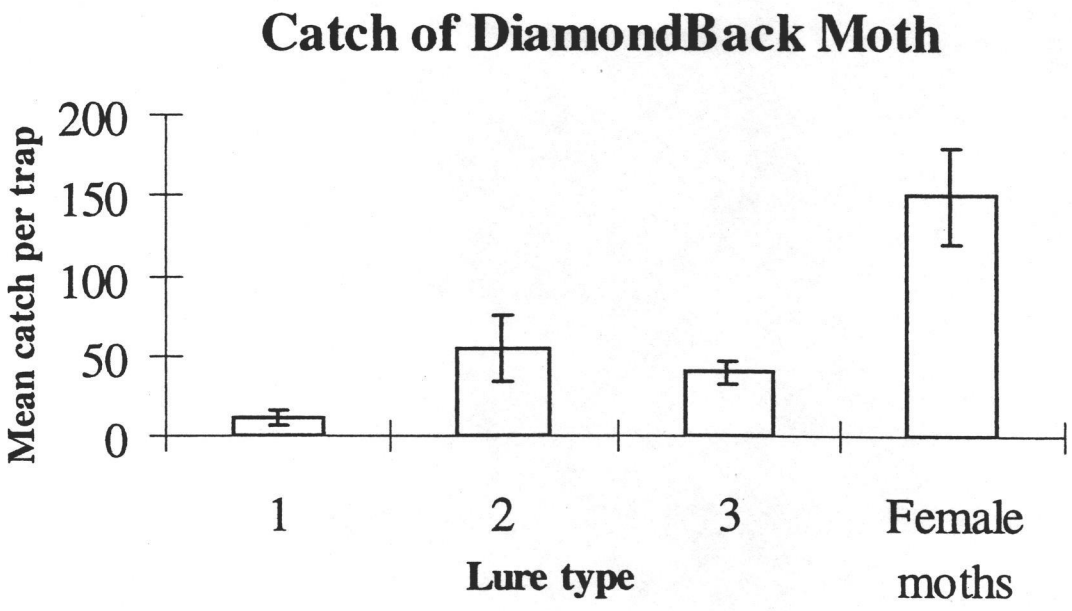

Fig. 2. Catch of DBM in traps baited with three types of lures or virgin female moths.

Technology Transfer

A popular article was written and submitted to the Commercial Grower, published in the March 1998 edition. It covered the "lure-and-infect" strategy for DBM. Media and press coverage (TV1 News, ZB Radio, NZ Herald, Christchurch Press, Canterbury Times, NZ Science Monthly, etc.) was also used to reach the public, with the underlying message that vegetable growers are interested in environmentally safe pest management.

Future Plans

Unfortunately, the lack of any public good science funding is a severe impediment to the development of the lure and infect strategy against DBM in NZ. Work will be continuing at Rothamsted, and the progress monitored. The investment on this project in the UK has been of the order of three people over eight years, so it is clear that even the last stages of development will require substantial input at some stage, and it is unlikely to proceed with vegetable industry funding alone. There has been chemical industry interest in lure and infect as part of a resistance management strategy, but the investment required is likely to be greater than offered by this source.

Instead of the lure and infect project, we propose to use VegFed funding to focus on the aspects of improving pheromone attractants for pest monitoring and the lure and kill tactic, since they do not require the labour-intensive culturing of fungus (although lure and kill does still require the growing of the plants and rearing of insects). The disadvantage of lure and kill is that the secondary effect of the disease outbreak is not present, and control must be exerted from a high rate of kill of males. However, results with leafrollers (a project funded by ENZA in 1997/98) look very promising for this tactic. Development of this approach for DBM is the proposal we have made for

1998/99. Eventual development of lure and infect remains a possibility when funds become available, since the isolates are in long term storage.

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Photo: Local dairy farmer Phillip Hunter inspects an infected diamondback moth caterpillar with insect disease specialists Dr. Tracey Bourner (Lincoln) and Dr. Judith Pell (Rothamsted-IACR) (Photo: HortResearch, Lincoln).