DETERMINING THE EFFICACY OF ORGANIC INSECTICIDES AND SYNERGISTS AGAINST A RANGE OF REPRESENTATIVE INSECT AND MITE PESTS USING A POTTER TOWER.

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GENERAL ABSTRACT

A variety of insecticidal formulations were examined for their efficacy against a range of insects under laboratory conditions using a Potter Tower technique.

The insecticides Yates Pyrethrum, Eco-oil, Defender, Orchex, Confidor, Agrimec, Encapsulated Pyrethrum, Encapsulated Pyrethrum and Neem, Azatin, NeemAzal, as well as a combination of the insecticides Azatin plus Eco-oil were tested at both the half as well as the full recommended field rate against a range of insect pests.

In addition, the ability to synergise natural pyrethrum by some or all of the natural compounds including sesame oil, the crystalline extract of a sesame oil crude extract, dillapiole, and the synthetic synergist PBO, in spray emulsions at a variety of rates and ratios was examined in tests against the pea aphid *Acyrthosiphon pisum,* passionvine hopper (*Scolypopa australis),* greenhouse thrip, and lightbrown apple moth.

Confidor and Yates Pyrethrum gave marked control (i.e. mortality > 80%) of the greatest number of test species including the aphid, thrip and mealybug and two of the moth species for Confidor and all of the moth, aphid and thrip species for Yates Pyrethrum.

It is suggested that the use of the synthetic synergist PBO could be replaced by the natural synergists including dillapiole, as well as the crystalline extract of a sesame oil crude extract at the highest ratio that was tested against the pea aphid, passionvine hopper, and lightbrown apple moth. Results with greenhouse thrip and tomato fruit worm were inconclusive.

A complete summary of the results is given in abstract form for each of the three parts of this dissertation.

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GENERAL INTRODUCTION

With the increasing emphasis by consumers and agricultural export markets, particularly in developed countries, towards sustainability, environmental agriculture, and organic production, there is a growing recognition that if New Zealand is to retain or expand access to these markets then it must respond to this demand.

Agricultural policy is being increasingly driven by these sociopolitical forces (Hall et al 1989) and in response to this pressure the adoption of organic practices and values in new farming systems are emerging with more sustainable methods and growing markets (McCrae et al 1989).

Although there is little consensus as to what sustainability is precisely, and a myriad of definitions have been proposed, in the wider sense it clearly involves biology, ecology, economics, and sociocultural and political considerations (Singh & Thornton 1992).

World Bank economist Herman Daly, (Daly 1991) suggested three conditions that would have to be met by society's material and energy throughputs in order to be physically sustainable. Firstly its rates of use of renewable resources do not exceed their rates of regeneration, secondly its rates of use of nonrenewable resources do not exceed the rate at which sustainable renewable resources are developed, thirdly its rates of pollution emission do not exceed the assimilative capacity of the environment.

MAF New Zealand (1994) defines sustainability in general terms as the ability of a system to endure, by maintaining the resource base, and the absence of unacceptable effects on people or the environment.

An alternative and defensible term of sustainability is sustainable development. The most widely adopted definition of sustainable development, which is the key concept of the Brundtland Report (1987), is defined as 'development that meets the needs of the present without compromising the ability of the future generations to meet their own needs'.
Included in its strategy for sustainable food security, the Brundtland Report states that 'Pest control must be based increasingly on the use of natural methods....The legislative, policy, and research capacity for advancing non-chemical and lee-chemical strategies must be established and sustained'. Further, included in its strategy for sustainable industrial development, the Brundtland Report states that 'The chemical producer and user industries...should bear the responsibility for ensuring that their products meet the highest standards of safety, have the fewest adverse side effects on health and the environment, and are handled with appropriate care by workers and users'.

Organic farming is therefore one of several systems, other than Integrated Pest Management, that can move New Zealand farming practices towards the goal of sustainability by the use of a range of primarily biological (as opposed to synthetic chemical inputs) strategies that produces a commodity free of conventional chemical use, while maintaining soil fertility and plant and animal health.
While some writers such as McCrae et al (1990) have pointed out that most organic farmers are only part of the way along a continuum between input dependent farming (conventional) and sustainable systems, others view sustainability differently. For instance Fisher (1989) from an economical viewpoint believes that a system using some

chemical inputs can be more sustainable than a strictly organic system as it is more able to endure than a system that does not use any chemical inputs.

Never the less, the use of organic pesticides is a valuable tool in the development of a sustainable agriculture, whether it is used by organic farming systems or more conventional systems.

Pyrethrum is the only chemical compound, other than soaps and oils and *Bacillus thuringiensis* which is accredited by the organic production standards in New Zealand and is the most dependable of these chemicals (Epenhuijsen et al 1992).
However, the most frequently used pyrethrum synergist at present, piperonyl butoxide (PBO) is synthetic (Wachs 1949) and non-organic.
As the ability of a synergist to be "environmentally friendly" or organic is now becoming more desirable with changing consumer attitudes (Hall et al 1989). There is a growing need for their synergists to be organic also, even though they may be less cost effective than the alternative synthetic synergists.

The widely accepted definition of a pesticide synergist was described by Matsamura (1985) as " compounds that greatly enhance the toxicity of an insecticide, although they are usually practically non-toxic by themselves".

Originally sought as a means to increase the insecticidal activity of pyrethrum in order to conserve it, today pyrethroid synergists are predominantly used to increase the cost efficiency of pest control by pyrethroids (Brown 1971; Yamamoto 1973; Bond et al 1973), by reducing the concentration of toxicant necessary to achieve a desired mortality when it is combined with the synergist.

The history of pyrethroid synergists stretches back to their origins in the first World War.

In 1940, the synergistic action of sesame oil was first discovered by Eagleson, its active components each having the methylenedioxyphenyl (MDP) moiety.
Recognition of the importance of the MDP moiety for synergism led to the testing for synergistic potency for hundreds of MDP compounds that were synthesised, or isolated from natural sources and is still continuing to a somewhat lesser extent today.

PBO, the first truly effective commercially viable synergist was patented in 1949 and as is previously mentioned it is still a requirement in most pyrethrum insecticides. PBO is an MDP synergist.

Today it is accepted that synergists primarily increase the toxicity of insecticides by inhibiting their metabolism (Casida 1970; Georghiou 1983; Sun & Johnson 1972). In particular, the synergistic effect of MDP synergists has been related to the greater competitive ability of these synergists (in comparison to the chemical insecticide) to form metabolic complexes with cytochrome P450 (Perry & Buckner 1970), as well as their production of adducts which inhibit metabolism of other substrates (Werringloer & Estabrook 1979), and thus inhibiting the oxidative metabolism of the insecticide by the mixed function oxidase system (mfo) of microsomes. In other words, the synergists act as alternative substrates of metabolism, sparing the chemical insecticide from detoxification. Although it is known that MDP synergists are metabolised by oxidation on various sites on their long aliphatic side chains, it is still unclear why the synergists are competitively superior to the insecticide in their ability to form P450 metabolic complexes. This may be due to either improved fit on the active site of the pyrethroid metabolising enzymes or to the availability of the additional sites on the synergists.

This study is divided into three separate parts and although they each have three different aims they are somewhat interrelated.

The aim of the first study was to undertake an assessment on a range of insect species of the efficacy of a range of pesticides, the majority of which are 'soft' pesticides i.e. are natural products which offer lower levels of impact on the environment than the alternative conventional synthetic chemicals. Some of these pesticides have not been released by pesticide companies in New Zealand. Three of these pesticides contain the toxicant natural pyrethrum which is examined more closely in the remaining two parts of this thesis.

Secondly, an assessment of the efficacy of the natural oils sesame and dill, and their extracts, as synergists for natural pyrethrum against the pea aphid *Acyrthosiphon pisum* were examined in comparison to the relative efficacy of the synthetic natural pyrethrum synergist piperonyl butoxide (PBO).

Thirdly, as both toxicity and the degree of synergism of synergists is specific to an insect species, the efficacy of the natural synergists from Part B were examined against a wider range of insect species.

The last two parts were undertaken with the ultimate aim of developing an effective natural pyrethrum product in New Zealand which contains an organic synergist.