Investigation of the ‘peppering’ technique on the control of Fuller’s Rose Weevil and Armoured Scale in kiwifruit orchards

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Abstract

"Peppering" as a method of pest control, was a suggestion put forth by Rudolf Steiner in the 1920's. Essentially, peppering is the process of burning the whole insect pest and spreading over the treated area. This is supposed to interrupt the reproduction process of the insect peppered, and discourage them from breeding within the treatment area (Steiner, 1993). The effectiveness of peppering in the control of Fuller Rose Weevil (FRW) and Armoured Scale in kiwifruit was investigated in this study.

This research was conducted in the Tauranga – Te Puke area of the Bay of Plenty region of New Zealand, and involved five orchards for the scale trial and six orchards for the FRW trial. The respective peppers, provided by Garuda Biodynamics and made in accordance with Steiner's guidelines, were applied via blast sprayer 4-6 times from October to March to one trial block per orchard; there also was a control block within each orchard. Monitoring was conducted approximately every 28-days starting in December and continued until June. For the Fuller's rose weevil (FRW), small tables were built and placed along the kiwifruit rows and monitored for egg masses; for the scale, 408-leaves were collected from the control and treatment blocks per sampling and examined for the presence of adult scale and crawlers.

The results of the peppering trial, showed a significant difference in the numbers of FRW egg masses located on the tables provided in the treatment block, compared to the control block in two orchards. Data from the other four orchards was not able to be analysed due to an experimental design oversight. Thus no definitive conclusions can be deduced from the findings of the FRW trial.

The analysis of the scale trial results showed that there had been a significant effect on the numbers of adult scale with crawlers on a percentage basis, between the treatment and control blocks. This result in theory could indicate an affect on the reproductive cycle of the scale from the application of the scale pepper spray. However, only two samplings were conducted after the appearance of the scale crawlers, which left a limited amount of data on which to conduct the analysis.

While these initial trials indicate a potential for peppering as an alternative means of pest control, it will require longer term trials on orchards, with proper control

measures basis, to confirm the effects of the application of a species specific pepper. Peppering is not a procedure that can be rushed, and while some anecdotal evidence has described miraculous results, it is more common for the effects to take a more prolonged time to develop. Steiner (1993) and Thun (1990) both stated that it could take up to four years for the full effects of the application of a specific pepper spray to develop.

Acknowledgments

This Masters thesis was only made possible through the encouragement of Ewen Cameron from the Department of Agricultural & Horticultural Systems and Management, whose guidance through my Honours year encouraged me to undertake my Masters in the field that has intrigued me since I read Steiner's *'Agriculture'* book. Ewen, along with Terry Kelly, also from the Department of Agricultural & Horticultural Systems and Management, have been my long-suffering supervisors throughout this rather long Masters ordeal. Throughout this five-year journey they have guided and prodded me into action when I entered one of my many lapses of concentration concerning my Masters. In this last year they have taken the time to read, and suggest changes to my writing style, presentation and arrangement of the final thesis. This final thesis would not have been possible without their invaluable input.

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1. Introduction

"Peppering" as a method of pest control, was a suggestion put forth by Rudolf Steiner in the 1920's. Steiner (1993) stated that with insects it is imperative that the whole insect is burnt, and for optimum results the burning process needs to be carried out when the Sun is in Taurus. The burning, Steiner implied, reverses the reproductive influence of the Moon on the insect, thus inverts the insects fertility process. Once the ash of the insects is spread over the desired treatment area the pepper should have the effect of interrupting with the reproduction process of the insect peppered, and discourage them from breeding within the treatment area (Steiner, 1993).

Simply put, it involves collecting a small quantity of the specific pest, for example green vegetable bugs, and burning them in a small wood fire. The ash is then collected and spread over the area that the grower desires to be pest free (Steiner, 1993).

Steiner (1993, p 124-125) in lecture six states:

> *"With insects you must burn the whole insect, if you make your pepper this way you can then scatter it over your fields and the pest will gradually become powerless. After the fourth year you will certainly find that they have become quite powerless. The pest cannot survive; they shy away from life if they have to live in the area that has been peppered in this fashion."*

1.1 Research aim

The aim of this research is to firstly, determine the effects on the associated pest populations of applying peppers of two of the most significant pests in the kiwifruit industry today, Fuller's rose weevil (FRW) and scale. Secondly, determine whether it is possible to disrupt the reproductive cycles of FRW and scale, through the application of their associated pepper spray.

Adult Fuller's rose weevil (FRW) mainly emerge from January through to April (McKenna *et al*., 2003), and because of the stringent withholding periods imposed on kiwifruit growers, none of the present insecticides known to control FRW are permitted. KiwiGreen growers can control scale with Lorsban pre-flowering, and with a maximum of three diazinon sprays after fruit set up to 60-days prior to harvest. While the KiwiGreen growers can also apply mineral oil sprays to control scale, mineral oil is presently the main scale control option for the organic growers (Zespri^{TM} Crop Protection Programme, 2003). If peppering can be shown to be an effective alternative, it would offer both the conventional and organic growers another tool to aid them in controlling some of the kiwifruit pests, and reduce the need to apply some insecticide sprays, resulting in a cost saving to the grower.

Presently, there are limited options for controlling FRW; they consist of applying sticky bands around all plants, poles and wires leading up into the canopy to prevent the FRW gaining access to the fruit; trapping; and biological control agents. Information on the use of peppers is limited, both in formal publications and in less formal fora. While there is little published material available to support the use of peppers, farmers that follow Dr. Steiner's biodynamic principles believe they have strong anecdotal evidence to support their use. In New Zealand and Australia, growers have reported success using peppering for control of a wide range of pests, including possums, rats, mice, rabbits and birds; insects such as scale, passion vine hopper and Fuller's rose weevil; and weeds such as thistles and ragwort.

1.2 Research area

These research trials were conducted in the Bay of Plenty region of New Zealand, primarily around the Tauranga - Te Puke area (Map pg 3). The orchards were chosen primarily from growers associated with the Seeka Kiwifruit Industries Limited company, and had shown a problem with either scale or FRW over the previous seasons. Orchards with previous pest problem history were chosen primarily to ensure significantly high pest numbers in the orchards for the trial. Five orchards were used in the scale trial and six in the FRW trial. Garuda Biodynamics prepared all the pepper sprays applied to the kiwifruit vines during the course of the trial. Details for the procedure of how the pepper sprays were prepared are in Appendix A, pg 90.

Map showing the part of the North Island of New Zealand where the research trial occurred.

Indicates the area where the research trial was conducted

(www.backpack-newzealand.com/**map**ofnewzealand.html)

1.3 The Kiwifruit Industry in New Zealand

Over the last forty-plus years, the New Zealand kiwifruit industry has developed from small beginnings, with a handful of growers, to become what it is today: Zespri™ International is the world's largest marketer of kiwifruit, and globally New Zealand is recognised for producing the world's best kiwifruit (Zespri™ Group Limited Annual Report, 2003). From those humble beginnings there are presently 12,000 hectares of kiwifruit planted in New Zealand (Statistics New Zealand, 2003), however this is down from the high of 18,900 hectares in 1988 (MAF Statistics, 2003). The kiwifruit industry today employs thousands of people nationwide during the harvest period, and hundreds of staff year round with many more employed overseas in sales, promotion, research and growing kiwifruit in other countries under license to Zespri™ International.

Zespri™ Group Limited achieved net sales of $860m [1] for the 2002-03 season, this was an increase of 7.5% over the previous season. Japan is the most lucrative market for New Zealand kiwifruit, earning 296.1m in 2002-03 at an average of $24/tray for all trays submitted; this includes 10.4m (approx.) of organic fruit. However, the Japanese market only accounts for approximately 20% of the annual crop volume (Zespri™ Group Limited Annual Report, 2003). The average 2002-03 orchard gate return of $33,685 per production hectare was an increase of 15% above the previous year (Zespri™ Group Limited Annual Report, 2003).

While these figures are impressive, in the 2001-02 season 48% of all Zespri Green variants, and 55% of all Zespri Gold variants of New Zealand kiwifruit entering Japan were fumigated (Max, pers. comm.). Eighty-one percent of fruit fumigated was directly attributed to the incidence of either Fuller's rose weevil (56%) or scale (25%) (Max, 2002). Even though this level of fumigation is lower than for the two previous seasons, it has still cost the industry seven million dollars (Max, 2002; Kaye, pers. comm.).

Although the Japanese are the most stringent amongst importing nations about fumigating infected fruit, importers to most of the other countries that purchase New Zealand kiwifruit still fumigate fruit depending on the pest found. All costs associated with fumigation reduce returns to the growers, so any measures that can reduce the

[1] All monetary figures are in New Zealand dollars unless otherwise stated.

levels of pest contamination of fruit before it leaves New Zealand should lead to increased returns for the growers.

1.4 Development of the integrated pest management system in kiwifruit

Prior to the introduction of the kiwifruit Integrated Pest Management (IPM) system - commonly known as KiwiGreen - in the 1991-92 season, the key pests of kiwifruit, armoured scale and leafrollers, were controlled by a calendar spray programme of broad-spectrum insecticides (Steven *et al.*, 1994). KiwiGreen came about due to the industry having the foresight to see that it was desirable from a marketing, and production perspective, to be able to supply fruit internationally with reduced pesticide levels (Steven, 1999). Under the KiwiGreen system more emphasis is placed on monitoring; application of an insecticide spray is only permitted when pest numbers have surpassed a predetermined threshold, and then only sprays that do not leave unacceptable residue levels can be applied (Steven, 1999).

KiwiGreen developed and changed quickly so that by 1997 the industry had adopted a new definition:

> "KiwiGreen is an environmentally responsible production system that produces safe fruit for the consumer" (Steven, 1999).

The kiwifruit industry in 1997 introduced a range of key elements for the production of KiwiGreen, these included:

- <u>Only</u> applying a spray in response to a demonstrable need
- Limiting choice of sprays with emphasis on safer, more selective products
- Extending withholding periods imposed on conventional sprays to further restrict their use, e.g. 60-days for diazinon.
- Providing a system that is completely auditable by major international purchasers.
- Requiring that all spray applicators are properly trained and have a current Growsafe certificate
- Requiring that all orchards submit spray dairies before their crop can be exported (Steven, 1999).

KiwiGreen growers were still allowed to apply 3-4 'hard' (diazinon chlorpyriphos) insecticide sprays over the winter-spring period if scale was a problem the previous season (Steven, 1999). In the KiwiGreen programme monitoring for scale should begin in early January, as applications of sprays after 1st January are only permitted if backed up by monitoring results over the threshold of 4% (Zespri™ Crop Protection Programme, 2003).

All kiwifruit growers are supplied with a spray program listing the permitted sprays relative to the growers' category – KiwiGreen, organic or KiwiGold. All sprays have a pre-harvest withholding period that must be adhered to i.e. diazinon is 60-days, even the organic sprays i.e. mineral oil is 14-days and Bt is 2-days (Zespri™ Crop Protection Programme, 2003). After the withholding period has been reached for any given material, the grower must change to a control agent with a shorter withholding period. For the control of armoured scale, mineral oil has the shortest withholding period (Kay, 2002).

Thesis presentation

The thesis is presented in four main sections. Chapter Two, which follows, comprises an explanation of peppering derived from what literature could be found and from reviews of the work of the proponents of the approach. This section aims to provide the reader with an understanding of the peppering approach. The next two Chapters focus on each of the problem pests successively. Within each Chapter is a literature review, description of the experimental and methodological approach, results, discussion and conclusions section. The fifth and final Chapter of the thesis is a summary of the project as a whole. It contains discussion of the results overall and conclusions and recommendations for further research.

2. Peppering for Pest Control

Rudolf Steiner first proposed "Peppering" (so-called as the final ash resembles pepper) as a method of pest control, in the 1920's. Rudolf Steiner was the founder of the Biodynamic agricultural movement that had its beginnings in Europe. In 1924 Rudolf Steiner was invited to present a series of eight lectures on various agricultural topics. The concept of peppering animal, insect and weed pests was introduced during the sixth lecture.

Lecture six, presented on June 14, 1924 (Steiner, 1993) covered animal, insect and plant pests, and plant diseases, along with a brief description of the spiritual-scientific ideas that relate to these. The lecture was not given as a definitive answer for pest control but more as a guideline for future experimentation. Steiner presented a series of examples, along with practical advice to convey his ideas and principles behind peppering. Steiner believed peppering was totally species specific and will only affect the plant, insect, or animal used to make the pepper, e.g. a pepper made from mice will not affect other rodents; likewise a pepper made from nodding thistle will not disrupt the germination of Scotch thistle seed.

Steiner (1993) asserted plants grow with the influence of cosmic forces arising from the stars, and moving through the planetary spheres and the Earth's Moon before being absorbed by the Earth. These forces work onto plants from above, on their way in, as well as from the Earth, as they work back through the plants. The Moon, or lunar forces are especially influential on the watery growth of plants. The Moon is not only reflecting the Sun's energy and light down to the Earth, but also the entire cosmic forces that come to it (Steiner, 1993). These forces are absorbed by the plants and aid in the development of reproductive plant processes, eg. starting with cell division and tissue formation and finally showing in the fertility of seeds (Steiner, 1993).

Steiner (1993) suggested taking some of the seeds of the plants we desire to eradicate, and burning them in a simple wood fire. The burning, Steiner implied, inverts the fertility present in the seeds; once burnt the ash is collected. Steiner (1993) goes on to say that this ash contains the opposite force to what developed in the seeds with the aid of the lunar forces, so reverses the effects of the Moon by preventing the treated earth from absorbing these forces. When this ash is spread over the desired area, its influence is to disrupt the germination of seeds of the plant species burnt (Steiner, 1993). Total cover of the area with the pepper ash is not necessary; Steiner believed there is a substantial radiating effect from a well-made pepper. The cosmic influences have a four-year cycle, i.e. It can take up to four-years for the influence to be totally effective; so while the effect should be noticeable in the second year, by the forth year there should no longer be any of the weed present in the treated area (Steiner, 1993; Kolisko, 1939).

Steiner (1993, p 125) in lecture six states:

> *"It is important to develop a relationship to the Earth where we know – on the one hand – that it is right that the Earth is enabled by the lunar and watery influences to bring forth plants. On the other hand, however, what is in the plant, what is in every living thing, also carries in itself the germ for its own destruction. Just as water is indispensable for fertility, so is fire a destroyer of fertility. Fire consumes fertility. Therefore, if something that is ordinarily treated with water in order to promote fertility is instead treated with fire, then within the household of nature you bring about the opposite – namely destruction. Under the influence of Moon-saturated water, a seed develops fertility and proliferates: under the influence of Moon-saturated fire – or fire saturated with any other cosmic force – the same seed spreads a force of destruction".*

With plants, Steiner (1993) stipulates that the effect of the lunar forces alone are sufficient in the plant kingdom to push the growth process, such as cell division, into a reproductive phase, but in the animal kingdom a greater emphasis needs to be placed on the effects of the planets, and the zodiac – 'animal circle'. Steiner (1993) goes on to state, that when peppering animal pests, only the skin of the animal is required, as the Moon forces are understood to help form the reproductive organs before ending in the formation of the skin. The size of area being treated will determine the amount of ash (pepper) required, while a small area i.e. a 1-hectare block may only require one animal skin, while a 10-hectare block may require five or more, depending on the size of the animal being peppered (Steiner, 1993).

Steiner (1993) stated that the effects of the Moon need to be supported by Venus for successful reproduction in animals. For this reason, when making an animal pepper eg. mice; for the best results the animal skin, along with testes of males (Pearce, 1993), should be obtained and burnt in the period when Venus is in the constellation of Scorpio (Scorpio is chosen as it is the constellation that rules the reproductive ability (Atkinson, pers. comm.; Pearce, 1993)). The ash obtained through the burning process at this time will contain the negative force of the animal's reproductive force, and will disrupt the Moon's fertility influence of the treated animal pest, so discouraging it from staying or breeding in the area (Steiner, 1993). Once this ash is spread over the desired area the pest usually vacates the area within a few weeks, in some cases only days (Atkinson, pers. comm.). Anecdotal evidence by Kemp (2003), and other members of the Biodynamic association has suggested that peppering animal pests is one of the quickest, and most successful long-term approaches to controlling animal pests (Appendix B, pg 91). Insects and weed peppers can take considerably longer to be effective, as previously stated.

Garuda Biodynamics has adopted a homeopathic method to produce their pepper preparations. The insects for the FRW and scale pepper solutions Garuda Biodynamics provided for this trial were all collected from the local area. The peppers were prepared according to Steiner's astrological guidelines, within the 12-months prior to the commencement of the trial.

2.1 Importance of the zodiac constellations in relation to the 'twelve groups of animals'

Peppering insects requires a different approach to that of the higher animals, as insects are considered to be 'lower' animals, and so are subject to a totally different range of cosmic influences. Eugen Kolisko published a paper in 1936 titled *'The twelve groups of animals'*, in which he has associated a different group of animals to each zodiac constellation (Figure 1).

Kolisko (1936) divided these groups in two. The first seven phyla embrace the totality of the invertebrate sub-kingdom – animals with no true skeleton and soft bodies. The five remaining phyla are members of the vertebrate sub-kingdom – animals with true skeletons. As you proceed anticlockwise around the circle the organ development of the groups becomes more differentiated. Each of the major organs has an associated planet; therefore the more organ differentiation present in the group the more planetary influence has taken place (Kolisko, 1936) and so more notice of the planets needs to be considered when working with the higher animals than with the lower animals (Atkinson, pers. comm.).

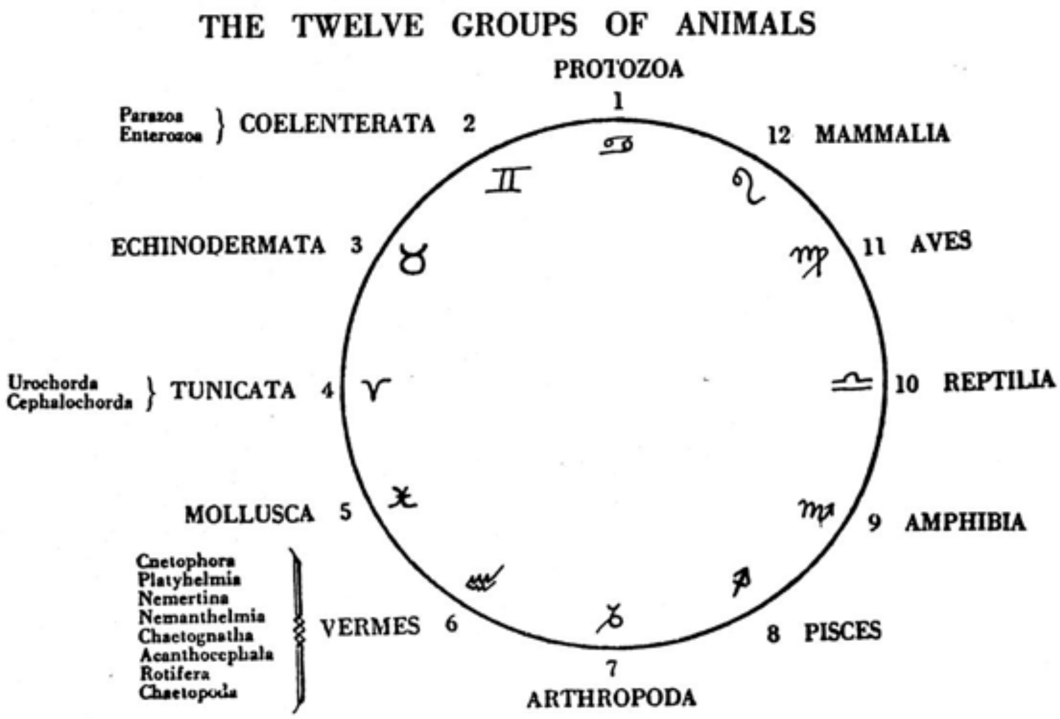


Figure 1: The twelve groups of animals by Kolisko (1936)

Since insects have little organ differentiation, when peppering insects the influence of the constellation is more important than that of a planet. With mammals, eg. mice, there is a far greater differentiation and development of internal organs to that of insects, so in these instances the planets have the greater influence (Atkinson, pers. comm.). With insects it is imperative that the whole insect is burnt, but for optimum results the burning process needs to be carried out when the Sun is in Taurus (Steiner, 1993). For this reason it may be necessary to dry and store the insect pests until the time is right. Steiner (1993) said that the forces that develop as the Sun moves through the zodiac houses of Aquarius, Pisces, Aries, [Taurus], Gemini and Cancer affect the whole insect world, Taurus to the greatest extent and Aquarius and Cancer to lesser extents.

Once this ash is spread over the designated area, the Moon's influence is reversed, thus discouraging the insect from reproducing within this area (Steiner, 1993). The insect pepper is usually applied several times each season to ensure control, but fewer applications appear to be required in subsequent years (Atkinson, pers. comm.).

2.2 Dr Lievegoed's theory of the cosmic influences on all species

Some of Dr. Steiner's own agricultural work was based on earlier work conducted by Goethe (mid 1800's). Goethe's concept suggests life manifests on Earth, due to a harmonic resonance being established on Earth, from the constant interplay of forces emanating from the Fixed Stars. These forces from the stars are mediated by, and altered as they pass through the planetary spheres of our Solar System (Lievegoed, 1950). All the planets, and the asteroid belt radiate their respective energy fields not only along their orbit paths, but also as a complete envelope as shown in the schematic drawing in Figure 2 (Atkinson, 2002). It is not so much the planetary body itself, but the whole sphere of electro magnetic activity that the planet exists in that is influential (Atkinson, pers. comm.). Astronomy has shown that each star force has its own unique resonant signature. It is this signature that is characterised as an archetypal imprint that eventually manifests as the individual plant, insect or animal species (Atkinson, pers. comm.).

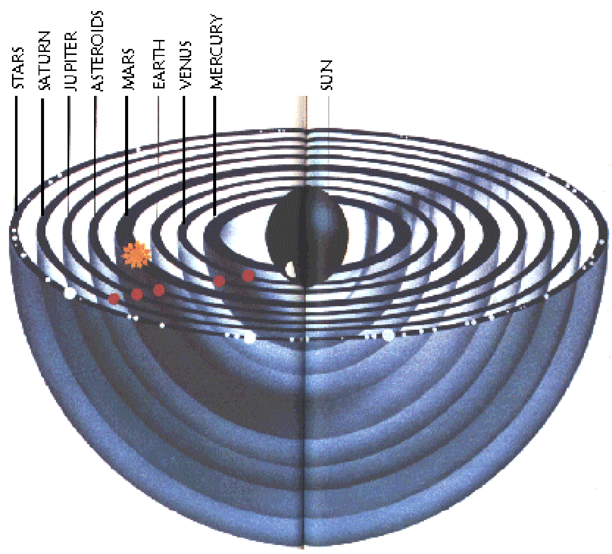


Figure 2: The solar system onion. (Atkinson, 2002).

It was Lievegoed (1950) who extrapolated Goethe's original work to make it easier to understand. In Goethe's 'Being' and 'Manifestation' diagram (Figure 3) he described the formation of manifest life forms as a two-stage process. A 'primary' building up of potential, he called 'Being', followed by a 'secondary' process where this potential comes into 'Manifestation'. This two-stage process occurs regardless of whether the entity is an animal, insect or plant.

The ‘Primary planetary processes’ (Fig 3), are built up as the cosmic forces emanating with a constant force/electromagnetic pulse, from the stars in the other galaxies, move towards the Earth, through the planetary spheres. Saturn initially mediates these star forces (Atkinson, pers. comm.). Saturn focuses these forces’ direction and strength to incarnate the ‘Archetype’ (Lievegoed, 1950), or core intention of the species. Each species (plant, animal, insect etc) has its own associated star ‘Archetype’ force (electromagnetic resonance), eg. the archetype force that makes a rose a rose is different to the archetype force that makes a Fuller’s rose weevil a Fuller’s rose weevil (Atkinson, pers. comm.).

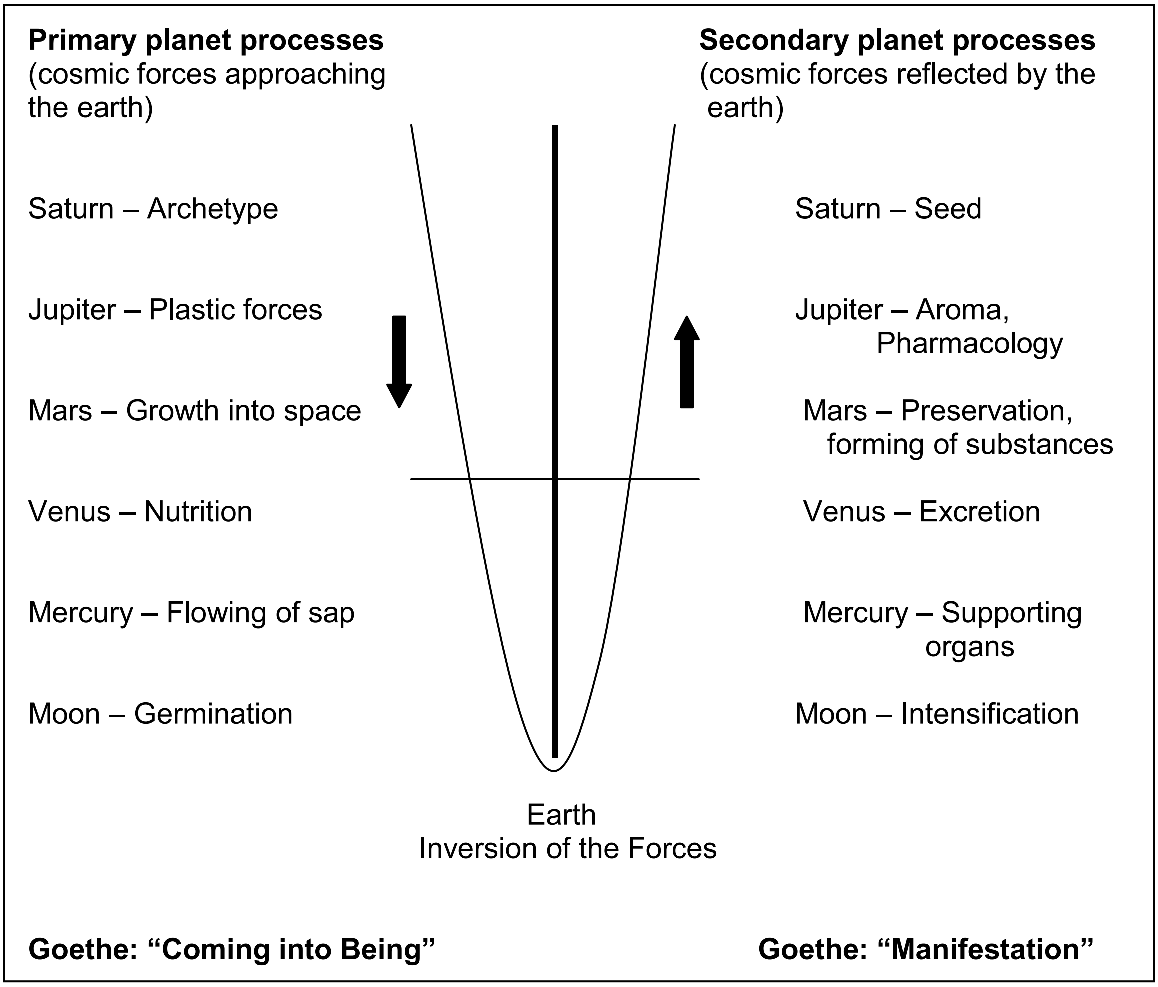


Figure 3: Goethe’s ‘Being’ and Manifestation’ model showing the primary and secondary processes associated with each planet (Lievegoed, 1950).

Saturn focuses the building blocks to start the process of ‘the desire for life’. This basic impulse holds true throughout the subsequent stages until it reaches fruition in reproduction. While the Saturn activity holds the plant on track “to be a rose” it also shows strongly in animals in their skeletal structure, while in the plants this archetypal force works through the silica processes, providing the plants structure and physical support (Atkinson, pers. comm.).

The forces that are influenced by Saturn are then passed on to Jupiter, here they are moulded and softened. Jupiter's process gives rise to order and harmony moulding the forces, so they can fit into the environment they find themselves and later into organs and muscle in animals, and in plants the supporting tissues (Lievegoed, 1950). Mars forms and orders the substances that enable growth to expand; blood flow and protein formation in animals. Mars takes this organised and moulded impulse and thrusts it into its new environment.

Lievegoed (1950, p 10) states:

> *"Mars represents the force by means of which the Spiritual archetype of the plant pierces through and penetrates into the physical, and which also pushes it out again into the world".*

Initially this brings the plants desire 'to be' to the Earth and secondarily it shows as the plants ability to push out back into the space around it, at its growing tips. It is responsible for the shooting and sprouting of buds and seeds each spring (Lievegoed, 1950). In plants, the Mars process is involved with the nitrogen cycle and building healthy protein, as well as the act of fertilisation. This Mars process is seen as the plant's growing part pushes into space (Lievegoed, 1950). The Venus process creates an environment of growth, and is particularly concerned with the nutrition of the cells in both plant and animals (Lievegoed, 1950), and preparing it for the fertilisation of the Mars activity. The Mercury process initially helps the plant adapt to its environment further. In its secondary phase it forms the lymphatic system in animals, and sap flow in plants (Lievegoed, 1950). Moon's processes are active wherever cell division, reproduction and propagation are active. It is responsible for all eternal repetition and heredity (Lievegoed, 1950).

The 'Primary planet processes' are seen as occurring prior to germination, taking place outside the plant in the environment around the plants, rather than in the plant itself. This can be explained by following an annual plant through the seasons. From mid-summer until late autumn the activity of plants moves increasingly back towards the Earth. As the fruits of the present season are ripening, effectively fulfilling the 'manifest' stage of the present plant, there is an invisible dynamic phase taking place around the plant (Atkinson, pers. comm.). It is as if the environmental conditions of the present season act as the carrier of these activities. In late autumn and winter the ripe seeds and the new ‘Being’ impulses crystallise together in the Earth, so that once the seed germinates this ‘Being’ potential from the last season begins its ‘Manifestation’ phase.

As the fruit forms, the Saturn archetype forces are present ensuring that a tomato will continue to grow into a tomato (Lievegoed, 1950; Steiner, 1993). The secondary Jupiter processes become active in the ripening process, while at the same time helping to mould the developing seed to the environment it will grow in next season. Mars’s process ensures the production of proteins and starches which inturn help the Venus process to provide adequate nutrition for the seed. The Mercury process continues to carry the nutrition in the sap around the plant while ripening is occurring (Lievegoed, 1950).

The Moon processes in the ripening period are condensed into the seed and show as the seeds inherent fertility; however they also build up in the environment and soil as a potential for next season (Atkinson, pers. comm.). Without the moon processes the seed could not germinate, the insect or animal could not reproduce, as cell division would not be possible. It is this Moon process that peppering interferes with and terminates while the effect of the pepper is present. If the pepper is not regularly applied the effect wears off and so the Moon process can continue again.

At the bottom, or winter phase of the cycle, the growth processes enter into the Earth; this is where the inversion of the forces takes place and the growth processes begin to move outward again into the next season (Atkinson, pers. comm.). This can be likened to what happens in winter; seeds lie dormant until the soils start to warm up in spring to germinate; larvae feed on roots and organic matter then pupate, so when spring arrives they are ready to emerge as adults; some insect eggs remain in a dormant state in bark crevices until the air temperatures warm up so signalling spring. In many animals the adult female carries the unborn young until time of birth in spring.

This leads on to the ‘Secondary planet processes’ (Fig 3) or the spring to mid-summer phase. It starts with the Moon process, or intensification, here the cell division begins and tissue formation takes place (Lievegoed, 1950), the seed has germinated and started to grow, while in animals the young are born. The Mercury process develops the supporting structure of the plant, such as wood formation or the nervature of the leaves (Lievegoed, 1950). In animals the bones are growing and getting stronger. Closely related to this Mercury process is the Venus process described as excretion. All the substances no longer required by the plant are excreted in some way eg. excess salts are excreted in the bark of some trees, or in cellulose formation (Lievegoed, 1950). In animals the kidney formation sees to the excretion processes where excess salts and waste products are excreted as urine and faeces, providing food for soil organisms (Bacchus, pers. comm.).

The secondary Mars process is involved in the nitrogen chemistry, the shooting into space and the formation of proteins in later growth (Atkinson, pers. comm.). These substances are preserved in different ways; liquid sugars are stored in leaves until needed later for bud maturation, or fruit formation; starches are deposited in seeds or storage stems (potato), or a more permanent form as in sugar cane (Lievegoed, 1950). In animals the excess substances are deposited and stored as fats and sugars around kidney, liver and gall bladder areas for later use (Bacchus, pers. comm.).

Jupiter's process is described as the chemist; for it is here that the aroma and pharmacological effects are bestowed on the flowers and fruits as colour, flavour and aroma. Sugars are broken down to form glucosides, disintegration proteins form alkaloids, and out of the carbohydrates the ethereal oils are formed (Lievegoed, 1950). Jupiter's function in animals/insects is linked to the development of the hormones responsible for fertility/maturity, so enabling reproduction (Bacchus, pers. comm.).

During the Saturn process comes the completion of the seed formation (Lievegoed, 1950) and for annual plants the death of the plant. In insects the Saturn process is borne out in egg laying, prior to death in many insect species; in animals the mating period. The Saturn process can also lead to the further breakdown of substances left over from the Jupiter process, so with the excretion of hydrogen and oxygen, the finer cyanogen aromas evident in the plum, peach and apricot arise. It is said that in the apple we eat Jupiter, but in the plum we eat Saturn (Lievegoed, 1950; Steiner, 1993).

Atkinson (pers. comm.) explained Goethe's model by saying, simply put, what is being stated here is that the archetypal 'formative' forces coming from the stars pick up the different planetary forces as they pass through the energy fields of each of the planets (Figure 2), until the earth absorbs them. This is the 'Up-building stream' or coming into 'Being' as Goethe explained it. An inversion process takes place in the Earth, the absorbed cosmic forces then work back upwards from the Earth and 'manifest' themselves in the forms of the plant, insect, mammal or other life forms during the "secondary planetary process.

Steiner (1993, p35) in lecture two states:

> *"In the seed we have an image of the whole universe. Each single time a seed is formed, the earthly organizing process is led to its end, to the point of chaos. And each time, within the seed-chaos, a new organism is built up out of the whole universe. The parent organism simply has the tendency, through its affinity for a particular cosmic setting, to bring the seed into relationship with the forces from the proper directions, so that what emerges from a dandelion is a dandelion and not a barberry. But the image reflected in the individual plant is always the image of some cosmic constellation and is built up out of the cosmos.*

2.3 Potentisation

When peppering small insects such as scale or Fuller's rose weevil, it is impractical to collect large quantities of ash to treat large areas. Some researchers have been experimenting with potentising peppers as a way of better utilizing small quantities of raw materials. Samuel Hahnemann (1755-1843) conceived the principles of potentisation of substances, also known as Homoeopathic dilutions, in an attempt to decrease the dosages of toxic substances to reduce their side effects, without reducing their 'curative powers'. To his surprise he discovered by trials on patients, that by subsequent dilutions the 'curative powers' actually increased while after a number of dilutions there was no longer any detectable molecules of the original substance (Pearce, 1993).

Potentisation is a process of rhythmic dilutions (to the power of ten) of a substance; in the case of peppering this is the pest ash; eg. the first potency is 10^1 and usually referred to as 1x. Potentisation requires one part material to nine parts water, or alcohol; this solution is successed (rhythmically shaken) for a number of minutes; this is the *first* potency (1x). One part of the first potency is then added to nine parts water/alcohol, successed for same time, this results in the second potency (2x) or a dilution of 1: 100 (10^2). This process continues until the desired potency is reached eg. 8x or dilution of 1: 100,000,000 (10^8) (Kolisko, 1939; Pearce, 1993).

Kolisko (1939) showed that the potency of a substance does not increase with every dilution, but rather plots out in a wave pattern. Kolisko (1939) conducted numerous experiments to determine the potency peaks of a substance; this allowed them to trial the most potent, and beneficial dilutions.

While it has been noted by some members of the Biodynamic association that the treatment effect with un-potentised peppers can last many times longer than potentised peppers, however, with insects in most cases the practicality issues limit the use of un-potentised ash (Atkinson, pers. comm.).

2.4 Developmental work of Steiner's guidelines for peppering

Maria Thun with the assistance of her staff carried out peppering experiments on weeds between 1968 and 1979 (Thun, 1990). Their findings suggested that the effects of the application of a pepper lasted over four years. They noted that if the pepper was mixed in water and stirred biodynamically (stirring in one direction until a vortex is created, then changing direction until vortex again created, etc) for one hour prior to applying, that the effect could last even longer than four years (Thun, 1990). Thun (1990) took Steiner's work further and experimented with homoeopathic solutions of the peppers, which has enabled large amounts of a pepper to be produced from relatively small amounts of ash. In Thun's book *'Gardening for life – the biodynamic way'* (1999), she gives more precise times in relation to which constellation the Sun should be in at the time of burning (Table 1), depending on type of pest.

Thun has conducted numerous experiments and trials to substantiate her findings, but has never released any of the results to be scrutinised by other scientists. Many biodynamic farmers and growers have also conducted their own trials, but mostly without control areas for comparisons, so rendering the results anecdotal.

There are biodynamic farmers and growers that have been experimenting with using potentised peppers for a number of years. Thun, as stated above and Garuda Biodynamics mainly use 8x potencies, and Kemp (2003) in Australia mainly uses 12x potencies. Members of the biodynamic associations in Australia, and New Zealand have conducted numerous anecdotal pepper trials over the years, some of these have been summarized in Appendix B, p91.

Table 1: Thun's pest peppering table ('Gardening for life – the biodynamic way', 1999. pg 94).

Pests	**Time**
Day-flyers, such as Cabbage White, flies and midges, white fly	Sun and moon in Twins, *also* Venus and moon in Twins
Night-flyers and moths	Sun and moon in Ram, *also* Mercury in Ram
Colorado beetle, Varroa mite (pest of bee family), Turnip gall weevil, all beetle pests	Sun and moon in Bull
Cutworm, leatherjackets (jar worm)	Sun in Bull and moon in Scorpion
Scale insects and slugs	Moon in Crab, *also* moon and Mars in Crab
Aphids	Moon in Twins, *also* Venus in Twins
Blossom weevil	Moon and Venus in Twins
Mites, red spider mite	Venus or moon in Waterman

Atkinson (pers. comm.) added that it should be noted that when looking at treating large areas, whatever the species, that it is desirable to source the material to prepare the pepper from as wide a range as possible. The reason behind this is to give as diverse a phenotype (genetic variations as a result of environmental factors), within the genotype (genetic constitution of an organism) of the pest/weed as possible.

Garuda Biodynamics have shown in their trials that insect peppers made from pests sourced within the Bay of Plenty, are not as effective in the Waikato, as peppers made from insects obtained within the Waikato itself (Atkinson, pers. comm.). A Kaipara farmer peppered thistles from one area on his farm then spread the ash over the whole farm. He found it only affected the germination of the thistles in the area from where the thistles for the pepper were gathered; it was not until he made a pepper from thistles collected from different areas of the farm that he achieved the desired result.

There are a number of kiwifruit growers in the Bay of Plenty region that have been applying the passion vine hopper pepper for a number of seasons now (Atkinson, pers. comm.). Upon interviewing a number of orchardists applying Garuda Biodynamics peppers, it became apparent that while most of these growers believe that applying the peppers has helped reduce the damage caused to their kiwifruit, none of them have ever left a control block for comparison. Garuda Biodynamics' (now BD Max) released the scale pepper for commercial use for the 2001-02 season but has to date has yet to conduct field research to determine the effectiveness of their peppers.

Garuda Biodynamics made their scale pepper from scale insects collected from a range of sites throughout the Bay of Plenty region. Garuda Biodynamics however do recommend for the best results, making the pest pepper from insects collected off the orchard concerned. This is usually only feasible on large orchards due to cost of preparing pepper.

2.4.1 Possum peppering trial based on Steiner's principles

Various Biodynamic growers' association members and organic growers have experimented with peppering possums to keep them out of gardens and orchards, but these have mostly been small-scale trials. Blake and Bacchus (2000) conducted the first large scale peppering trial during 1998-99, to eradicate possums from a 200 ha site in the Tararu Creek catchment block, north of Thames, North Island, New Zealand.

Environment Waikato conducted a possum count prior to the possum pepper application and two afterwards. Environment Waikato concluded that since the total number of possums captured increased each time, that the trial was unsuccessful and the peppering had not worked. Blake & Bacchus (2000) found it interesting to note that while the numbers of possums caught on one of the two trapping lines inside the treatment zone decreased, the numbers of possums caught on two of the three lines outside the treatment zone increased.

3. Effectiveness of peppering for scale control in kiwifruit

3.1 Introduction

In New Zealand, three species of armoured scale insects are known to infest kiwifruit vines: these are greedy scale *Hemiberlesia rapax* (Comstock), latania scale *Hemiberlesia lataniae* (Signoret), and oleander scale *Aspidiotus nerii* Bouché (Berry *et al.*, 1989; Lo & Blank, 1989). Greedy scale is the dominant species in the Bay of Plenty region (Blank *et al.*, 2000). Greedy scale is more common in the North Island than either latania or oleander scale, with most South Island kiwifruit growers considering it a minor pest (Steven, 1990). Despite this, armoured scale continues to present export-marketing problems even though they cause only minor cosmetic damage to fruit, a major problem being that even once dead they continue to hold fast to the fruit.

Greedy scale became recognised as an international quarantine problem soon after the commencement of kiwifruit exports in the late 1960’s (Sale, 1980). This led to the commencement of insecticide trials to control scale, and by the 1979 season phosmet and diazinon had been accepted as the main scale control agents. Carbaryl had been the accepted late season insecticide until then, but problems with residue levels prompted the dropping of carbaryl from the spray program (Sale, 1980). Work carried out during the 1970’s on the scale lifecycle helped to advance the methods of scale control dramatically, this allowed for more precise timing of insecticide application (Sale, 1980).

Historical scale control methods revolved around a calendar style spray program involving the application of 7-9 sprays of broad spectrum insecticides, such as azinphos-methyl, diazinon, chlorpyrifos, and phosmet (Blank *et al*, 1985). Most of the sprays applied were organophosphates, and by the early 1980’s the market started to demand more stringent controls on the maximum insecticide residue limits (MRL’s) permissible on the fruit (Sale & Steven, 1984). These measures saw the introduction of the synthetic pyrethroids, dichlorvos, mineral oils and organophosphates with lower mammalian toxicity levels, to control scale in the later part of the season.

Since then due to overseas pressures, the kiwifruit industry has been moving towards growing systems that have less reliance on calendar style pest and disease control, towards more environmentally friendly systems. These include the introduction of the KiwiGreen programme in the early 1990's that restricted the use of selected sprays after a predetermined date. The predetermined dates are set by the use of the MRL's; these have been determined by the Codex Alimentarius Commission (established under the World Health Organization to develop safe food standards for consumers). The MRL's have been reviewed over time, and this has forced the withholding period for selected insecticides to be brought back to 60-days from harvest. After this date only insecticides such as mineral oil for scale control, and Bt sprays for the control of leafroller are permitted.

Sprays applied after January to control scale may only be applied after a proven need has been shown through monitoring (Max, 2002). For scale, leaf monitoring is the accepted procedure for determining the need to apply an insecticide (Blank *et al.*, 2000). In 2003, Permethrin-based insecticides (Attack and Averte) were banned from use on kiwifruit. This ban is in response to overseas pressure to stop the use of the older style board-spectrum insecticides that kill all orchard insects, including the beneficial insects (Martin, 2003). These changes to the allowable sprays are forcing the industry to look for other alternatives.

Figure 4 shows the scale infestation rates for all the Apata-Centrepac KiwiGreen growers orchards over the 10-year period 1993 - 2002, as determined from the packhouses pest monitoring records. The steady increase in scale rates can partly be attributed to the fact that, since 1997 the numbers of insecticide 'hard' sprays applied to the kiwifruit vines during the early part of the season have been reduced, leaving a reliance on the 'softer' oil sprays in the latter part of the season. Part of the reason for the increasing rates of scale found can also be attributed to many growers now being prepared to delay spraying until much higher rates of scale are detected on the leaves of their vines. Stevens *et al.*, (1997) found that delaying application of an oil spray from the recommended 4% scale threshold until 8% scale on leaves saved on the number of oil sprays required, with economically insignificant fruit loss due to scale on fruit.

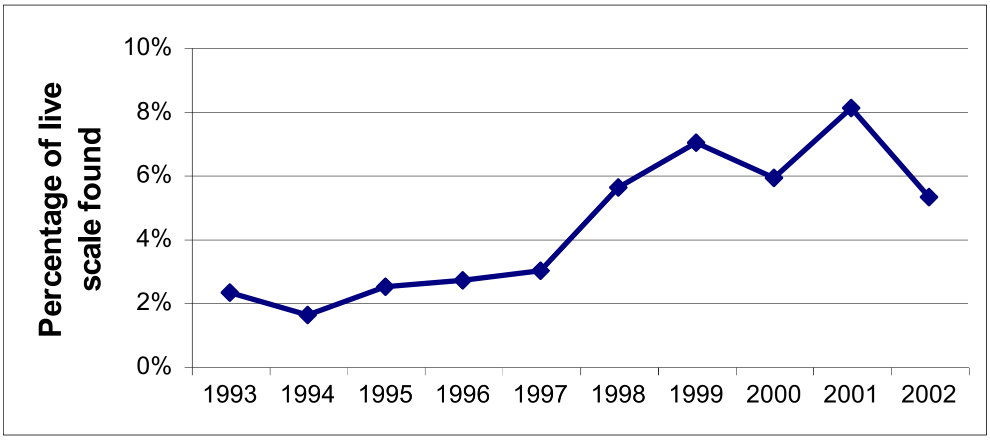


Figure 4: Scale rates of all Apata-Centrepac KiwiGreen growers orchards over the last 10-years (Max, 2002)

3.1.1 Research objectives

The objective of this research was to determine the effects on the armoured scale's population from the application of the scale 'peppers' in organic and conventional kiwifruit orchards.

3.2 Scale lifecycle

All scale species can have two generations per year, the first from October to late November, and the second occurring through February to April (Figure 5) (Ferguson, 1998).

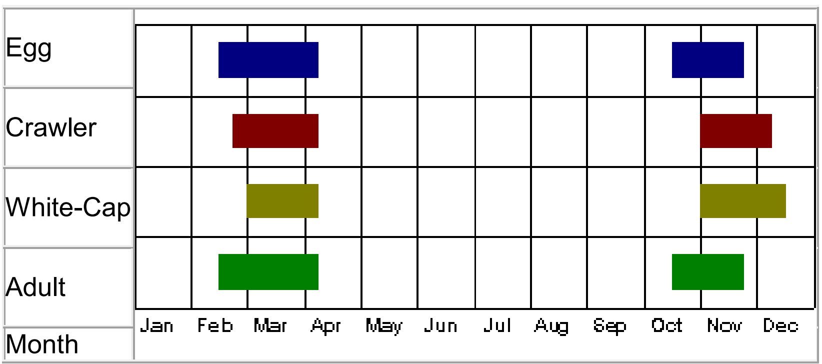


Figure 5: Indication of peak activity times for respective life stages of armoured scale (HortFACT, 1998)

With greedy scale (Figure 6) and other armoured scales, reproduction is by parthenogenesis, that is, unfertilised eggs are laid (Steven, 1990).

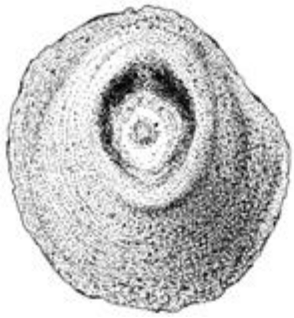


Figure 6: Greedy scale, *Hemiberlesia rapax* (Comstock) (HortFACT, 1998)

Eggs are produced in batches of 3 - 8 over a period lasting up to two months. Each adult produces a total of 26 - 120 eggs over this time (Ferguson, 1998). The eggs are held under the female's protective shell until they hatch; at which time the small six-legged crawlers disperse.

The crawler commonly inserts its piercing mouthparts into the leaf midrib or leaf stalk, as this is where the main supply of sap is flowing. The crawlers can settle on fruit if present, or woody parts of plant. If the crawlers are in shelter trees they can drift on the wind to new host plants, this becomes one of the main ways kiwifruit become reinfested each year (Blank *et al.*, 1990). Once the crawlers have located a suitable host plant they settle and moult, and spin a white silken cap (1st instar) (Figure 7). It takes approximately 15-weeks from crawler to full adult for the summer generation, and 26-weeks for the winter generation to reach the same stage (Ferguson 1998). In the early part of the season, the crawlers can only infect the kiwifruit leaves and wood, as the fruit is not yet present; generally leaves are colonized before fruit (Steven, 1990). Only the crawlers of this second generation that have settled on the woody parts of the vines, or other host plants can complete their lifecycle. Over winter, due to the abscission of the leaves, any scale that has settled on them will die due to lack of food (Blank *et al.*, 2000).

The adult scale will remain where it is for its lifetime, as seen in Figure 7. The next stage involves the scale forming its protective armoured shell by moulting its old skin and now superfluous legs (2nd instar). The final phase (3rd instar) is the maturing stage when the scale becomes fully mature and capable of laying eggs (HortFACT, 1998). Armoured scales have piercing mouthparts that are used to attach themselves to the plant and start sucking sap (Steven, 1990).

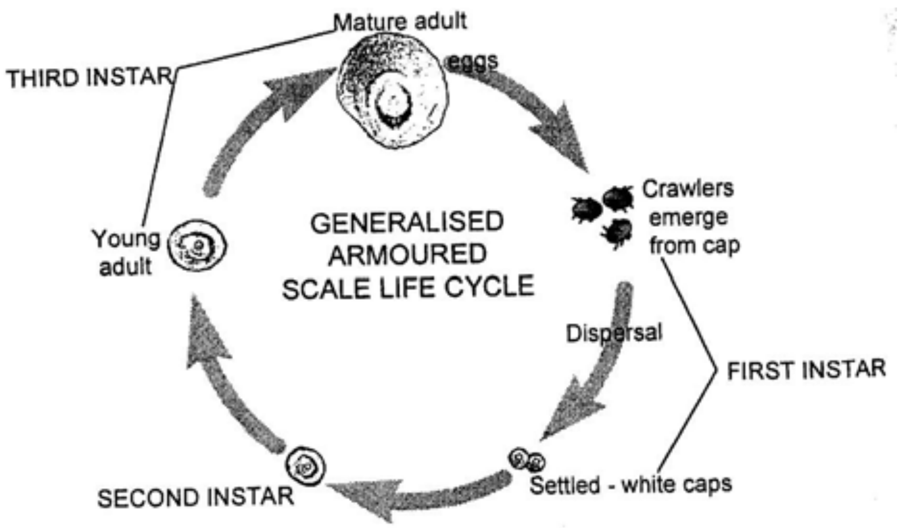


Figure 7: Generalised life cycle of armoured scale (Fellows, 1998)

It is possible to locate all the different life cycle stages of armoured scale throughout the year (Blank *et al.*, 1995; Blank *et al.*, 2000; HortFACT, 1998). The eggs laid during the February to April period hatch and survive the winter living in the crevices of the bark, on the vines, and on host plants. These scales mature slowly over the winter period and start laying eggs during the October to November period; it is this generation that cause the major problems for the kiwifruit growers (Blank *et al.*, 2000; HortFACT, 1998).

3.3 Armoured scale monitoring system

The armoured scale monitoring system was developed over several years of trials. The system involves determining the number of leaves in a sample that have live armoured scale on them, and using this as an indication of fruit infestation. The disadvantage of this leaf sampling system is that armoured scale levels on leaves may not always provide a reliable estimate of the potential level of fruit infestation (Blank *et al.*, 1994). An alternative approach would be to monitor armoured scale levels on fruit, but this would be impractical given the high cost of collecting repeated fruit samples.

In the original KiwiGreen Pest Monitoring manual, an arbitrary figure of 4% scale infestation was set as a threshold; this meant that unless leaf-sampling results showed more than 4% scale, a grower was not permitted to apply an insecticide. This threshold figure was set to try and reduce the amounts of insecticides being applied to the orchards, but this threshold figure had no scientifically validated research to support it (Blank *et al.*, 1994, Stevens *et al*., 1997). In an evaluative study of the present KiwiGreen monitoring system, which compared this model for scale monitoring to other monitoring models for scale, Worner, (2002) concluded that, to have a 90% confidence level at the present threshold level of 4%, that the number of leaves sampled would need to be increased from the recommended 100 leaves/block to a minimum of 258 leaves/block. If the block contains more than 258 bays then 1-leaf/bay should be taken (Worner, 2002).

Blank *et al.*, (1994) with pooled data found a scale infection level of 17:1 (leaves: fruit), therefore suggesting that any threshold figure up to 20% could be chosen. All the organic growers involved in this trial commented that they hold off applying oil sprays until scale levels reach approximately 20% or more, without detecting any significant scale problems on their fruit at packing time. Stevens *et al*., (1997) wanted to determine if there was a difference in scale numbers present on fruit, at harvesting, between using a spraying threshold figure of 4% or 8%. Their findings found that there was a difference, but it was not economically significant, and that the commercial packhouses would not detect the scale with the same degree of sensitivity as Stevens *et al*., (1997) did using microscopes.

3.4 Organic trials and implementation of scale control methods

The introduction of the KiwiGreen program in the 1991-92 season was facilitated by the fact there already was an effective control for scale and leafroller prior to this time. Organic growers had been experimenting with *Bacillus thuringiensis* (Bt) products for leafroller control, and mineral oil products for scale control. Had it not been shown by earlier research that mineral oil could control scale to some degree, and that Bt could control leafroller, both of which do not leave any unacceptable spray residues (Steven *et al*., 1997), it would have been difficult to get the KiwiGreen program accepted by growers.

3.4.1 Oils - petroleum

Tomkins *et al.*, (1996) conducted a field trial during the 1991-92 growing season, to evaluate the effectiveness of mineral spraying oil in comparison to the then conventional phosmet spraying programs. Their results concluded that the mineral oil gave adequate protection against scale only when used at the 2% solution rate, and not at the lower 1% or 0.5% solutions. The main problem Tomkins *et al.*, (1996) would have encountered in 1992-93 was that kiwifruit growers perceived that any scale found in their orchards was an unacceptable risk in terms of reject fruit, and that the orchard had to be absolutely scale free. This meant that they were looking for a protective solution that would provide this; hence the 2% solution rate was chosen.

Regardless whether an orchard is organic or conventional, today many kiwifruit growers are more accepting of scale on the vines, as long as the numbers on the fruit are less than 1% (McKenna *et al.*, 2002). This has allowed for the introduction of the now recommended mineral oil rate of 1% to be standard. Only in extreme infestations would a grower consider applying a 2% solution. The higher, 2% oil solution, rates led to fruit marking problems associated with phytotoxicity (McKenna *et al.*, 2002), hence the lower recommended rate.

In field trials conducted during the 1992-95 seasons on ‘Hayward’ vines using 1% and 2% oil sprays, McKenna *et al.*, (1997) found that the 1% solution resulted in some black speckling of fruit between 14 – 44 days after fruit set (d.a.f.s). When the 2% oil spray was used the susceptible period was 7 – 51d.a.f.s, with up to seven times more damage than encounted with the 1% oil spray.

Zespri Gold (Hort16A) is proving more susceptible to oil spray damage than Zespri Green. With Zespri Gold, oil sprays of 2% applied between 21 – 70 d.a.f.s resulted in some fruit showing phytotoxicity damage in the form of black speckling. When the 2% oil sprays were applied from approximately 100 d.a.f.s onwards, some orchards experienced premature fruit loss. Oil sprays of 1% generally resulted in substantially less damage to the fruit. Generally however, 1% oil sprays were found to be safe to apply pre-blossom; from fruit set to 21 d.a.f.s; and again from approximately 90 d.a.f.s (McKenna *et al.*, 2002).

From these types of trials, the use of mineral oil has become the main approach for the control of scale for the organic and KiwiGreen growers during the later part of the season. Current recommendations set the scale thresholds for applying an oil spray at 4% (from 1st March the threshold is 10% for KiwiGreen growers); under this level no spraying is permitted. From 4 – 20% scale infestation, an application of a 1% oil spray is recommended followed by leaf sampling 21 days later. If more than 20% scale infestation, apply a 1% oil spray and repeat 14 days later, then continue leaf sampling after 21 days. A 2% concentration can be applied if scale infestation is severe; however, the risk of phytotoxicity fruit damage is significantly increased (Zespri^{TM} Crop Protection Programme, 2003).

3.4.2 Oils - vegetable

McKenna (1999) conducted trials to evaluate vegetable oils to control scale in comparison to the standard mineral oils being applied presently. The two oils in the trial were an emulsified rapeseed oil (erso) and an emulsified reconstituted vegetable oil (evo). The results showed that a 2% solution achieved 100% and 99% mortality respectively, but both oils resulted in phytotoxicity damage to 63.8% of the fruit, leaving it unfit for export, while the application of the mineral oil resulted in no phytotoxicity damage to the fruit. The 1% solution resulted in higher levels of scale on the fruit, but still resulted in phytotoxicity damage to the fruit. In contrast no damage was observed with either concentration with the mineral oil.

3.4.3 Insecticidal soap

Tomkins (1996) conducted trials during the 1988-89 and 1989-90 growing seasons on the use of insecticidal soap for the control of greedy scale. The results concluded that the insecticidal soap alone could not control, reduce, or prevent the reinfestation of greedy scale on the leaves of the kiwifruit vines. The insecticidal soap resulted in a water-stain blemish that affected 40% of the fruit.

3.4.4 Parasitic controls

The most common endoparasitoid to attack scale in New Zealand is *Encarsia citrina*, and the two ectoparasites are *Signiphora merceti* and *S. flavopalliata.* All three parasites are tiny wasps, with *Encarsia* feeding on immature scale; primarily in the second instar stage. The two *Signiphora* species tend to attack adult scale (Steven, 1990). Parasitism varies greatly from region to region and increases as the season progresses. Samples taken at harvest from fruit and wood were found to be parasitised at levels of 39.6% and 30.4%, respectively (Steven, 1990). Individual samples taken in June of mature stages of greedy scale were found to be 87% parasitised (Berry, 1983).

While the proportion of parasitism can be high in the greedy scale population it is generally considered insufficient alone to prevent contamination of fruit at harvest (Steven, 1990). No trials have been conducted to determine the viability, or effectiveness of releasing large numbers of these parasitoids into the blocks early in the season to control scale. All the parasitoids are present at some level throughout the year, especially in the organic orchards (Steven, pers. comm.).

3.4.5 Fungal pathogens

A number of fungal pathogens have been found to kill scale, namely *Fusarium lateritium* and *F. coccophilum.* Sale & Ferguson (1975) conducted a trial for a selective control of greedy scale from a product derived from a culture of *Fusarium lateritium*. Their results indicated only limited success, and were not considered worth investigating further.

3.5 Peppering potential

Steiner (1993) stated that when preparing peppers to use on insects, it is imperative that the whole insect is burnt, and for optimum results the burning process needs to be carried out when the Sun is in Taurus. Once this ash is spread over the designated area, the Moon's influence is reversed, thus discouraging the insect from reproducing within this area (Steiner, 1993). The insect pepper is usually applied several times each season to ensure control, but fewer applications appear to be required in subsequent years (Atkinson, pers. comm.).

There are biodynamic farmers and growers that have been experimenting with using potentised peppers for a number of years. Atkinson (pers. comm.) added that it should be noted that when preparing generic peppers for treating orchards within a region eg. Bay of Plenty orchards, it is desirable to source the material to prepare the pepper from as wide a range as possible within that region. The reason behind this is to give as diverse a phenotype as possible.

3.6 Methodology

Five orchards were used in the scale peppering research. On each orchard two blocks were chosen; one control and one treatment block, both of approximately 0.5 canopy hectares. The treatment blocks received a scale "pepper' application approximately every month from October to March, a total of six applications. All blocks received the normal spray programme associated with the respective orchards.

Orchards involved in the research (Figures 9-13, pg 33-35) were chosen firstly on the basis of historical scale problems and secondly on the basis of locality, to ensure a cross section of orchards from the Tauranga and Te Puke area was obtained. Four of the orchards were chosen from "Seeka Kiwifruit Industries" growers, whose previous year's monitoring results showed known scale infestation problems. The fifth orchard was located through personal contact, and had a history of scale problems. Four of the five orchards involved in this scale research used an organic management regime, but the orchard being organic this was not a factor in determining the orchards chosen.

The fact that four of the five orchards in the trial were organic had more to do with location, and not as a result of organic orchards having higher levels of scale than conventional orchards in the region. An issue that did arise was that for convenience of spraying, block selection for the trial was somewhat dictated by the orchardists, this meant that in some cases there were differences between treatment and control blocks in terms of shelter plants and wind effects.

Most of the pepper applications were applied prior to the commencement of the sampling, hence the reason only a few pepper spray applications are indicated on the live scale population individual orchard graphs (Figures 16-20, pg 43-46).

3.6.1 Scale sampling procedure

In line with the recommendations for sampling in commercial orchards and consistence with the level of error expected, samples consisted of collecting 408 mature kiwifruit leaves from each treatment approximately every 28-days commencing in December until harvest. Both the control and the treated blocks were randomly sampled in the same manner. All the results for the numbers of live scale recorded per respective orchard during the course of the research can be seen in Table 2 (pg. 36). The seven samplings were taken between the 27th December 2002, and the 26th May 2003.

Due to differences arising from shelter and wind exposure there were effectively four treatments: treatment block affected by shelter (TBAS), treatment block unaffected by shelter (TBUS), control block affected by shelter (CBAS), and control block unaffected by shelter (CBUS). Four leaves were randomly collected from each side of a vine, per bay, within a row. Unfortunately due to the size constraints of some blocks involved in the scale pepper trial, it was not always possible to randomly select rows to be sampled from each block, as in most cases bays from each row were required to obtain the required number of leaves. However, the same rows were sampled throughout the research period.

Blank *et al.*, (1997) adopted a similar sampling technique; they chose to sample two leaves per bay resulting in 360 – 378 leaves per block as they were sampling larger blocks. Blank *et al.*, (2000) collected 100 – 130 mature leaves per block per sampling. Worner (2002) recommended sampling a minimum of 258-leaves per block if the block contains less than 258-bays. If there are more than 258-bays in the block, then one mature leaf per bay should be collected if a 90% confidence level is desired, while retaining a 4% live scale threshold before applying an insecticide.

The researcher for this trial wanted no more than a 5% sampling error at 95% confidence level, to achieve this required a minimum of 400-leaves (or 50-bays) per sample (de Vaus, 2001).

The leaves were examined with the use of a binocular microscope, in accordance with the instructions given in Section 6 – Scale monitoring – in the KiwiGreen Pest Monitoring Manual (1994). The leaves were examined for the presence of live and dead armoured scale, with special attention being paid to the petiole and leaf blade along the midrib, as shown diagrammatically in Figure 8 and in Photo 1.

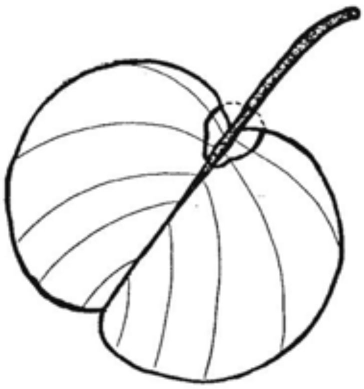


Figure 8: Diagram of kiwifruit leaf with the circled area indicating where the majority of scales are found (KiwiGreen Pest Monitoring Manual 1994).

Photo 1: Scale on leaf within circled area (KiwiGreen Pest Monitoring Manual 1994).

All scale found were recorded, with dead and live scale being recorded separately. Whether the scale was dead or alive could be determined by lifting the cap of the armoured scale and examining the colour and fluid content of the scale body. A live scale is recognisable by a bright yellow body-sac full of fluid (Photo 2), while dead scales have darker, dehydrated bodies (KiwiGreen Pest Monitoring Manual, 1994; Stevens *et al*., 1997). Evidence of subsequent generations was determined by the presence of crawlers under the cap of a mature scale, as can be seen in Photo 3.

In addition to recording the number of live and dead scale, the numbers of crawlers under the cap of the live scale was recorded once these were found. Since peppering targets the reproductive capacity of the target pest, this was likely to be an important measure of the efficacy of the pepper. However, due to the timing of the crawlers' appearance, this only allowed for two monitoring periods.

Photo 2: Adult scale with cap removed. In the centre is the upturned cap.

Photo 3: Adult scale with crawlers. Some of the crawlers are still inside the cap.

One of the reasons for recording the numbers of live and dead scale was to show that the time of pepper application had no effect on the scale population. This is because the pepper is a reproductive inhibitor and not an insecticide.

Blank *et al.* 1994, counted the leaf as infected whether the leaf had one or more scale present. Since 1994 the Kiwifruit Monitoring Manual has regarded infected leaves the same way. This approach was not used in this research reflecting the objective of this project, as opposed to the commercial drivers of most scale monitoring.

When monitoring for the purposes of determining when to apply a spray, determining exact quantities of pests present is not critical. The monitoring is conducted primarily to give approximations of the pest populations present at any one time within the orchard. However, when conducting research, a far more accurate estimation of the level of the pest population is critical if a high degree of confidence is desired, hence the reason for sampling 408-leaves rather than the 100 leaf sample recommended in the KiwiGreen Pest Monitoring Manual (1998).

3.6.2 Impacts on experimental design

The species of tree chosen by the orchardist for use as shelterbelts can have a major impact on the levels of scale present in the orchard, as the shelter trees are generally the over-wintering host plants for scale. Jamieson *et al.*, (2002), conducted a survey of armoured scale insects on kiwifruit shelter bark and concluded that *Cryptomeria japonica* was the best choice for shelter, as it harboured the least amount of scale on the tree bark of the twelve species in the trial. This therefore limits the amount of adult scale over-wintering on the trees to reinfest the kiwifruit the following growing season. Balsam poplar (*Populus trichocarpa*), Matsudana willow (*Salix matsudana*), and Leyland cypress (*Cupressocyparis leylandii*) were found to harbour significantly greater numbers of scale than other shelter species, and should be avoided when planting shelter trees (Jamieson *et al.*, 2002).

Blank *et al.*, (1987) found that there were many host plants and trees for scale near orchards, which become important sources of aerial reinfestation of scale crawlers into the kiwifruit orchards. It was also noted that the kiwifruit rows nearest the shelter or near other trees highly infected with scale, suffered the highest rates of scale infestation.

3.7 Property maps showing blocks involved in scale research.

Orchard 'A' - Paengaroa

The TBAS[2] and TBUS were to the left of the dashed line, with the TBAS from the SW end, and the TBUS from the NE end of the same rows and a minimum of 100m from the shelter. Bays from all six TBAS/TBUS rows were required to get enough leaves.

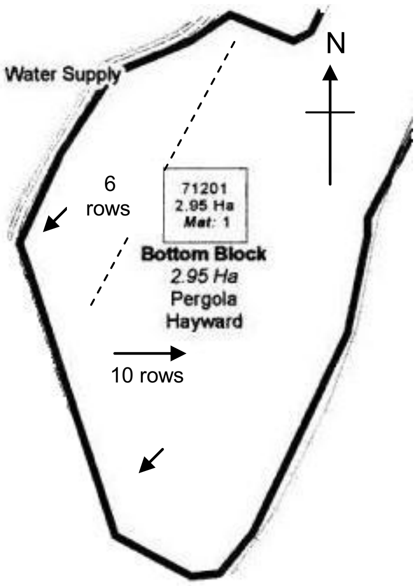


Figure 9: Orchard 'A' property map

The CBAS and CBUS came from rows in the middle of the block, ten rows to the right of the dashed line. These rows contained 70+ bays/row so only two rows required with the CBAS leaves coming from the SW end bays of the two rows, and the CBUS leaves collected from bays in the NE end of the block, and a minimum of 100m from the shelter. Between arrows is an old 15m+ high *Pinus spp* shelter. Along the NW side is a 2m wooden fence. A steep bank of over 10m provides shelter on the SE side. There is no internal shelter. The prevailing wind comes from SW. The orchard has been organic since 1998.

Orchard 'B' - Te Puke

Shelter on the E, S and W sides is 6m *Casuarina spp*, shelter at N end of map is *Pinus radiata* over 10m high. The prevailing wind is from the W. The orchard was organic when purchased in 2001. Block 6 is the control block with Block 7 being the treatment block. All rows contain 21 bays, but most end bays affected by shelter. CBAS came from outside W rows of Block 6 and first two end bays at N end of remaining Block 6 rows. TBAS came from outside E rows of Block 7 and first two end bays at N end of remaining Block 7 rows. CBUS and TBUS came from four rows in the middle of Blocks 6 and 7 respectively, avoiding the end four bays at either end of the blocks.

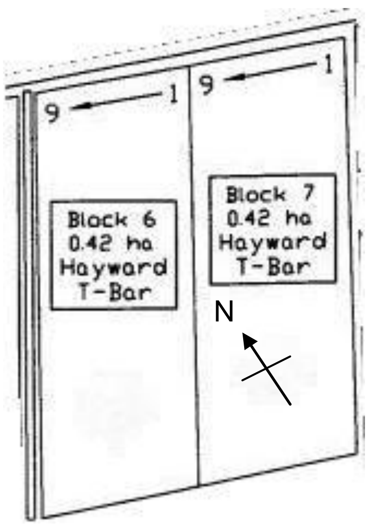


Figure 10: Orchard 'B' property map

[2] TBAS – treatment block affected by shelter, TBUS – treatment block unaffected by shelter, CBAS – control block affected by shelter, CBUS – control block unaffected by shelter

Orchard 'C' – Pongakawa

Shelter along SW side consists of a 5m high *Cryptomeria japonica* shelter with 10m+ black walnut trees behind these on the neighbours property. At the NW and SE ends of block are 5m *Cryptomeria japonica*. At the NE side is another kiwifruit block. The prevailing wind is from the SW. The orchard has been organic since 1997. In Block 3a the TBAS consists of the first three rows from the W, with the next three TBUS. In Block 3b the CBAS consists of the first three rows from the SW, with the next three CBUS. There are 19-bays/row, all three rows had to be sampled in order to obtain the leaves. The prevailing wind comes from the SW.

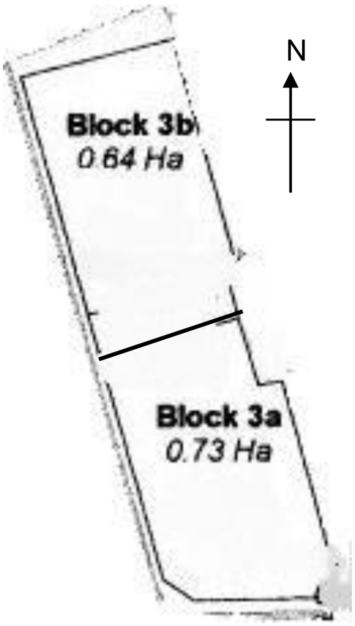


Figure 11: Orchard 'C' property map

Orchard 'D' – Lower Kaimai, Tauranga.

Shelter along W side is a combination of *Casuarina spp* (10m+) and *Cupressocyparis leylandii* (new). There is a row of *Casuarina spp* between blocks A and B, and between blocks A, B and C. At the S end of block C is a 10m+ *Pinus radiata* shelter. At the N end is a young 2m *Casuarina spp* shelter, on the E side is another organic kiwifruit orchard. The prevailing wind is a SW. The orchard has been run organically since 1997. Block A was the TBAS with 24-bays/row so only two rows and three bays had to be sampled to collect the required leaves. The TBUS rows were from the E side of Block B, with 17-20 bays/row this required three rows. The rows closest to the W shelter of Block C provided the CBAS and the CBUS came from the rows on the E side of Block C. The rows in Block C contain 29-32 bays/row so only requiring two rows each to provide the required leaves.

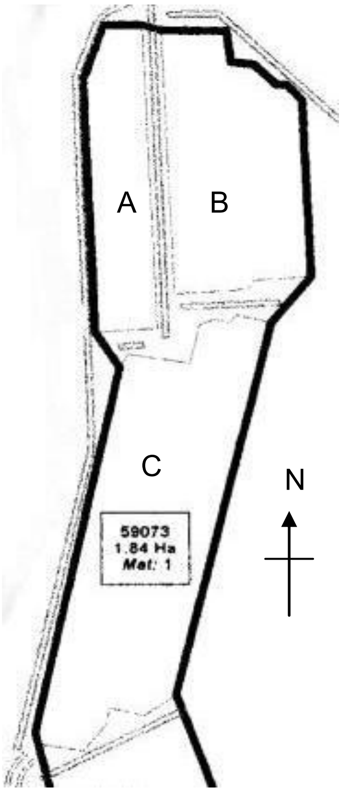
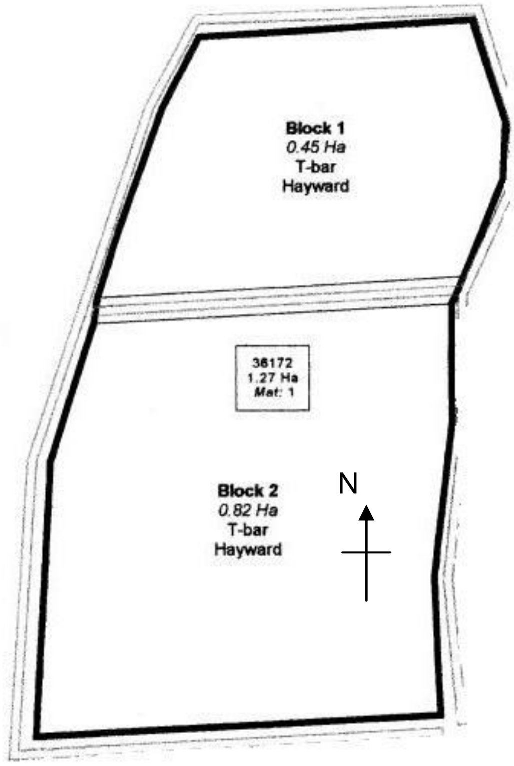


Figure 12: Orchard 'D' property map

Orchard 'E' – Tauranga



This is the only KiwiGreen orchard in the scale trial. Both the E and W sides of block sheltered by 20m *Eucalyptus spp* and *Pinus spp*, with middle shelter 6m high *Salix matsudana*. At the S end of block is the owner's home. Block 1 was the treatment block, with Block 2 control block. The prevailing wind comes from the W. Rows contained between 15-20 bays resulting in three rows required to obtain leaves.

Figure 13: Orchard 'E' property map

Full maps of all properties can be found in Appendix C, pg 98.

3.8 Results and discussion

3.8.1 Live scale results

This trial involved collecting 408-leaves approximately every 28 days starting on the 27th December, 2002. All live scale found upon examination of the leaves under a binocular microscope were recorded and appear in Table 2.

Table 2: Numbers of live scale recorded per orchard at each of the respective sampling dates.

Orchard	Date	TBAS	TBUS	CBAS	CBUS
A (Organic)	27/12/2002	32	19	17	21
	21/01/2003	30	24	12	17
	11/02/2003	43	21	49	42
	8/03/2003	25	33	48	20
	31/03/2003	42	24	49	42
	25/04/2003	34	37	69	72
	26/05/2003	26	21	31	26
B (Organic)	27/12/2002	32	12	35	19
	21/01/2003	31	23	43	37
	11/02/2003	50	6	59	37
	8/03/2003	31	27	27	27
	31/03/2003	50	47	38	27
	25/04/2003	40	44	44	55
	26/05/2003	60	47	33	41
C (Organic)	27/12/2002	230	154	70	43
	21/01/2003	364	220	64	22
	11/02/2003	365	286	81	59
	8/03/2003	549	382	78	64
	31/03/2003	420	272	53	54
	25/04/2003	277	241	89	71
	26/05/2003	210	277	50	50
D (Organic)	27/12/2002	76	34	50	14
	21/01/2003	28	12	9	9
	11/02/2003	37	15	22	8
	8/03/2003	39	13	37	23
	31/03/2003	52	26	57	21
	25/04/2003	75	25	45	12
	26/05/2003	70	25	59	20

Orchard	Date	TBAS	CBAS
E (KiwiGreen)	27/12/2002	44	37
	21/01/2003	35	60
	11/02/2003	43	41
	8/03/2003	32	70
	31/03/2003	26	54
	25/04/2003	12	37
	26/05/2003	13	45

TBAS = treatment block affected by shelter
TBUS = treatment block unaffected by shelter
CBAS = control block affected by shelter
CBUS = control block unaffected by shelter

- Orchard 'E' only had results for affects with shelter due the extremely tall shelter surrounding the blocks used in the trial. This meant that there were not enough vines left unaffected by the shelter to collect the required amount of data. This has resulted in the data from Orchard 'E' not being included in some of the analyses due to the lack of parameters to compare.

The purpose of applying the pepper spray is to disrupt the reproductive phase of the armoured scale. The clearest indication that the application of the pepper spray has had the desired effect would show up in the percentage of live adult scale with crawlers under their caps. The percentage of the total number of live scale with crawlers was calculated from the total number of live scale, rather than the number of leaves sampled. This gave a more direct indication of the treatment's affect, as it showed the true percentage of live scale that had been able to reproduce.

Table 3 shows the results of the total numbers of live adult scale found; the total numbers of live adult scale found with crawlers and the percentage of live adult scale with crawlers in the treated block and control block, per orchard. The percentage of live adult scale found with crawlers under their caps was calculated by dividing the total number of live adult scale found with crawlers, by the total number of live adult scale found.

Table 3: Percentage of total live adult scale found with crawlers under caps for the treatment and control blocks for the individual orchards, per 408-leaves sampled.

		Treatment block			**Control block**		
Orchard	Date	Total live scale	Live scale with crawlers	% Live scale with crawlers	Total live scale	Live scale with crawlers	% Live scale with crawlers
A	25/4/03	71	12	17%	141	28	20%
	26/5/03	47	10	21%	57	22	39%
B	25/4/03	84	7	8%	99	20	20%
	26/5/03	107	6	6%	74	14	19%
C	25/4/03	518	153	30%	160	69	43%
	26/5/03	487	223	46%	100	56	56%
D	25/4/03	100	9	9%	57	21	37%
	26/5/03	95	10	11%	79	39	49%
E	25/4/03	12	0	0%	37	11	30%
	26/5/03	13	0	0%	45	8	18%
Mean		89.5	9.5	9.8%	76.5	21.5	33.3%

It can be seen in Table 4 that not all the treatment blocks had lower numbers of scale with crawlers than the control blocks. However, the percentage results (Table 3 and Figure 14) indicate that speculatively there was a treatment effect, with the effect being more noticeable in orchards 'E' and 'D' and to a lesser degree orchard 'B'. On orchards 'B' and 'D' the percentage of live scale found with crawlers in the control block was substantially higher than the treatment block at both sampling times. On Orchard 'E' in the treatment block there were no live scale found with crawlers, whereas in the control block there were 30% and 18% per the respective samplings. However, this trend did not continue in Orchards 'A' and 'C,' where there were no significant differences between the numbers of live scale found with crawlers in the treatment block and control block.

Table 4: Number of live adult scale found with crawlers under caps for individual orchards for each sample date, per 408-leaves sampled.

Number of adult scale found with crawlers under their cap					
Orchard	Date	TBAS	TBUS	CBAS	CBUS
A	25/4/03	6	6	15	13
	26/5/03	5	5	13	9
B	25/4/03	3	4	12	8
	26/5/03	4	2	6	8
C	25/4/03	69	84	44	25
	26/5/03	87	136	27	29
D	25/4/03	5	4	19	2
	26/5/03	7	3	34	5
E	25/4/03	0		11	
	26/5/03	0		8	
Mean		5	4.5	14	8.5

TBAS = treatment block affected by shelter

TBUS = treatment block unaffected by shelter

CBAS = control block affected by shelter

CBUS = control block unaffected by shelter

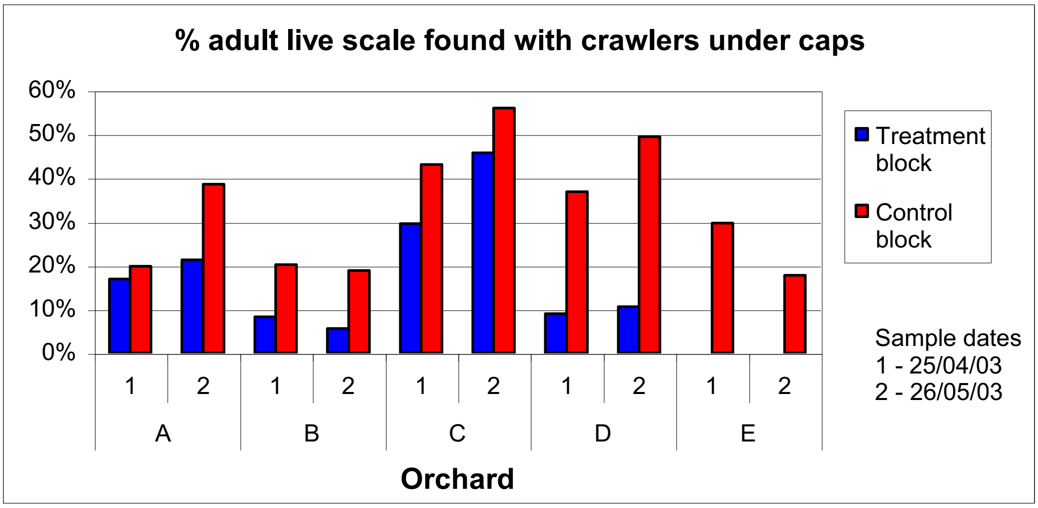


Figure 14: Percentage of adult live scale found with crawlers under caps for the two sample dates for the individual orchards, per 408-leaves sampled. Figure created from Table 3.

It could be argued that the percentage results seen in Table 3 for orchards B, D and E represent a treatment effect on these orchards, but then why not on orchards A and C. With only the two samplings conducted it is not possible to make a judgement on the success, or failure of the scale pepper spray. The difference here could just as easy be associated to chance selection of leaves. In hindsight at the first sign of reproduction the samplings should have taken place every fortnight until leaf-fall in June; this would have provided more detailed data. On reflection it had been noted that some of the live scale detected in the March sampling had been observed to have a grainy nature about them, this was actually the eggs inside the adult. This should have been recorded as a sign of reproduction and therefore would have resulted in at least three samplings and not two.

When the data from the two monitoring times when the scale crawlers were present was analysed, using the GENMOD procedure (Table 5) of the SAS statistical system, sample one from the treatment and control blocks was compared to the data from the second sampling. The GENMOD procedure took the individual results of orchards A, B, C and D and compared them to orchard E. With only the two sampling times it was not possible to do a comparison between the treatment, and control blocks within each orchard, hence the data has been pooled to produce Table 5.

Table 5: SAS system GENMOD procedure for results of Table 4.

Since only two samples were taken, the GENMOD procedure had to compare the results of sample one from the treatment and control blocks, to that of sample two from the treatment and control blocks. The pest indicator was a comparison between the total number of live adult scale with the total number of live adult scale found with crawlers.

Parameter		DF	Estimate	Standard Error	Wald 95% Confidence Limits		Chi-Square	Pr>ChiSq
treatment	0	1	0.5466	0.0373	0.4736	0.6196	215.14	<.0001
sample	0	1	0.0755	0.0359	0.0051	0.1459	4.41	0.0357
pest	0	1	-1.1996	0.0426	-1.2831	-1.1162	794.06	<.0001

Significance Pr > ChiSq (0.05) (NB. Scale parameter held fixed)

The data analysis presented in Table 5 shows that there was a significant difference between the two samples in relation to the treatment and control blocks, and the number of live scale with crawlers compared to the number of live scale found within the treatment and control blocks. The data recorded from orchards A, B, C and D were compared to the data of orchard E and were all found to be significantly different.

When the number of adult scale found with crawlers (Table 4 and Figure 15) is considered orchards 'C', 'D' and 'E' show real differences in the number of scale found with crawlers between the treatment and control blocks. In orchard 'C' it is the treatment block that has the higher levels of scale found with crawlers. However, when the percentage of scale found with crawlers is considered there were 10% more scale found with crawlers in the control blocks on orchard 'C'.

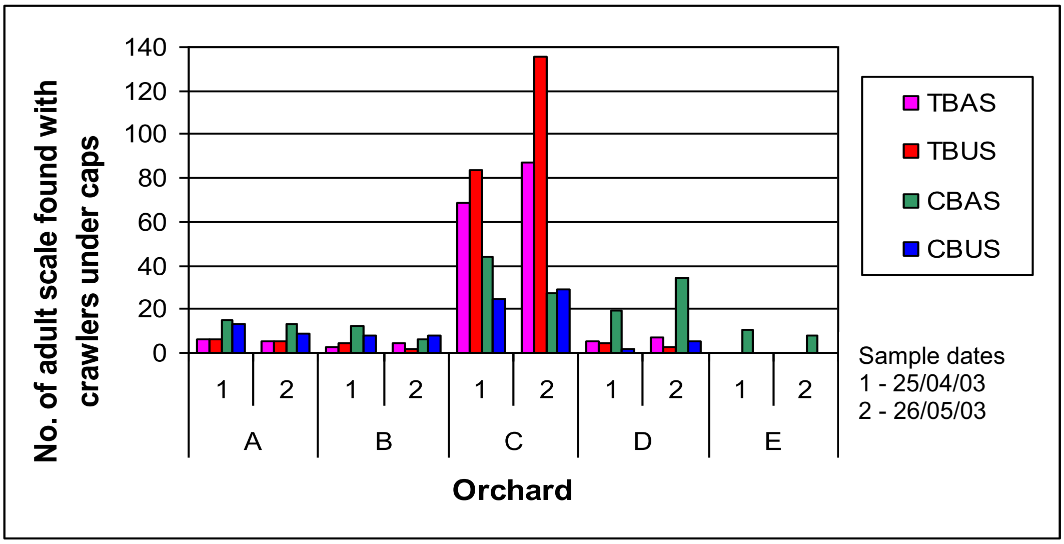


Figure 15: Number of adult scale found with crawlers under their caps for all individual orchards, on the two sampling dates, per 408-leaves sampled.

Higher numbers of scale found with crawlers were recorded in all of the control blocks affected by shelter (CBAS), than was found in the control blocks unaffected by shelter (CBUS). This could lead to the assumption that there is a shelter affect, and this could be true but would require further trials to prove. However, in the treatment blocks this trend was not followed, with orchards ‘A’, ‘B’ and ‘D’ showing no clear difference in the number of scale found with crawlers between the shelter affected or shelter unaffected blocks. In the treatment block on orchard ‘C’ it can be seen that in the area unaffected by shelter there were substantially more scale found with crawlers than in the area affected by shelter.

The results of the total numbers of adult live scale found with crawlers under their caps, from all the leaves sampled per individual orchard, were analysed using the SAS statistical programme. The effect of all the parameters (treatment, shelter, date of sampling, and treatment x date) were analysed. Orchard ‘E’ was not included in individual results due to only having shelter-affected results; this did not leave enough parameters to compare to conduct the ANOVA for orchard ‘E’. None of the parameters analysed proved significant; results can be found in Appendix D, pg 103.

Another ANOVA was conducted to compare the significance of other parameter effects (orchard, shelter and treatment) on the combined total number of adult live scale found with crawlers under their caps from all the orchards. This again showed no significant differences; the results can be seen in Appendix D, pg 103.

Table 6 is an ANOVA of the results of the total scale (alive or dead) found per individual orchard, in relationship to all the parameters (treatment, shelter, date, and treatment x date) tested. Orchard 'E' again not included due to not enough parameters to conduct the ANOVA.

Table 6: ANOVA results for individual orchards of total scale (live + dead) in relationship to effect of parameters shown.

	Pr > F			
Orchard	trt	shelter	date	trt*date
A	0.1832	0.1372	<.0001	0.0689
B	0.8039	0.1526	0.0048	0.3157
C	0.0726	0.3666	0.0042	0.0240
D	0.2589	0.0716	0.0036	0.5354

Significance Pr > F (0.05)

In this ANOVA (Table 6), for Orchard 'C' the treatment x date showed a significant difference. When this is reviewed in regards to Figure 18, pg 44, it can be seen that after the application of the last pepper spray that the numbers of live scale found in the treatment blocks continued to rise. The most noticeable significance in Table 6 is the date of the sampling. This factor is of only minor importance as it is common for pest populations to increase during the season.

The ANOVA of the combined scale, dead or alive, for all the orchards in relationship the all the parameters tested can be seen in Table 7. These results reflect the same trends seen in Table 6, with significant differences between scale numbers on dates of sampling, and orchard locations.

Table 7: ANOVA results of combined scale (live + dead) data, in relationship to effect of parameters shown.

All orchards	Pr > F
orchard	0.0030
shelter	0.0680
trt	0.2347
trt*shelter	0.9867
date	0.0003
shelter*date	0.9364
trt*date	0.5436
trt*shelter*date	0.8973

Significance Pr > F (0.05)

These differences are to be expected as all the orchards involved in the trial were in different areas, with different surroundings, shelter types and heights both within the orchards and on the boundaries. Finding no significant difference in the treatment effect on the numbers of live scale was expected since the pepper is a reproductive inhibitor, and not an insecticide. The true affects on the live scale population will not be known until next seasons monitoring results are reviewed, but it could take up to four years before the full effects are seen, as stated by Steiner (1993).

3.8.2 Live and dead scale results

The data (Appendix E, pg 104) show that the numbers of live and dead scale fluctuate from sample to sample, and from orchard to orchard. At no time did an application of the scale pepper have any detrimental affect on the live scale populations. However, after almost every application of a mineral oil spray there was a decrease in the live scale population.

3.9 Individual orchard analysis

Legend codes for the different orchards are the same for all charts. These are as follows:

- TBAS = treatment block affected by shelter
- TBUS = treatment block unaffected by shelter
- CBAS = control block affected by shelter
- CBUS = control block unaffected by shelter

In the live scale monitoring there were a total of seven sampling times.

3.9.1 Orchard 'A'

The part of orchard 'A' that the trial was conducted on was one large 2.95 ha pergola block with no internal shelters. For the majority of the season the live scale population in the CBAS was higher than the others (Figure 16), with a high of 69-live scale on the 25/04/03, but had the low of 12-live scale on the 21/01/03. After the application of a mineral oil spray on the 10/02/03 the live scale population decreased in the TBAS from 43-live scale to 25-live scale, and CBUS from 42-live scale to 20-live scale, with the CBAS remaining unchanged, but the live scale population in the TBUS actually increased from 21-live scale to 33-live scale. However by the time of the last sampling there was no significant difference between the treatment and control blocks with only a difference of 10-live scale covering all four treatments.

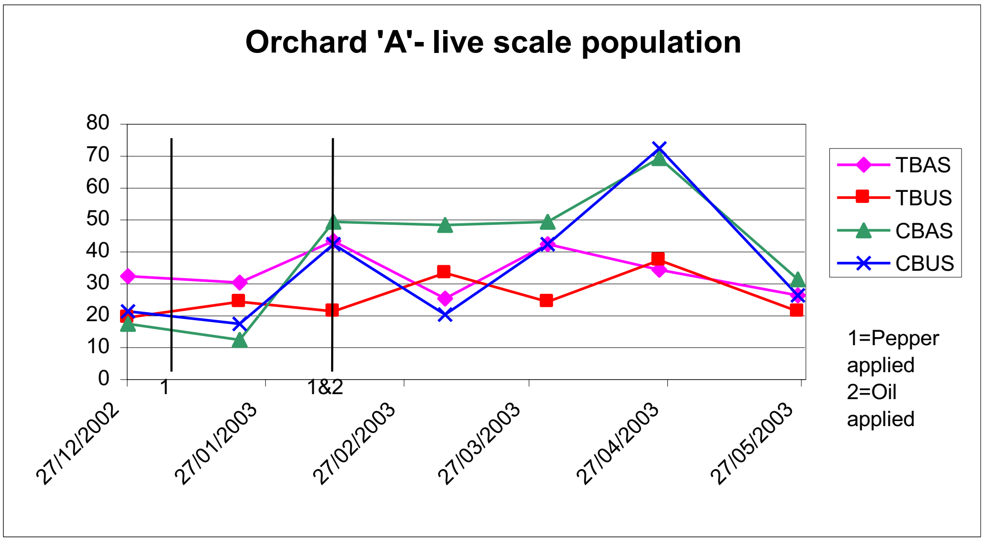


Figure 16: Plot of live scale on orchard 'A' for CBAS, CBUS, TBAS, and TBUS over sampling period, per 408-leaves sampled. Sprays and peppers applied during sampling times indicated.

3.9.2 Orchard 'B'

The two blocks involved in the trial on orchard 'B' were both 0.42 ha T-bar blocks, surrounded by shelterbelts. Only at the third sampling date on the 11/02/03 did the scale population of either the treatment, or control blocks differ greatly with the CBAS on 59-live scale, TBAS on 50-live scale, CBUS on 37-live scale and TBUS on only 6-live scale (Figure 17). However, by the next sampling the results for all four treatments were similar. This result may indicate an error occurred in the monitoring of the leaves of TBUS on the 11/02/03.

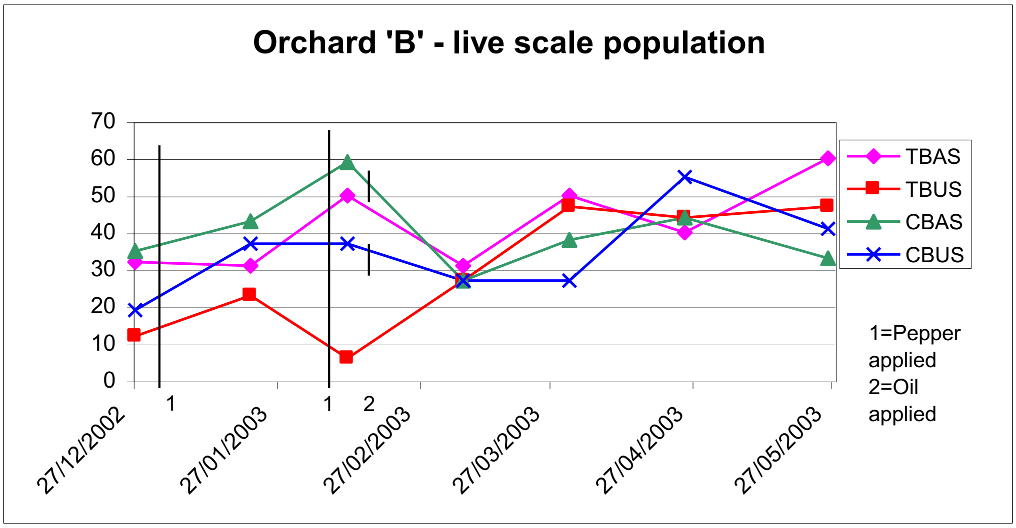


Figure 17: Plot of live scale on orchard 'B' for CBAS, CBUS, TBAS, and TBUS over sampling period, per 408-leaves sampled. Sprays and peppers applied during sampling times indicated. Only control block sprayed with oil on the 12/02/03.

A mineral oil spray was applied on the 12/02/03 to all orchard blocks except blocks 4 and 7. Blocks 6 and 7 were the blocks the research trial was being conducted on, with block 7 being the treatment block. By the next sampling on the 8/03/03 the live scale population of the CBAS and CBUS had decreased to 27-live scale, which was expected after a mineral oil spray. What was unexpected was the decrease in the live scale population of the TBAS to 31-live scale, as the treatment block was not sprayed. The increase in the live scale population of the TBUS to 27-live scale was more typical of what would have been expected by not spraying. The gradual increase in live scale numbers in all areas towards the end of the sampling period was theorised to have been due to young scale drifting in on the wind from the surrounding shelterbelts.

3.9.3 Orchard 'C'

On orchard 'C' at every sampling time the number of live scale found in the treatment block was higher than in the control block (Figure 18). It is likely that the vines in the treatment block suffered from a constant aerial invasion of scale crawlers blowing in from the neighbour's 10+m high black walnut trees on the SW boundary; as this was the direction of the prevailing wind. These trees did not extend along the boundary so were not present along side the control block. In future trials it would be desirable to choose blocks that both suffer the same problems.

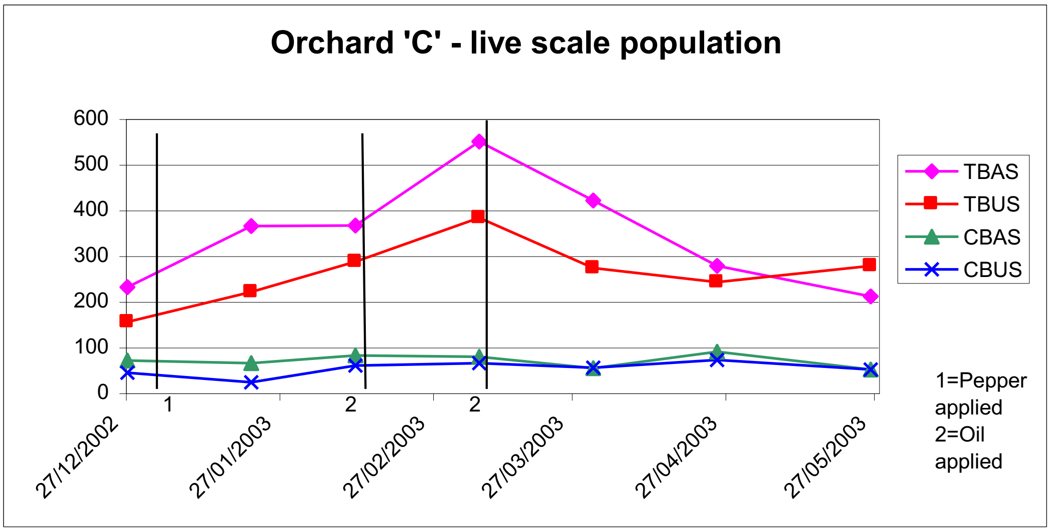


Figure 18: Plot of live scale on orchard 'C' for CBAS, CBUS, TBAS, and TBUS over sampling period, per 408-leaves sampled. Sprays and peppers applied during sampling times indicated.

It was noted that during the sampling period two mineral oil sprays were applied to the blocks. The first mineral oil applied appeared to have little effect as the scale population continued to increase in the blocks. It was only after the second mineral oil spray on the 13/03/03 that the live scale populations started to decrease. The live scale population high in the TBAS of 549-live scale on 8/03/03 was still decreasing at the last sampling at 210-live scale, while with the TBUS the live scale population decreased from a high of 382-live scale to 241-live scale before rising slightly again by the last sampling. In contrast the live scale population high in the CBAS was 89-live scale and in the CBUS was 45-live scale, and this was recorded at the last sampling.

Between the 27/12/02 and 8/03/03 the live scale in the CBAS increased from 70-live scale to 78-live scale, while in the TBAS 230-live scale increased to 549-live scale. In the shelter unaffected block, live scale in CBUS 43-live scale increased to 64-live scale while in the TBUS 154-live scale increased to 382-live scale.

3.9.4 Orchard 'D'

In orchard 'D' on all but one of the sampling times it was the two parameters affected by shelter, TBAS and CBAS that exhibited the higher live scale population levels. While this factor was not unexpected orchard 'D' was the only orchard that this scenario did occur. The TBAS live scale population high of 76-live scale was recorded on the 27/12/02 and 75-live scale on the 25/04/03, with the low of 28-live scale on the 21/01/03 (Figure 19).

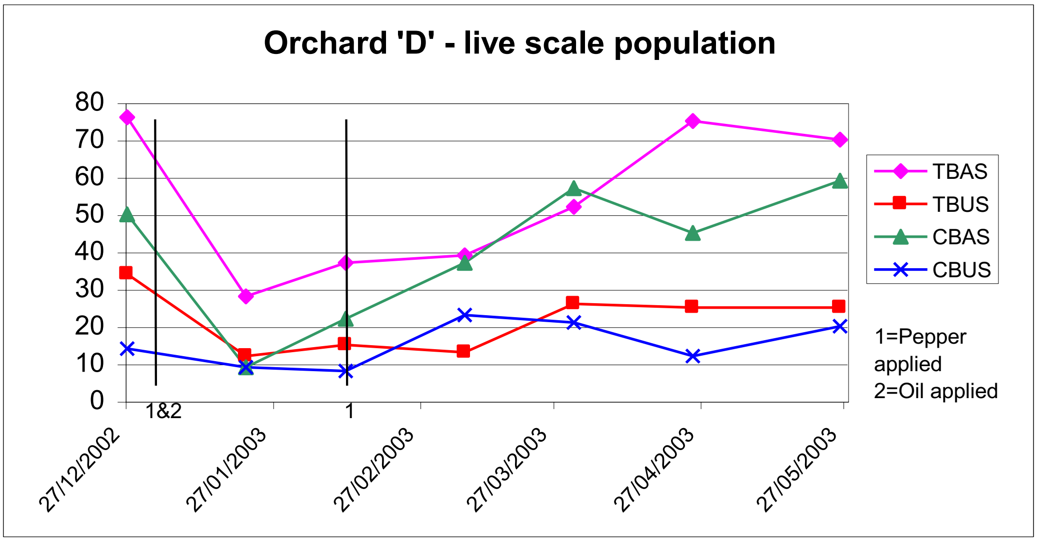


Figure 19: Plot of live scale on orchard 'D' for CBAS, CBUS, TBAS, and TBUS over sampling period, per 408-leaves sampled. Sprays and peppers applied during sampling times indicated.

The live scale population decreased in both the control and treatment blocks after the mineral oil application on the 27/12/02. This was the only oil application after fruit set that season, and only the live scale population of the two shelter affected parameters increased to any significant level after the mineral oil spray. The TBAS increased from a low of 28-live scale to a high of 75-live scale, while the CBAS increased from a low of 9-live scale to a high of 59-live scale. Due to the fact that it was only the two shelter affected areas that experience the large increases in live scale, it was theorised that the main reason for these increases was the introduction of new scale crawlers blowing out of the shelterbelts and settling on the vines, and not scale already present in the canopy reproducing. Had this been the case, crawlers should have been detected earlier.

3.9.5 Grower 'E'

Orchard 'E' was the only KiwiGreen orchard amongst the trial orchards. It also had old 25+m high pine and gum tree shelterbelts surrounding it, so making it impossible to obtain leaves unaffected by shelter. An Averte spray for scale was applied on the 27/12/02 to both blocks, after this application the live scale population decreased for the TBAS from 44-live scale to 35-live scale, but appeared to have no effect on the live scale population in the CBAS, as that increased from 37-live scale to 60-live scale (Figure 20).

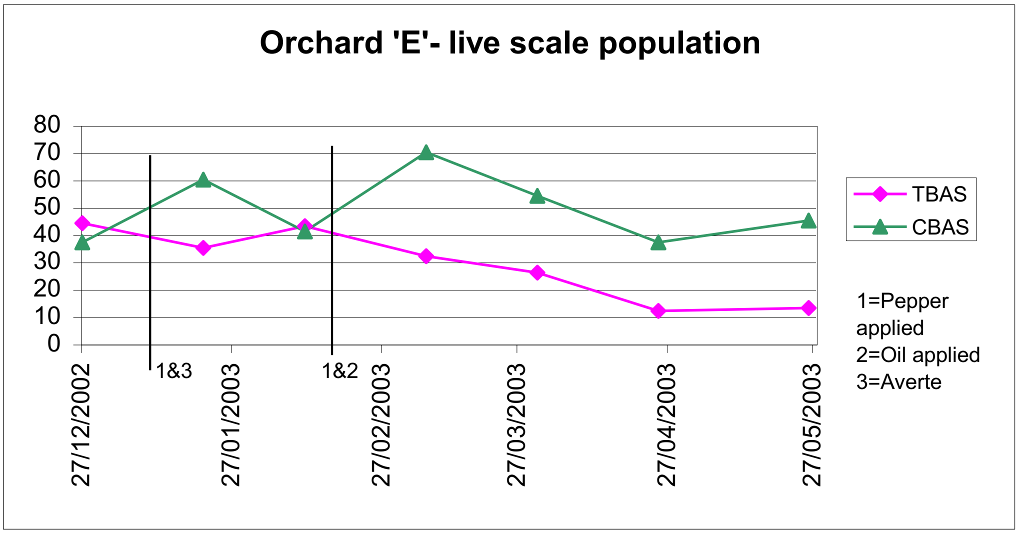


Figure 20: Plot of live scale on orchard 'E' for CBAS and TBAS over sampling period, per 408-leaves sampled. Sprays and peppers applied during sampling times indicated.

A mineral oil spray was applied on the 11/02/03 again resulting in a decrease in the live scale population in the TBAS from 43-live scale to a low of 12-live scale on the

25/04/03, but appeared to have no effect on the live scale population in the CBAS, as that again rose from 41-live scale to a high of 70-live scale on the 8/03/03. The live scale population in the CBAS did however decrease from then until the last sampling date. During the majority of the sampling times the live scale population figures were higher in the CBAS compared to the TBAS.

The shelter surrounding orchard 'E' was so tall that it made it impossible to have areas unaffected by shelter. This factor does not invalidate the data received on this orchard; it just limited the data sets for orchard blocks unaffected by shelter from five to four.

3.10 Conclusions

Analysis of the data generated from this research showed a significant difference between the percentage of live scale with crawlers between treatment and control blocks. However there were no significant differences between treatments in terms of the numbers of scale with crawlers. When Figure 15 (pg 40) is observed it can be seen that orchard 'C' had high numbers of scale in both the treatment and control blocks. This had the affect of nullifying any significant difference between the treatments in terms of numbers of scale with crawlers in the orchards. With only the two sampling times, it was not possible to do a comparison between the treatment and control blocks within each orchard. This finding can be further investigated in future research and could provide a much deeper insight to the effectiveness, if any, of the application of the pepper sprays.

The analyses of the results clearly show that the application of the scale pepper spray had neither any detrimental effect on the scale population in the orchard that season, or on preventing the scale crawlers blown into the treatment blocks from settling. These findings were not unexpected as the pepper spray is a reproductive inhibitor, not an insecticide. It was not certain where the crawlers originated from but since no crawlers were evident during the early samplings, it was theorised that the most likely source of the crawlers was from the shelter trees. There is nothing in the pepper spray to prevent the aerial reinfestation from scale crawlers and them settling, as they do not have wings they do not have a choice in where they land. Any over-wintering adults with eggs would have been unaffected by the early scale pepper sprays, and their young would have hatched in early spring.

Calculating the percentage of live adult scale found with crawlers from the total number of live adult scale found (Table 3, pg 37 and Figure 14, pg 38), appears to have provided a speculative indication of a treatment effect, compared to the number of live adult scale found with crawlers per 408-leaves. While this information goes someway to support the theory that a scale pepper spray can have an affect on the reproductive phase of the scale, this by no means supports the use of the scale pepper spray.

The results of the pepper spray application at an orchard level were variable. Three orchards appeared to have benefited from the pepper spray while two did not. Steiner (1993) said it could take up to four years after the application of the pepper sprays for the full effects to become evident. Kemp (2003) also stated that while animal peppers can work very quickly, that pepper sprays prepared from insects, or weeds can take considerably longer to be effective. The effects of the pepper sprays were perhaps masked by “noise” attributable to shelter and wind effects on scale distribution in the blocks.

Grower ‘C’s orchard suffered from large numbers of new scale constantly blowing into the orchard from the high shelter trees, but the application of the scale pepper sprays was supposed to have prevented them from reproducing, so theoretically it should not have mattered how many live adult scale were present in the block, there should have been no crawlers detected, but there were. Furthermore, more scale was found in the treatment block than in the control block; this researcher could find no clear explanation for this result.

While the ANOVA of the individual orchards showed no treatment effect on the number of adult scale found with crawlers, this could well be attributed to the lack of data available to conduct the ANOVA in the first place. With only two samplings conducted after the first discovery of crawlers there was simply insufficient data to analyse. In hindsight, at the first sign of reproduction sampling should have occurred fortnightly in order to ensure sufficient data was produced.

One particularly intriguing result was for Grower ‘E’ where no crawlers were found under the live scale in the treatment block on either sampling. This was the only conventionally run (KiwiGreen) orchard amongst the five orchards. Among some suppliers of pepper sprays it is thought that the effect of the pepper spray is nullified by the use of the conventional kiwifruit sprays; this may not prove to be the case.

However, this was the only orchard of the five in the trial not to find crawlers under the live scale, so being the exception and not the norm, therefore should be looked upon as a promising result rather than a vindication of the success of the pepper spray. Further investigation would be required to determine the effect of conventional sprays on the pepper spray.

The type and height of shelter trees surrounding the orchard blocks can play a major role in the incidence of scale within a block. As previously mentioned in a survey conducted by Jamieson *et al.*, (2002) on scale insects found on shelterbelt tree bark, it was concluded that *Cryptomeria japonica* harboured the least amount of scale of the twelve shelter species in the trial. Balsam poplar, willow and Leyland cypress proved to be among the worst shelterbelt trees due to the incidence of scale found on their barks.

Prominent wind direction can also play an important role in scale infestation of a block, particularly if it passes through a type of shelterbelt that is prone to harbour large numbers of breeding scale. Shelter on orchards is necessary to prevent wind damage to the fruit so the type chosen for the orchard in the development phase is important, but in many cases, such as for orchard 'C' there was no choice as the problem trees were on the neighbour's property.

The constant reinfestation of scale from certain species of shelter will probably always exist to some extent, but a factor that does now seem to be arising more often, and was experienced by growers during this research, is the failure of the mineral oil sprays to control the scale. This could pose a serious threat to the entire kiwifruit industry in years to come, since the use of harder type insecticides is prohibited within a certain time of harvest. Organic growers rely on the ability of the mineral oil sprays to control scale, as it is presently the main option available to them.

This research was limited to a one year trial; Steiner (1993) and Thun (1990) both stated that it can take up to four years for the full effects of the application of a specific pepper to fully develop. Therefore, it would be prudent to undertake a longer-term trial to determine the validity of the claims supporting the use of the scale pepper spray, before condemning them as anthroposophical rhetoric. The results obtained from growers 'B, D and E' were intriguing, and it would be interesting to see the scale population curves for these orchards over the next few years.

More parameters would have been available for analysis had the 408-leaves collected per sample been collected as 4 x 102-leaf samples, thus providing sixteen pieces of data per orchard, per sample rather than four, as was the case. More variability may have occurred if leaves had been collected from every row in the blocks being sampled, rather than limiting the collection to two or three rows.

One failure of the research methodology that became evident as the research proceeded was the block selection process, this process was however controlled somewhat by the orchard owners and what was convenient for them. Trying to obtain two blocks per orchard that are subjected to all the same conditions in relation to wind and shelter, proved difficult due to the owners choice of blocks that could be used for the trial. The importance of this limitation became evident in the results from grower 'C' and to some extent grower 'D'. Both the control blocks and treatment blocks on these orchards were exposed to different degrees of shelter effect, with the treatment blocks in both cases being exposed to a greater degree of shelter than their corresponding control blocks.

In the future, trials involving more orchards would be advisable, but to do so would require at least one extra person to aid in collection, and checking for scale under the microscope, as this was by far the most time consuming element of the research. If the leaves are stored in the fridge for extended periods, due to the time required to check them, they start to deteriorate and become hard to examine.

It is the view of this researcher, that given the current limited controls available for scale in the later part of the growing season, for both the organic and conventional growers, the use of a product such as the pepper sprays that could potentially reduce the numbers of crawlers present in the orchard at this stage, warrants continued research and investigation.

4. Effectiveness of peppering for Fuller's rose weevil control in kiwifruit

4.1 Introduction

Fuller's rose weevil (FRW) (*Asynonychus cervinus*) (Boheman) is thought to have arrived in New Zealand via Australia by 1940, and is now well established throughout all of the North Island and the Nelson area (May, 1998). FRW used to be considered a minor pest, with damage limited to adults nibbling leaf edges and larvae feeding on roots. It was only after Japan declared FRW to be a quarantine pest in 1985 that its pest status changed (James, 1991). This has led to intensive research to find a treatment to control FRW, chemically, biologically or physically, from entering the canopy and laying their eggs.

The U.S. and Australian citrus growers were the first to suffer the financial consequences of FRW when Japan fumigated all contaminated shipments of fruit. The interception of FRW egg masses in shipments of New Zealand kiwifruit into Japan has increased significantly over the last three years (Harley & Kay, 2001). The FRW egg mass detections (Figure 21) are the main reason for 52% of all kiwifruit entering Japan being fumigated (Max, 2002), which is costing the industry an estimated $7 million per year (Kay, pers. com).

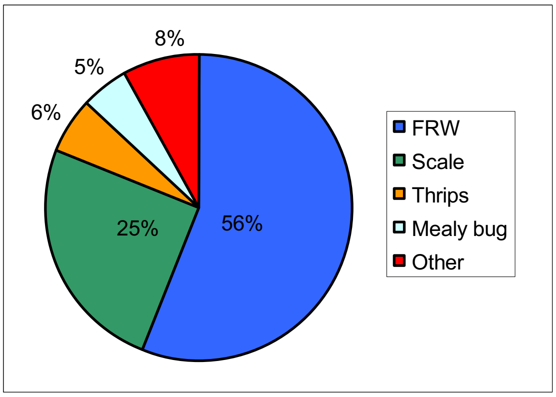


Figure 21: Proportion of pests found on fruit entering Japan resulting in fumigated fruit (Max, 2002).

Japan has now confirmed the presence of FRW domestically, but still maintain the high pest status for FRW on all imports of citrus and kiwifruit (McKenna, 2002). Japan currently fumigates contaminated fruit with methyl bromide, which can lead to excessive losses of fruit due to damage (Soderstrom *et al.*, 1993). Furthermore, the added fumigation expense is borne by the exporter. Organic kiwifruit treated this way can no longer be sold as organic, losing the associated price premiums.

FRW have been shown to exist in the orchards all year round, rapidly increasing from late December, with a definite peak in adult FRW numbers in the orchards between March and May (Madge *et al.*, 1992). McKenna *et al.*, (2003) reported that 96% of total FRW emergence on trial orchards in the Bay of Plenty occurred during January to April. Following pupation, the flightless adult FRW crawl up into the canopy via any means possible, and will lay eggs anywhere on the tree or vine, particularly in bark crevices, but have a preference for laying eggs on fruit, especially under the calyx of citrus (Griffiths *et al.*, 1986; Coats & McCoy, 1989; Anon[1], 1986a).

On Hayward kiwifruit, the egg masses are mainly found at the stem end, while with Zespri™Gold they can be found at either end, but more commonly are found inside the beak (Zespri™ KiwiTech Bulletin, 2001). The egg parasitoid *Fidiobia citri* (Nixon) has been found to be active during the peak egg laying periods, but rarely parasitises 100% of all FRW eggs, therefore reliance on *Fidiobia citri* (Nixon) to control the FRW population would not satisfy Japan's stringent quarantine requirements (Morse & Larkin, 1987; Morse *et al.*, 1988; Madge *et al.*, 1992).

4.1.1 Research objectives

The objective of this research was to determine the effects on the Fuller's rose weevil (FRW) population from the application of the FRW 'peppers' in organic and conventional kiwifruit orchards.

4.2 Industry relevance

In the 2001-02 season 48% of all Zespri Green variants, and 55% of all Zespri Gold variants of New Zealand kiwifruit entering Japan were fumigated (Max, pers. comm.). Fifty-six percent of fruit fumigations were directly attributed to the presence of FRW eggs. Adult FRW mainly emerge from January through to April (McKenna *et al.*, 2003), and because of the stringent withholding periods imposed on kiwifruit growers, none of the present insecticides known to control FRW are permitted. Presently there are limited options for controlling FRW; they consist of applying sticky bands around all plants, poles and wires leading up into the canopy to prevent the FRW gaining access to the fruit; trapping and biological control agents.

FRW does not cause any actual physical damage to the kiwifruit; the problem arises when the FRW eggs are found on the fruit. Not all countries to which New Zealand exports kiwifruit consider FRW to be a quarantine issue. If an orchard's monitoring results indicate the presence of FRW, then the fruit harvested from that orchard is consigned to a country that tolerates FRW. If Zespri wants to maintain the premiums it receives for kiwifruit exported to Japan it is imperative to ensure that fruit is free of FRW eggs.

4.3 Fuller's Rose Weevil Life Cycle

Fuller's rose weevil (FRW) (Photo 4) do well in free draining soils, hence, they do so well in the volcanic soils of the Bay of Plenty (Stephen, 1991). They are predominantly nocturnal, feeding (Photo 5) and egg-laying mainly at night while passing the daytime in crevices or dark places (McKenn,a 2002). The newly emerged adults climb into the canopy where they feed for one to two weeks prior to commencement of egg laying (Morse *et al*., 1988). Since FRW are unable to fly, they rely on climbing up the trunks of trees, or weeds, to gain access to the tree canopies (Madge *et al*., 1992); climbing upwards seems to be a natural tendency of FRW (Morse & Larkin, 1987).

Photo 4: Fuller's rose weevil, *Asynonychus cervinus* (Boheman) (Morse & Larkin, 1987).

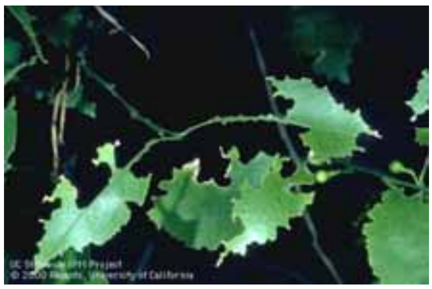


Photo 5: Fuller's rose weevil damage. www.ipm.ucdavis.edu. Photo by Jack Kelly Clark, (2000).

Figure 22 provides indications as to the peak activity times for each stage of the FRW life cycle, although it is often possible to find any of the stages throughout the year (May, 1998).

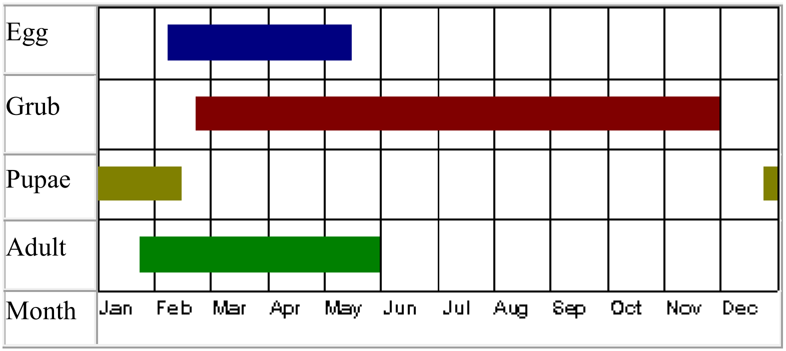


Figure 22: Coloured bars indicate periods of peak activity in each of the FRW life cycle stages (May, 1998)

Eggs are deposited by the use of a retractable ovipositor (Photo 6) and typically egg laying commences in early February and continues until mid May (May, 1998). An adult FRW can lay up to 200 eggs during her 3-month adult lifespan (McKenna *et al*., 2003). Eggs are usually laid in clusters (Photo 7) of thirty or more (Anon[1], 1986a), held together with a white fibrous substance that is insoluble in water (McKenna, 2002). The eggs are yellow and approximately 1mm long and oval in shape (McKenna, 2002). Egg development has been shown to be temperature dependant, requiring approximately 300 degree-days at a mean temperature of 10.95°C for 50-99% hatch (Larkin & Morse, 1987), and hatching can vary from three weeks to three and a half months depending on time of year laid (Morse *et al*., 1988).

Photo 6: Adult FRW showing retractable ovipositor which she uses to deposit eggs under fruit calyx and in crevices in bark (Morse & Larkin, 1987). Eggs also laid inside the beak of Zespri™Gold, and around stem end of Zespri™Green.

Photo 7: Freshly laid FRW egg mass between cellophane and underneath of table provided in orchard.

Once hatched, the legless grubs (Photo 8) burrow into the soil and remain there, feeding on roots and organic matter for up to ten months (Morse *et al.*, 1988). Approximately 50% of a FRW's life is spent as a larvae (Griffiths *et al.*, 1986); they are approximately 8-9mm long when mature and ready to pupate (May, 1998; McKenna, 2002).

Photo 8: Two larvae (left) and pupae (right) of FRW. www.ipm.ucdavis.edu. Photo by Jack Kelly Clark (2000).

The pupation (Photo 8) period of one to two months occurs in the soil, after which time the adult emerges. In California and Australia, prolonged dry periods have shown to delay FRW emergence, however trials conducted by McKenna *et al.*, (2003) failed to find any significant relationship between FRW emergence and rainfall in New Zealand. It is thought that the dry periods experienced in New Zealand are not long enough to encounter this phenomenon.

FRW have highly polyphagous feeding habits and have been recorded feeding on, Azalea; Acacia spp; all members of the Citrus family (orange, lemon, mandarin, grapefruit, etc); Cucurbits; Diospyros kaki (persimmon); Fragaria x ananassa (strawberry); Juglans spp. (walnuts); Malus spp. (apples); Musa spp. (banana); Persea americana (avocado); Phaseolus spp. (beans); Prunus spp.; Rheum hybridum (rhubarb); Rosa spp.; and Solanum tuberosum (potato) (McKenna, 2002). However, they can withstand two to three weeks without food (Morse & Larkin, 1987) so enabling them to survive transportation over long distances (McKenna, 2002).

4.3.1 FRW dispersal and distribution

Morse & Larkin (1987) undertook a trial to determine the dispersal pattern of FRW. They coated the weevil in a fluorescent powder and released them on to the citrus canopies. They found that they moved around the canopy extensively during the night, but movement between trees was limited to trees that were touching. There was no evidence to suggest that the FRW migrated back down the trees to get to other trees. McKenna (2002) found in New Zealand that the FRW did travel through the canopy system, but this was not unexpected as kiwifruit canopies are linked. What was unexpected was that at night many FRW would migrate back down the trunks to feed on the clover in the sward, before returning to the vine canopy before sunrise.

McKenna *et al.*, (2001c) found that the distribution of FRW is very varied within blocks. Figures 23 and 24 show two of the nine FRW egg distribution maps presented by McKenna *et al.*, (2001c). Viewing figure 23 it can be seen that adult FRW would have been detected within the block regardless of which two, or three rows were monitored. The fruit from this block could have been harvested and packed for a destination that did not have quarantine restrictions on FRW. However, in figure 24 if any row other than rows 1 or 2 were monitored for the presence of adult FRW, then the block would have most likely been found to be FRW free. The main concentration of adult FRW were only present between rows 1 and 2 in figure 24, and it is this variability in the distribution of adult FRW within blocks that has lead to fruit been found overseas contaminated with FRW eggs.

McKenna *et al.*, (2001c) found FRW distribution to be contagious, for example where there was a high population of FRW adults on a vine, the vines in close proximity tended to be infested with FRW adults which had presumably spread from the initial vine.

McKenna *et al.*, (2001c) findings highlight the implications to developing an effective FRW monitoring system. Unlike scale, which tend to have greater population densities in the shelter rows (Blank *et al*., 1987), FRW appear to have no discernable distribution pattern.

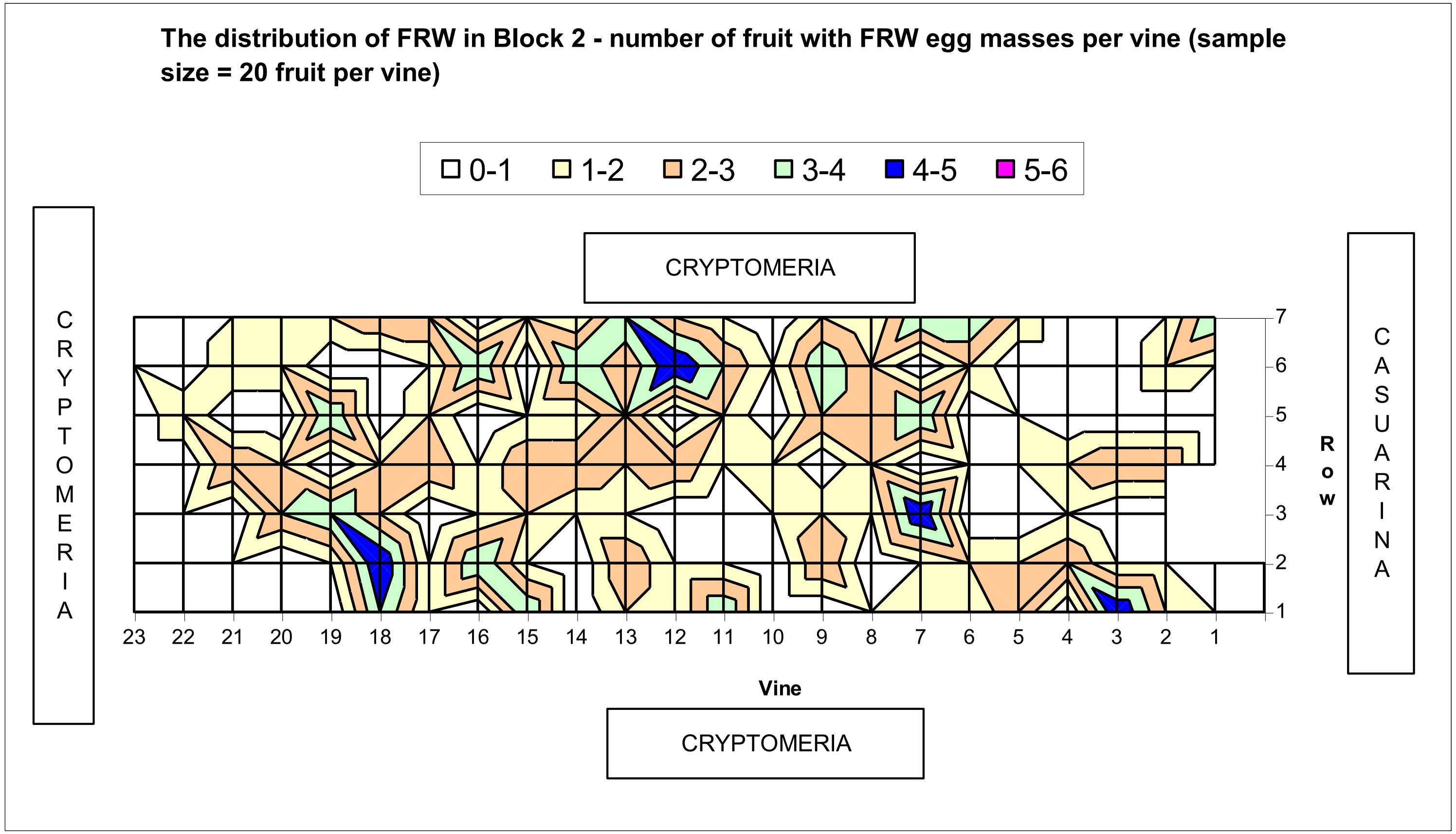


Figure 23: Distribution of FRW egg masses found on fruit. Source: McKenna *et al.*, (2001c).

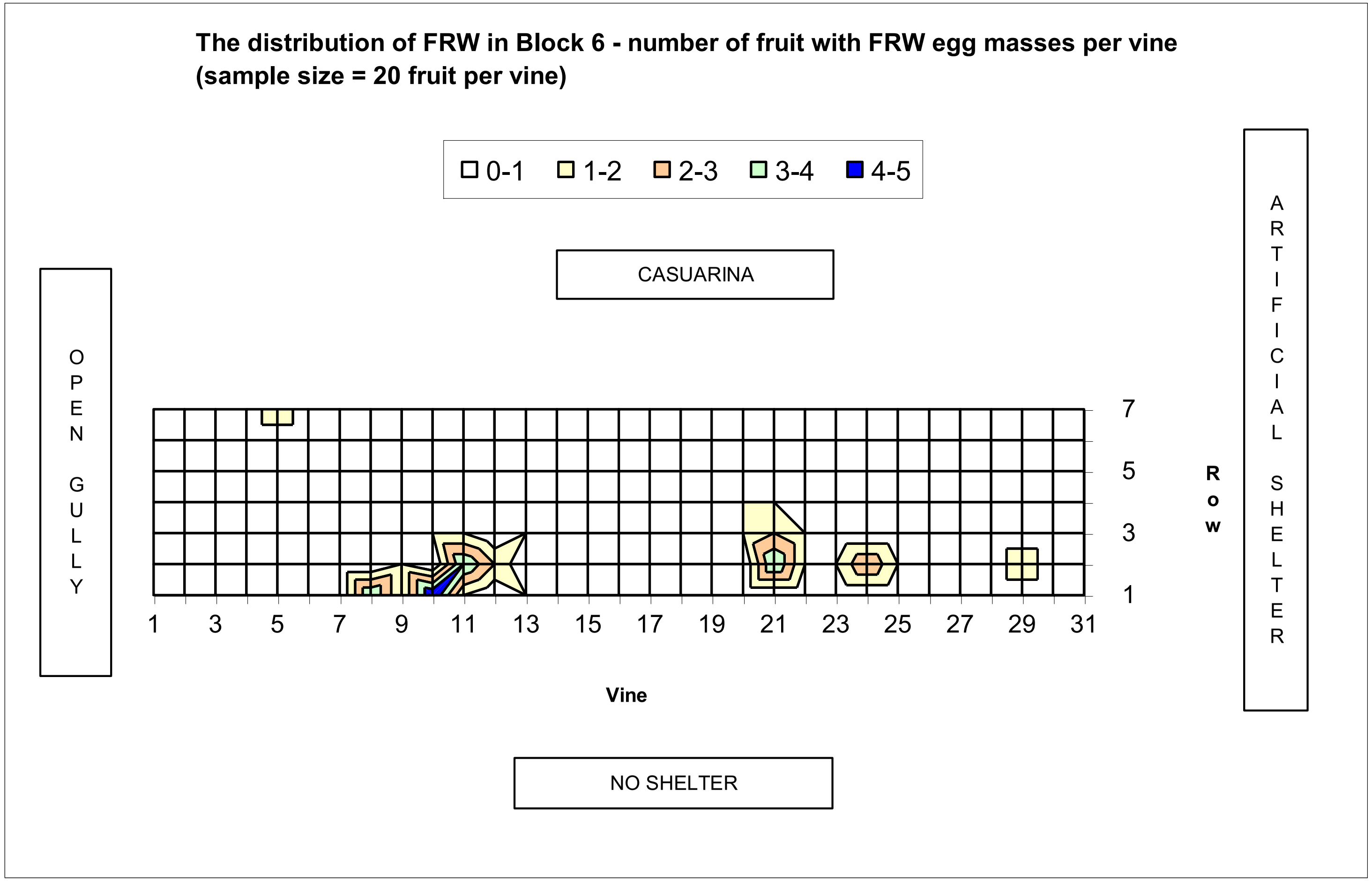


Figure 24: Distribution of FRW egg masses found on fruit. Source: McKenna *et al.*, (2001c).

4.4 Monitoring systems

4.4.1 Adults

There have been numerous methods devised to monitor FRW adults' emergence, or presence in orchards and canopy. Morse & Larkin (1987) conducted trials with emergence boxes, timed observational searches, beating nets and beating cloths. The 20 to 40 wooden emergence boxes, covering $0.37m^2$ were spread throughout a citrus grove and monitored every one to two weeks. The boxes proved effective for determining FRW emergence patterns. Of the other methods involved in the trial, beating cloths proved the most successful. A $0.9m^2$ cloth was laid on the ground under the canopy, the canopy was then shaken, or the branches tapped with a stick a number of times to dislodge the weevils. The weevils were counted to determine population numbers; up to 40 such samples were taken within a grove. Madge *et al*., (1992) used a similar beating system but collected the weevils in a $0.28m^2$ tray; the weevils once counted were released at the base of the sampled tree.

James (1991); Madge *et al*., (1992); Morse & Larkin (1987); Sale (1993) have all conducted trials with the use of sticky bands as monitoring tools with varying degrees of success. The main problems are associated with the sticky compound losing its stickiness over time, but all thought it was a worthwhile tool. Anon[2] (1986b) and Magarey *et al.*, (1992) found that the FRW tended to detect the sticky compounds prior to getting stuck and returned to the ground, so questioned its use as a monitoring tool.

4.4.2 Eggs

Morse *et al.*, (1987) developed a system to monitor FRW eggs in the field, or alternately in the packhouse. The field system involved sampling a minimum of 500 fruit/block, five fruit from ten trees, from ten different locations within a 2.4ha block and examining under the calyx of each fruit for FRW eggs. Packhouse guidelines required a minimum of ten fruit/bin to be examined for the presence of FRW eggs. Morse *et al.*, (1987) produced guideline tables based on percentage eggs present; these determined the risk of detection in Japan. If the crop showed a high risk it was not exported, but sold domestically. Fumigation rates in Japan on fruit exported by the packhouses adopting these new guidelines dropped by 50% in the first year's trial (Anon[3], 1990).

McKenna *et al.*, (2001c) conducted intensive trials to develop more reliable sampling methods for monitoring FRW eggs in Zespri™Gold blocks. Under the current guidelines three fruit/vine are sampled from one third of all the internal rows. This method resulted in 100% of the heavily infested blocks being detected, but only 80% of the lightly infested blocks being detected. It was recommended that in the lightly infested blocks, that five fruit/vine be sampled from one third of all internal rows to obtain between 95-100% detection.

4.4.3 Research monitoring system

The monitoring approach adopted for this research involved the development of small tables, which were tied to kiwifruit poles down predetermined rows. Any adult FRW found on the tables at sampling would be counted, along with the numbers of egg masses laid on the tables. This approach was developed after consultation with other FRW researchers, and chosen over already proven methods of canopy detection of adult FRW due to some of the orchards in the trial having sticky bands applied to the trunks and poles, therefore preventing the adult FRW entering the canopy.

4.5 Current control options for FRW

Presently, of the chemical, biological and physical options available to control the FRW, the chemical option is theoretically void due to the emergence time of the adults being too close to harvest. Adult FRW start emerging from late January until late May, peaking around early March (May, 1998). At this stage of the kiwifruit season none of the chemicals known to kill FRW are permitted due to their MRL. The chemicals currently available either do not have Zespri approval, or the withholding period of the chemical renders them unusable. Current opinion amongst the experts seems to favour a varied approach for controlling the FRW, namely using sticky bands and biological controls.

Sticky banding has been shown to reduce the number of egg masses detected amongst the fruit in the canopy, but does not greatly diminish the numbers of FRW within the orchard, as most FRW do not get caught in the sticky bands. The parasitic wasp *Fidiobia citri*, the parasitic nematode *Heterorhabditis bacteriophora,* and a fungal pathogen *Beauveria bassisna,* have all been shown to have a detrimental affect on the populations of FRW eggs and larvae, but rarely are 100% of the eggs or larvae in an area affected (Prestidge & Willoughby, 1990; Ferguson *et al*., 1990; Jackson *et al*., 1985). Since FRW reproduction is parthenogenic, no males have ever been recorded (McKenna, 2002), and an adult is capable on average of laying 200 eggs (McKenna *et al*., 2003); it only requires a few to survive to continue the cycle.

Steiner (1993) never made any distinction between whether the plant, insect, or animal reproduced through means of asexual or sexual reproduction, but did state:

> *"Where there is a spinal cord, you need to skin the animal. Where there is a ventral cord, you need to burn the whole animal."*

Steiner (1993, p 133).

Steiner (1993) stipulated that the application of the pepper will interfere with the reproductive nature of the pest being peppered, so discouraging the pest from breeding within the treated area. If this is the case, then theoretically within 3-4 years the orchard should be free of FRW. The fact that FRW cannot fly is an advantage for this type of control measure. Once all the resident adult FRW have died it could take a number of years for any FRW to re-occupy the orchard. While the effect of the pepper spray is claimed to last several years, it should be reapplied annually to ensure effect is always present in the orchard environment (Bacchus, pers. comm.).

4.5.1 Chemical control

In citrus, chemical control of FRW has been tried for many years (James, 1991). The problem is that FRW are present in the orchard for such a long time that for the chemicals to be effective they also have to persist for a long time, or require frequent reapplication. The persistence of many of the chemicals applied to the ground or the trees to control the FRW became a problem, as the trees absorbed the chemicals and unacceptable residue levels were detected in the fruit at harvest time.

Sale (1997) conducted an experiment using Karate® (250g/litre lambdacyholthin) at 1.5-ltr/100-ltr water, applied to citrus tree trunks during the 1995-96 growing season to control FRW. The six-month trial involved two treatment regimes; one involved applying the Karate® every second month, the second, involved monthly applications; there were also untreated control trees. The same concentration of Karate® was applied in both treatments. The tree canopies were monitored for adult FRW. At the conclusion of the trial 200 fruit from each replicate were examined for

FRW egg masses under the calyx. Final results showed a significant difference between the numbers of adults found in the untreated trees (2.04 adults/search), compared to the treated trees (0.12 adults/search), but no difference between the two treatments. It was not until the fruit was tested for the presence of egg masses that a significant difference was seen between the monthly treatments (mean 0.13%), two-monthly treatment (mean 1.54%), and the control (mean 10.80%). Magarey *et al.*, (1993) had conducted a similar trial with Karate® during the 1991 season, again applied to the citrus trunks as a spray. This trial reported three month's suppression of FRW from the canopy from a single application of Karate®.

The main problem faced with using a chemical control for FRW in kiwifruit is the time at which the chemical needs to be applied. Peak emergence period for the adult FRW is January to April (McKenna *et al.*, 2003), this would mean regularly applying a chemical trunk spray through this period. In kiwifruit, due to the proximity to harvest in late April, this action would not be an option, especially for the organic growers. To date Zespri International has not approved any chemical trunk treatments for kiwifruit.

4.5.2 Biological control

Chemical control of FRW may not be an option at present but there are some biological agents that may hold potential.

4.5.2.1 Parasitic wasp

Fidiobia citri (Photo 9) is a small 1mm long parasitic wasp that has been found to parasitise FRW eggs in California. The female wasps spend most of their short 16-day (average) adult life searching crevices and cracks for eggs. In California up to 79% of FRW egg masses have been found to be parasitised (Photo 10) (Morse & Larkin, 1987). *Fidiobia citri* however is very susceptible to insecticide sprays so limiting their effectiveness in conventional kiwifruit orchards. The fact that some eggs are also left un-parasitised would mean that reliance on this type of control would probably not be sufficient to satisfy the Japanese authorities.

Photo 9: Fuller's rose weevil eggs being parasitized by *Fidobia citri* wasp. www.ipm.ucdavis.edu. Photo by K. Larkin (2000).

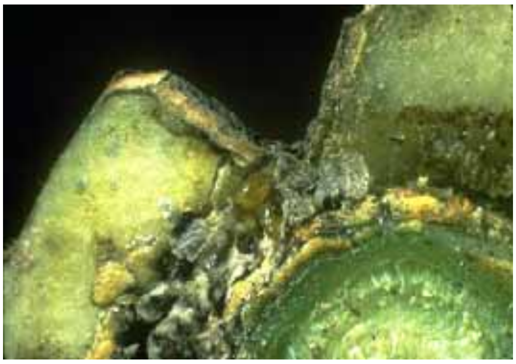


Photo 10: Dark gold Fuller's rose weevil eggs parasitised by *Fidiobia citri* wasp. www.ipm.ucdavis.edu. Photo by M. Badgley (2000).

4.5.2.2 Nematodes and Fungal pathogen

Prestidge & Willoughby (1990) Ferguson *et al*., (1990) and Jackson *et al.*, (1985) have conducted research using the parasitic nematode *Heterorhabditis bacteriophora* and the fungal pathogen *Beauveria bassisna* to control various soil dwelling insects with a great deal of success. The mortality rates reported in the nematode and fungal pathogen trials are impressive; unfortunately the trials to date have not included FRW. Further research involving large-scale field trials of FRW would need to be undertaken to evaluate the potential of these two control agents.

4.5.3 Physical control

Physical control methods are presently proving to be the most effective way of preventing the adult FRW from entering the canopy to lay eggs. The use of sticky bands has been reported to work well but needs annual reapplication.

4.5.3.1 Sticky bands

James (1991) investigated the use of three sticky bands (Photo 11), and seven insecticides, as trunk treatments for barriers to prevent FRW entry into citrus canopies. The sticky bands alone significantly reduced the numbers of FRW egg masses found in the canopy. The addition of any insecticide made no difference, and alone, none of the insecticides gave adequate protection. Magarey *et al.*, (1993) trialled sticky polybutene bands, and reported that the sticky bands were very effective in controlling the FRW entry into the canopy, but was expensive in terms of material used and time required applying.

Photo 11: FRW sticky banding (Max, 2002).

Sticky bands lose their effectiveness over time mainly due to dust and debris becoming stuck to them, so require annual reapplication. The bands do not catch all of the FRW, it has been noted that many of the FRW detect the bands before becoming stuck (James, 1991; Magarey *et al*., 1992), and only around 6% of the weevils actually get caught (Anon[2], 1986b). It was noted that, if the citrus trees were left unskirted, or the weeds were not sufficiently controlled to prevent natural bridges, that no treatment was successful (James, 1991; Magarey *et al*., 1992; Sale, 1997). Since FRW adults are flightless they can only climb into the canopy, and will use any natural bridge provided (James, 1991; Magarey *et al*., 1992).

4.5.3.2 Nylon bag covers

McKenna & Maher (2000) undertook a trial to determine the effectiveness of nylon bag covers for preventing insect access, and therefore avoiding contamination or damage to the kiwifruit. The bags provided a significant reduction in the percentage of fruit contaminated with FRW eggs, armoured scale and sooty mould due to passion vine hoppers. However due to high costs of applying bags, and their subsequent removal prior to packing, this method was deemed uneconomic.

4.6 Postharvest treatments

Postharvest treatments have been trialled for many years; it is hoped that if a successful postharvest treatment can be found, then having FRW in the orchard will no longer pose a problem. Unfortunately, to date, most of the postharvest treatments involved in the trials have proven either too expensive or impractical due to disruption of normal orchard maintenance.

4.6.1 Temperature treatments

Edwards *et al.*, (1992) conducted post harvest disinfestation trials on citrus for FRW eggs, using cold temperature storage, or hot water dipping. Their findings concluded that cold storage at 1°C, for up to 32-days had no significant effect on the viability of the FRW eggs. However, hot water dipping at 55°C for between 3.6 – 4.4 minutes achieved 99% mortality of the FRW eggs under the calyx of the citrus. Exposing certain cultivars of citrus to more than four minutes hot water treatment resulted in severe fruit damage, and predisposed the fruit to *Penicillium* breakdown during storage.

Soderstrom *et al.*, (1993) trialled treating lemons infested with FRW eggs with hot water immersion. Their results suggested that when immersed for 8-minutes at 52°C, it was possible to achieve 100% mortality of the eggs. The authors reported a lack of visible damage to the fruit.

Heated vapour treatment was trialled on grapefruit by McCoy *et al.*, (1994) using heated forced-air. At 48°C for ≥15 minutes 100% mortality rate of the FRW eggs was achieved, along with excessive fruit damage. When lower temperatures were tried the time taken to achieve the desired mortality rate was excessive, while still resulting in unacceptable levels of fruit damage.

4.6.2 Gamma radiation treatment

Gamma radiation as an alternative to methyl bromide, as a quarantine treatment for FRW eggs was trialled by Johnson *et al.*, (1990). Results showed that subjecting the fruit (lemons) to 150 Gray (Gy) for the 49-min treatment resulted in 100% mortality, with only minimal fruit damage. The maximum fruit loss of 6% was significantly less than the 65% fruit loss recorded after treatment with methyl bromide. The time required treating all kiwifruit trays, plus the acceptance of fruit treated with gamma radiation from importing countries, would limit this procedure's acceptance in the kiwifruit industry.

4.6.3 Other treatments

Insecticidal dips may be a solution for citrus, but for kiwifruit there would be the major problem of drying the fruit again prior to packing. There would be an increased risk of spreading disease from fruit to fruit with a dip treatment (C. McKenna pers. comm.).

Mechanical removal is not deemed practical, as nearly 100% of FRW eggs detected on Zespri™Gold are found within the stylar beak, and are only visible once the beak has been prised open (McKenna *et al*., 2000, 2001a) rendering the fruit unsaleable.

McKenna *et al.*, (2001b) conducted trials that involved covering the ground with weed matting to prevent the newly emerged FRW entering the canopy. The trial was successful however the cost was prohibitive. It was also noted that the weed mat would interrupt with some basic orchard tasks such as mulching prunings and spreading compost.

4.7 Methodology

Six orchards were chosen for the FRW 'pepper' trial on the basis of known FRW activity the previous season. One control and one treatment block were selected for each orchard. The treatment blocks received a FRW 'pepper' application approximately every month from October to March, totalling six applications. Monitoring consisted of checking each table (see table design 4.7.1) for FRW adults, and FRW egg masses with the use of a mirror, approximately every 28-days, with both the control and the treatment blocks being sampled in the same manner.

4.7.1 Table design for FRW

As it was not possible to dictate orchard management regimes to growers who agreed to host this research, and some growers used sticky banding as a FRW control measure, an alternative to canopy beating to monitor FRW was required. Searchers of relevant information were undertaken but no monitoring system could be found in regards to banded orchards.

Using a design suggested by McKenna and Maher, twenty-five small tables were built and placed within each of the sample areas for the FRW to lay their eggs on. The tables consisted of untreated, rough sawn timber, and were approximately 300mm long X 200mm wide, with four 90mm x 50mm pieces of 0.25mm thick cellophane stapled on to them; the cellophane is on the underside of the tables (Figure 25 & photo 12). It has been shown that the FRW like to lay their eggs within small crevices (Coats & McCoy, 1989; Anon[1], 1986a). The cellophane stapled flat to the tables, provides the FRW with crevice-like structures between the cellophane and the wooden table in which to insert their ovipositor and inject their eggs (Maher, pers. comm.). The tables have three legs; stand approximately 550mm above the ground, and tied to the kiwifruit support poles to aid stability (Figure 26).

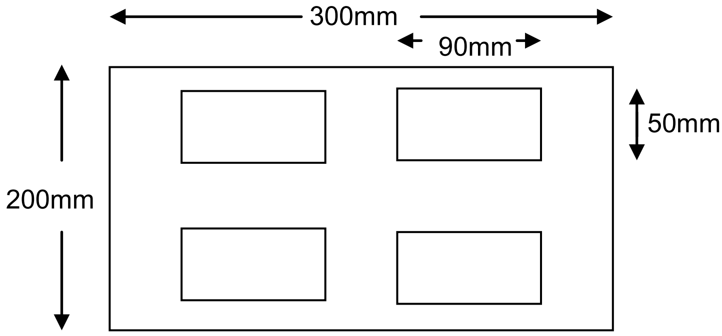


Figure 25: Wooden table showing approximate position of the four cellophane pieces stapled to the underside of tables.

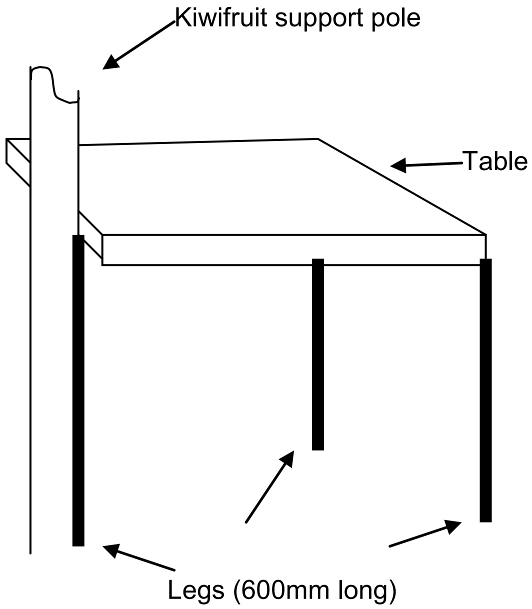


Figure 26: Set-up of table in orchard situation

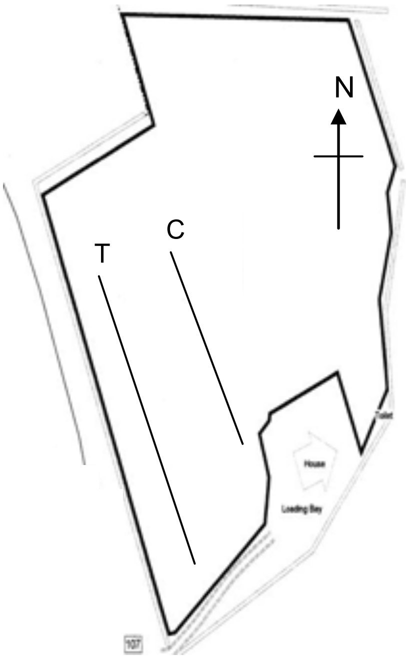
Photo 12: Table in orchard position

The tables were placed in randomly selected rows, one table at every second pole. Placing the tables down randomly selected rows rather than by randomly selected plants was chosen after consultation with Cathy McKenna of HortResearch. Cathy said that since the FRW tend to be scattered throughout a block, and not shelter row dominant, as is most often the case with scale, that randomly selecting rows rather than plants would provide reliable data, and simplify the data collection process. McKenna *et al.*, (2003) adopted the same experimental design for their FWR emergence research.

4.8 Property maps showing blocks involved in FRW research

Orchards 'A' and 'B' orchards from the scale trial were also involved in the FRW trial.

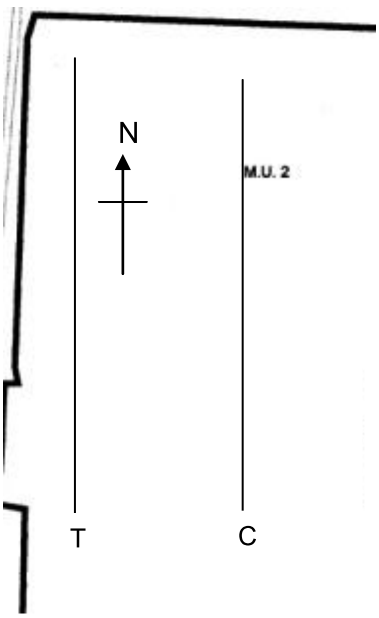
Orchard 'F' – Pongakawa



Approximately 15km from Te Puke this orchard block comprises a large area of pergola canopy with no internal shelter. The orchard has been under organic management for 3-years. Shelter consists of mature 6m+ *Cryptomeria japonica* trees all around. This orchard was chosen due to the presence of FRW in the previous year. Treatment (T) and control (C) areas marked on map. Due to length of rows only two rows were required per treatment areas. The two rows were randomly selected from rows within designated areas.

Figure 27:Orchard 'F' property map.

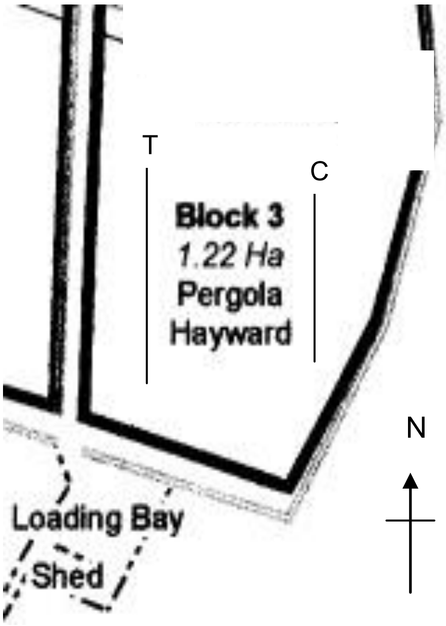
Orchard 'G' – Te Puke.



A flat orchard block on the boundary of the Te Puke township. The block is one large pergola canopy with only a 4-5m *Casuarina spp* external shelter. The block was unbanded and run conventionally. FRW had been recorded on fruit in the previous year. Treatment (T) and control (C) areas marked on the map. Due to length of rows only two rows were required per treatment. The two rows were randomly selected from rows within designated treatment areas.

Figure 28: Orchard 'G' property map.

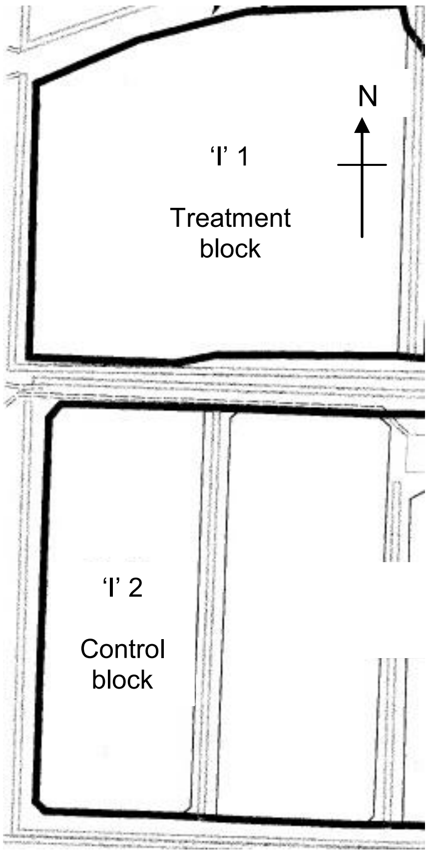
Orchard 'H' – Paengaroa.



Block 3 is part of a mainly flat, well-sheltered 9.5ha orchard; shelter includes *Casuarina spp, Cryptomeria japonica and Salix spp* (willow) all 4-6m in height. The orchard is on a pergola structure and is run conventionally under KiwiGreen. Treatment (T) and control (C) areas are marked on the map. FRW had been recorded on the orchard the previous year, and from block 3. Due to length of rows only two rows were required per treatment. The two rows were randomly selected from rows within designated treatment area.

Figure 29: Orchard 'H' property map.

Orchard 'I' – Rangiuru



There were two neighbouring orchards used in this location. The top block was completely sticky banded, but the entire property had the scale and FRW peppers applied so leaving no control (owner's choice). A neighbour's orchard was used for the control, however the orchard was not sticky banded. FRW had been reported on both properties in the previous year. Both properties have been organic for 4+ years. Block 'I' 1 contained 14-rows, from which three rows were randomly selected to accommodate the 25-tables. Block 'I' 2 required three rows to accommodate the required number of tables. Shelter consists of 5-6m *Cryptomeria japonica.*

Figure 30: Orchard 'I' property map.

Full maps of all properties can be found in Appendix F, pg 106.

4.9 Results

Observation of the tables for the presence of the FRW adults and eggs commenced on the 4th December, 2002 and ended on the 21st June, 2003. In all the tables were visited nine times during the trial. In general the tables failed as an orchard monitoring tool for FRW. On most occasions no adult FRW were found. Only at two orchards were egg masses located and only one adult was found at any of the other orchards. FRW egg masses located at the successive samplings are shown in Table 8. All egg masses located were marked with a permanent marker to distinguish any new egg masses from those already present. However, at each monitoring all egg masses found were recorded, so data displayed in Table 8 is the total number of egg masses located on orchard. All data recorded can be seen in Appendix G, pg 110.

Table 8: Collected data results from orchards 'A' and 'F' where FRW egg masses were located.

Number of FRW egg masses located at successive samplings					
Orchard 'A' (organic)			**Orchard 'F' (organic)**		
Date	Treatment	Control	Date	Treatment	Control
4\12\02	0	0	4\12\02	0	0
27/12/02	0	0	27/12/02	0	0
21/01/03	0	0	21/01/03	0	0
11/02/03	0	0	11/02/03	0	0
8/03/03	0	0	8/03/03	0	0
31/03/03	0	5	31/03/03	0	1
25/04/03	3	20	25/04/03	0	4
11/05/03	4	29	11/05/03	2	9
21/06/03	4	45	21/06/03	2	11

An ANOVA was conducted on the data collected from orchards 'A' and 'F', with the results displayed in Table 9.

Table 9: ANOVA results for FRW egg masses located on grower 'A' and 'F' properties.

'A' and 'F'	Pr > F
orchard	0.0391
trt	0.0089

Significance Pr > F (0.05)

4.10 Discussion

For the two orchards on which FRW eggs were found, the results from the SAS ANOVA (Table 9) indicate a significant difference between the treatment and control blocks, in relation to the number of egg masses recorded during the sampling period; this is signified by the treatment (trt) result of Pr>F 0.0089 (Significance 0.05). This difference is more noticeable in Table 8, and visually in Figures 31 and 32 of the individual orchards data.

The fact that no FRW eggs were located in any of the other four orchard blocks in the trial does not mean that were not adult FRW present in these blocks (as previously stated some were found in orchards 'H' and 'I'), or that the adult FRW present did not lay any eggs. The absence of egg masses on the tables in the other four orchards highlighted to this researcher the oversight in the experimental design in relation to the sticky banding issue, and to in future have a secondary monitoring system to take into account the lack of banding in some orchards. If one of HortResearch's FRW egg mass canopy monitoring systems had been employed along with the table design, then more data may have been obtained.

However, results were only obtained from two of the six orchards in the trial. This provided limited data to analyse, and with only tables located in two rows per treatment on two orchards, this does raise the issue of creditability of results. FRW distribution can be erratic throughout any block, as has already been demonstrated in the distribution figures 23, and 24 (pg 57 & 58) by McKenna *et al.*, (2001c). This factor alone could explain the differences in the numbers of FRW located on the orchards. On orchard 'A' the treatment area was at the NE side while the control area was in the middle of the 2.95ha block. The differences in the number of egg masses located on orchard 'F' were less than on orchard 'A' and could theoretically be considered a random event and nothing to do with the application of the FRW pepper spray.

While the tables provided for egg laying sites were tied to the kiwifruit support poles, they only came into contact with the poles in one small area. This meant that for the FRW to get onto the table to lay its eggs, it had to cross onto the table at this connection, or climb up one of the tables' three narrow legs.

The ANOVA orchard results of Pr>F 0.0391 (Significance 0.05) show there was an orchard affect; this is not unexpected due to the difference in location of orchard 'A' (Paengaroa) and 'F' (Pongakawa).

4.10.1 Orchard 'A'

On orchard 'A' 5-egg masses were first located in the control block on 31/03/03, the first egg masses in the treatment block were not found until the next monitoring on the 25/04/03. By this date there were 20-egg masses in the control block compared to the 3-egg masses in the treatment block. At the next monitoring on the 11/05/03 the number of FRW egg masses found in the treatment block had only risen by 1, to 4, in comparison the number of FRW egg masses in the control block had increased by 9 to 29. At the last monitoring date of 21/06/03 there had been no more egg masses laid in the treatment block, but there had been a substantial increase in the number of egg masses laid in the control block, up from 29 to 45 (Figure 31).

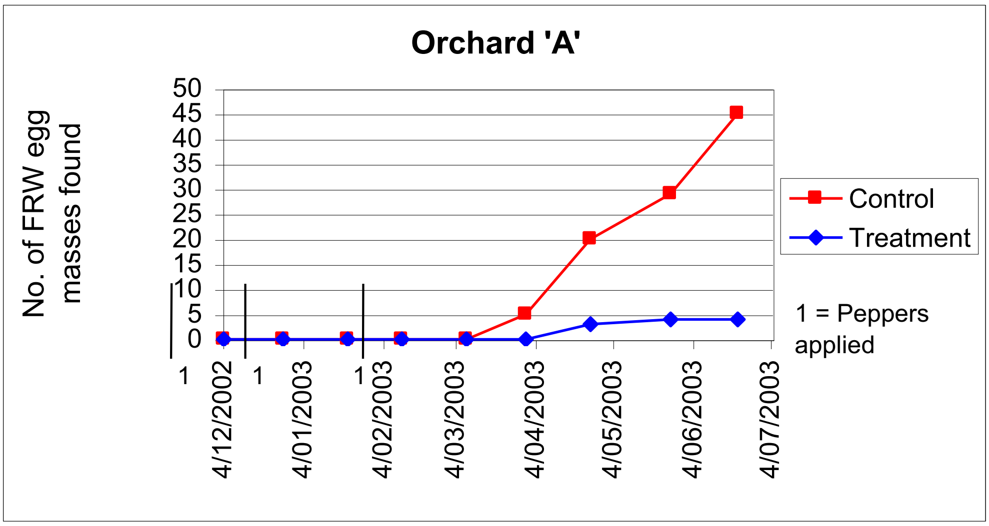


Figure 31: Number of FRW egg masses recorded on orchard 'A'

4.10.2 Orchard 'F'

On orchard 'F' the first FRW egg mass was found on the 31/03/03 in the control block, this rose to 4-egg masses by the next monitoring on the 25/04/03. There were only two FRW egg masses found in the treatment block on the 11/05/03, these were the same 2-egg masses recorded at the next monitoring on the 21/06/03. During the monitoring on the 11/05/03 9-egg masses were recorded in the control block, and this rose to 11-egg masses by the time of monitoring on the 21/06/03 (Figure 32).

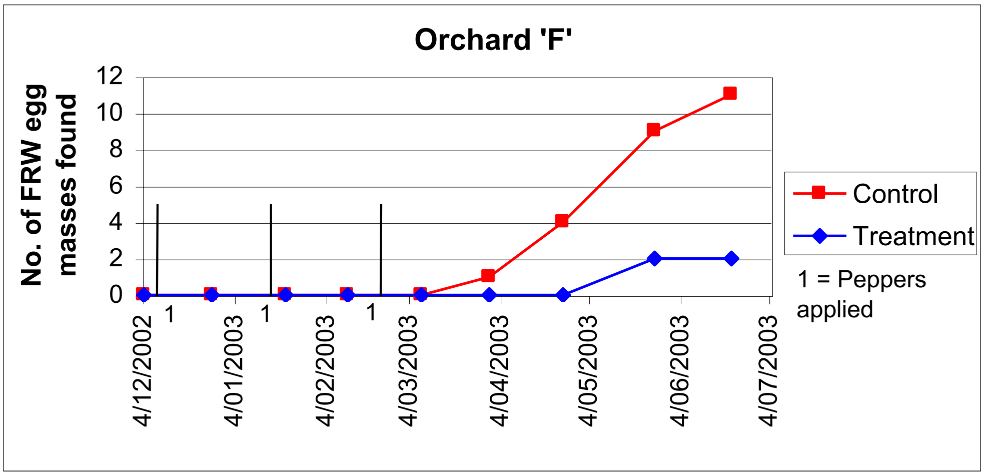


Figure 32: Number of FRW egg masses recorded on orchard 'F'

In both orchards 'A' and 'F' the number of FRW egg masses found in the treatment blocks did not increase after the 11/05/03, whereas the number of egg masses recorded in the control blocks continued to rise at each subsequent sampling. The reason for the quick levelling off of egg masses recorded in the treatment blocks is not fully understood. Maybe it could be associated with the fact that being the first year the FRW pepper had been applied to the block, the reproductive inhibiting effect of the pepper had taken time to establish within the environment, or simply due to the patchy distribution of the adult FRW in the orchard, or the FRW found other places to lay their egg masses other than the tables provided. Further research trials would need to be conducted on the same blocks over successive years, to determine the effect, if any, of regular FRW pepper applications.

4.10.3 Other FRW trial observations

During the six-month period in which this research was conducted, the presence of egg masses was recorded nine times from December '02 – June '03. From these observations it appears that FRW in orchards 'A' and 'F' laid eggs one month later than had been expected, and later than is considered the norm (May 1998; McKenna *et al.* 2001a, 2003). This phenomenon could simply be geographical and therefore typical of the egg laying time in this region, or may have been later due to environmental factors. Morse & Larkin (1987) reported that growth conditions in the host plants may trigger FRW emergence. They also noted that irrigation and/or rainfall can influence emergence times. Research conducted by Morse & Larkin (1987) showed that emergence times are also affected by what the FRW larvae are eating.

Since no egg masses, and only a few adult FRW were recorded on any of the other orchards involved in the trial, there was no data to evaluate. The veracity of claims about the use of peppers for FRW could not be evaluated. There was no way to tell if any of the FRW on orchards ‘B’, ‘G’, ‘H’ and ‘I’ had been affected by the application of the FRW pepper.

At the commencement of this research it was decided to record the number of adult FRW located on the tables, as well as the number of egg masses. However as the research progress it was realised that even though FRW egg masses were being located on some of the tables in orchards ‘A’ and ‘F’, it was rare to find an adult on the tables. Due to this realisation, the value of the data collection of the number of adult FRW located on the tables was meaningless as an indicator of the numbers of FRW visiting the tables, or present in the block. This factor did not affect the outcome of the research, as the main objective of the research was to determine if the application of the FRW pepper has any affect on the reproductive capability of the adult FRW.

While the table method did prove effective as a FRW monitoring tool on banded orchards, it was not an effective monitoring tool for unbanded orchards. Morse & Larkin (1987) reported that FRW adults have a natural tendency to climb upwards, therefore there was no reason for the FRW adults to lay their eggs on the tables in the unbanded orchards, as they could easily by-pass the tables and climb higher into the canopy to lay their eggs.

4.11 Conclusions

The results obtained from grower ‘A’ and ‘F’ orchards of the number of FRW egg masses located in the control block compared to the treatment block, could indicate that there has been a significant treatment effect from the application of the FRW pepper spray. However, with no eggs found from orchards ‘B’, ‘G’, ‘H’ and ‘I’, it means that data from only two orchards has been used to create the ANOVA results.

The significance of the results obtained, if they can be duplicated, is that as FRW cannot fly, they can only migrate into an orchard by walking from a neighbouring orchard, or being transported in on orchard vehicles, orchard machinery, or orchard workers. This being the case, once the population of adult FRW was eliminated from the orchard, it could take many years for the population to re-establish.

The initial intension of recording the number of adult FRW found on the tables, in an attempt to get an indication of the numbers of adults visiting the tables failed. The problem was that there was no way to retain the adult FRW on the tables, so unless they were actually present at the time of the monitoring, or egg masses had been laid, their visitations would go unnoticed. Coats & McCoy (1990) and Morse & Larkin (1987) used emergence cages to trap FRW as a monitoring tool for determining the population of FRW within a block, but found that monitoring had to be conducted every two weeks otherwise some of the FRW started to die from starvation, and were then hard to find amongst the grass. In hindsight the implementation of such traps may have proved worthwhile in this research situation.

Morse & Larkin (1987); McKenna *et al*. (2001b); and Madge *et al*. (1992) all found that shaking or tapping the plants to dislodge the adult FRW on to cloths, or trays, placed under the plants was the most effective tool for determining the numbers of adult FRW present in the block. This method would only have been of limited assistance in this trial as some of the orchards were banded so preventing the FRW entering the canopy. On the unbanded orchards however there was no need for the FRW to lay their eggs on the tables as they could continue climbing up into the canopy, so in hindsight an alternative monitoring system should have been adopted on the unbanded orchards.

Conducting this type of research on only six orchards from throughout the Tauranga and Te Puke area is limiting enough to start with, but to end up with only two of the six producing analysable data was disappointing. It proved impossible to determine, with the experimental design chosen by this researcher, if the pepper spray application reduced FRW numbers in the blocks. A drawback of the table method is the inability to trap, and therefore count the numbers of adults visiting the tables within the block. This could be overcome by the implementation of one of the proven trapping methods undertaken by McKenna *et al*. (2001a, 2003), Madge *et al*. (1992) or Morse & Larkin (1987). Adult FRW were seen regularly in grower ‘A’ and ‘F’ orchards on the kiwifruit poles. A combination of the table system and a trapping system should be able to provide adequate data information for monitoring the FRW population and egg mass numbers within banded orchards.

5. Research conclusions

This chapter will be presented in two sections. The first section will present the key findings of the research, and discuss how well the research objectives were met. The second section will reflect on the concept for the trial, processes involved in the research, and look at further research possibilities.

5.1 Key findings

Upon analysing the collected data the research showed a significant difference in the percentage of live scale found with crawlers between the control and treatment blocks. However, the ANOVA's conducted showed no significant differences between treatments in terms of the numbers of scale found with crawlers. With the limited data available there was a degree of 'statistical noise' to account for in the analysis; this can lessen the impact of the significant results obtained. When Figure 14 is considered it can be seen that the significant differences between the treatment and control blocks was not distinct in all orchards.

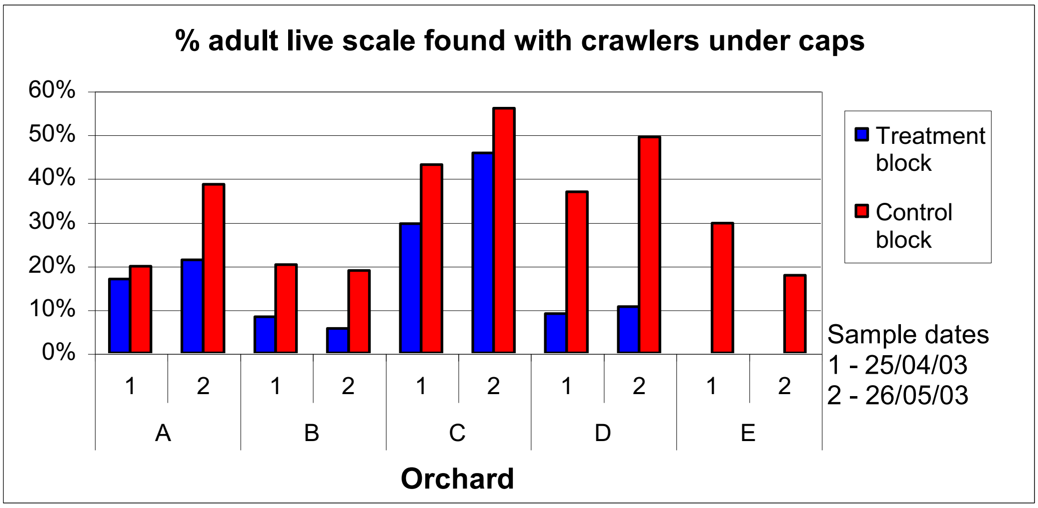


Figure 14: Percentage of adult live scale found with crawlers under caps for the two sample dates for the individual orchards, per 408-leaves sampled. Figure 14 created from Table 3.

Any significant difference is even less obvious when looking at the actual number of live scale found with crawlers (Table 4, pg 38). It is therefore worth treating the results with caution. With only two samplings conducted after the detection of the crawlers not enough data was obtained to do a comparison between the control and treatment blocks within each orchard. The results gained from the application of the pepper spray was varied over the five orchards, with only three of the orchards eliciting some form of benefit from the application of the pepper spray.

Shelter trees surrounding kiwifruit blocks can have an impact on the numbers of scale crawlers entering the blocks via aerial infestation, depending on the type, and height of the trees. Jamieson *et al.*, *(*2002) conducted research to find out the levels of scale per cm^2 on the bark of a range of different shelter tree species. The results ranked the shelter tree species in order of the least amount of scale, to the most. *Cryptomeria japonica* proved to be the least susceptible to scale infestation, with *Salix spp* and *Cupressocyparis leylandii* the most susceptible. The problem of aerial infestation can be aspirated if the shelter along the boundary of the prevailing wind is scale prone.

The ANOVA results for FRW egg masses (Table 9, pg 70) show a significant difference in the number of egg masses located in the treatment blocks, compared to the control blocks of the two orchards, and this is clearly evident in Figures 31 (page 72) & 32 (page 73) of the two individual orchards. However, the research experiment design was meant to have resulted in data from six orchards, not two. Due to oversights in the experiment design, orchards 'B', 'G', 'H' and ' I' produced no analysable data; this meant that the ANOVA was created from the data of only two orchards. No conclusions about the performance of the pepper spray can be drawn from these limited results.

FRW distribution throughout the orchard has been shown to be erratic by McKenna *et al.*, (2001c). There is the possibility that the favourable results obtained from the two orchards were due to FRW population distribution in the treatment and control areas, and not an effect of the FRW pepper application. No trapping mechanism was employed during the monitoring phase that would have answered this question. Only further, long term trials could provide a better understanding to the effects of the application of the FRW pepper spray.

5.2 Achievement of objectives

The objective of this research was to determine the effects on the scale and Fuller's rose weevil (FRW) population from the application of their respective pepper sprays in organic and conventional kiwifruit orchards.

In both the scale and FRW, the results were not conclusive enough to state that there had been an effect on the two pest's reproductive cycle through the application of their respective pepper sprays. In the case of the scale, there was a large amount of 'statistical noise' associated with the results, so this lessens the results' significance. Similarly the results were not evident on all orchards. With the FRW, the results that the ANOVA was created from came from only two of the six orchards involved in the trial; this is an extremely small number of orchards considering the numbers of orchards in the trial area, on which to base any definitive conclusions.

Three of the five scale trial orchards showed a 50% or greater reduction in the percentage of adult scale with crawlers in the treatment block, compared to the control block. Orchards 'B', 'D' and 'E' had between 0-11% adult scale with crawlers in the treatment blocks, compared to their respective control blocks having between 18-49% adult scale with crawlers. However, looking at the numbers of scale with crawlers, the figures between the treatment and control blocks are not significantly different.

The analyses of the results indicate that the application of the scale pepper spray had no detrimental effect on the scale population in the orchard that season. On some of the orchards there were significant numbers of young scale throughout the trial. It was theorised that these were young scale being blown in to the orchard from the surrounding shelter, rather than as a result of breeding from within the canopy; however this assumption was never tested. Had the constant presence of young scale been a result of breeding within the canopy, the appearance of the crawlers should have been noticed much earlier.

Only two of the six orchards involved in the FRW trial provided any data; no egg masses were recorded on any of the other four orchards. With such a limited amount of data collected, no definitive conclusion could be drawn on the effectiveness of the pepper spray. The two orchards on which data was collected were sticky banded orchards; on three of the other four orchards the adult FRW could climb higher into the canopy to lay their eggs. FRW can be very spasmodic (McKenna *et al*., 2003) throughout an orchard, so where the tables are placed could play an important role in whether you get results. In hindsight an alternative monitoring system should have been implemented for the unbanded orchards.

At the commencement of this research, it was decided to record the number of adult FRW located on the tables, as well as the number of egg masses, in an attempt to gauge the effect, if any, that the pepper spray had on adult FRW populations within the treated block. However as the research progressed it was realised that even though FRW egg masses were being located on some of the tables, it was rare to find an adult on the tables. Due to this realisation, the value of the data collection of the number of adult FRW located on the tables was meaningless as an indicator of the numbers of FRW visiting the tables, or present in the block. Therefore it was impossible to determine any effect that the application of the pepper had on the adult FRW present within the treatment area.

5.3 Reflection on research trial concept and process

5.3.1 Peppering as a means of pest control

The use of 'peppers' to control pests was first proposed by Rudolf Steiner in his sixth lecture of the agricultural lectures he gave to an audience of biodynamic farmers in 1924. Unfortunately in the 80-years since then, most of the work been carried out on the effectiveness of such peppers has been informal, and little has been published in a formal setting. This thesis comprises some of the first trial based research work to be conducted into the effectiveness of the application of an insect pepper to a crop.

This peppering trial was a single year project for the researcher, this in itself led to a number of issues. Steiner (1993) believed it could take up to four years after the commencement of the application of a pepper spray, to become fully effective, but results can become evident in the first year. Due to logistic issues the researcher had to rely on the peppers being applied by growers, contract sprayers, or orchard managers. This meant that the peppers did not always get applied at the optimum times; however, this is often the case with research and was not the reason for the failure of the experimental design.

The focus of the trial was to investigate whether the application of a pest-specific pepper spray would have any effect on the reproductive cycles of the scale or FRW. In relation to the scale trial, the monitoring was carried out in accordance with the Zespri monitoring guidelines manual. After discussions with members of Zespri and HortResearch the once-per-month monitoring period was adopted. In hindsight, it is the opinion of this researcher that potentially more definitive data could have been obtained had the sampling time been increased to every fortnight, upon the first sign of crawlers.

The species and type of shelter trees surrounding the blocks appears to have an affect on the amount of scale aerial reinfestation of the blocks (Jamieson *et al.*, 2002). For this reason, initially large blocks with few internal shelterbelts were looked for; however, time restraints and orchard availability resulted in accepting the orchards offered. Once the orchards were obtained it was then largely up to the orchard owners or managers to determine which blocks were involved in the trial. This lead to some blocks having more shelter affects than others within the trial orchard, which was not ideal but unavoidable.

In relation to the FRW trial, the table design and idea was valid, and developed with the aid of discussions with members of the HortResearch team. No other research trials conducted on banded orchards could be located during the literature search, or comparisons between banded and unbanded orchards, so there were no proven monitoring procedures to adopt. The results obtained from the two orchards that had the sticky bands applied, indicated that the tables could be used as a monitoring tool in conjunction with other methods.

The FRW trial downfall in hindsight was two-fold; firstly, was the failure to employ some means of counting egg masses in the canopy on the orchards not using the sticky bands. Secondly, was in not adopting a method by which to catch, and therefore be able to count numbers of adult FRW within the monitored areas to determine their presence. This is an area that would need to be taken into consideration in future research trials of this nature.

FRW's impact on the kiwifruit harvest tends to be variable from season to season; the reasons for this are still unclear. The year this trial was conducted the FRW were not a major issue (McKeena, pers. comm.). Emergence patterns of FRW carried out by McKenna *et al.*, (2001c) have shown them to be extremely varied from block to block, and between orchards. For this reason it was chosen to place the tables down two or three rows rather than randomly throughout the treatment areas. In hindsight it may have provided more variation and been more informative had the tables been placed randomly.

The final monitoring dates were later than originally planned due to the later emergence times of the FRW that year. The monitoring for scale continued after the scheduled end date due to the identification of eggs inside the adult scale.

This research did go some way in helping better understand the principles of Rudolf Steiner's theory on peppering. The results on some of the orchards indicated some effect had likely occurred in the treatment blocks that had received the pepper sprays, in both the scale and FRW.

5.3.2 Methodoloical considerations

A new monitoring system had to be developed for the monitoring of the FRW due to having orchards in the trial that were implementing the sticky bands. The sticky bands are placed around all vines and poles to prevent the adult FRW from climbing into the canopy to lay their eggs. A series of small tables were built and placed down randomly selected rows, at every second pole (FRW section, figures 25 & 26 and photo 12, pg 67).

This system was successful in monitoring for FRW egg masses on the banded orchards, but failed as a monitoring tool in the unbanded orchards. The table system had no means by which to keep adult FRW on the tables once they had visited so it was unsuccessful as a monitoring tool for determining how many adult FRW were in the blocks. The issue of monitoring unbanded orchards along with banded orchards would have to be more carefully thought through in future trials, and a secondary monitoring system would be required for the unbanded orchards to provide analysable data.

For the scale trial, a monitoring system was developed based on proven leaf monitoring systems used in previous research trials. All the orchards involved in the trial were chosen on the basis of previous scale or FRW infestation; whether this was scientifically valid is open to debate.

Being limited to only one year's data is an unavoidable aspect of undertaking a one year Masters. While in most cases one year's worth of data would prove adequate, this researcher now believes that when dealing with a product that can take several applications, or sometimes a generation to be effective, more than one year's data would be both beneficial and statistically more reliable.

While these initial trials show the potential for peppering as an alternative means of pest control, they do not provide any definitive endorsement that the application of the peppers was successful. It will require conducting trials over a number of years on a larger number of orchards, to confirm the peppering techniques real potential, and not just anecdotal type experiments, as has been the case with the peppering technique in the past.

5.4 Further research

Upon completion of this research it has become evident that to achieve a more definitive result, would require the research fieldwork to be conducted over a period of three to five years, and preferably using orchards that are not subjected to the effects of shelter. One of the main problems arose from working with a substance (the peppers) that requires an extended period of time for their reproductive inhibiting effects to radiate throughout the orchard environment.

Although there was a significant difference in the percentage of adult scale found with crawlers between the treated and control blocks, this was based on only two samplings and not conclusive across all orchards. In future research trials it would be recommended that at the first signs of egg development within the adult scale, that monitoring be increased to fortnightly.

An interesting observation from the scale trial was the presence of the predatory wasp '*Encarsia citrina*', and the resultant numbers of parasitised scale noticed later in the season. On the basis of these observations it may be worth investigating their potential as a biological control, and releasing the '*Encarsia citrina*' on mass early in the season, at the first signs of scale present in the orchards.

The application of the FRW pepper did show a significant treatment difference on the orchards where analysable data was collected. However, this amounted to two of the six orchards in the trial. The results obtained from the FRW trial were encouraging and would be worth further investigation and follow-up research. If further FRW trials are conducted the same table system could be employed for counting egg masses, but the orchards involved would all have to be sticky banded, or the research team would have to employ a different monitoring system in any unbanded orchards. A trapping system should also be employed to determine the presence of FRW within the monitored area. The only way to determine the long-term effects of applying the peppers would be to conduct multi-year trials.

Endnote

It should be noted here that when this trial was proposed back in 2001 FRW was considered a major quarantine pest for the NZ kiwifruit industry, especially for the lucrative Japanese market. This lead to intensive trial work been undertaken to find a way of providing FRW contamination-free fruit for export. However, in mid-April 2005 the Japanese lifted its quarantine status on a range of pests, this included FRW (Steven, 2005). Now FRW, greedy scale and latania scale are considered non-actionable pests in Japan; however FRW is still considered an actionable pest in Mexico (Steven, 2005).

Finally, on a personal perspective, orchard 'D' has continued to apply the peppers trialled in this trial, along with a leafroller pepper made by Garuda Biodynamics (now BD Max) from moths collected off orchard 'D'. Over the preceding years the prevalence of all three pests has declined to the stage that last season only two fish oil sprays were applied to control the scale, and two Bt sprays to control the leafroller; this is substantially less than Zespri's recommended pest control programs for either the conventional or organic growers. Orchard 'D' is an organic orchard and has both green and gold kiwifruit with all the fruit making the required pest-free status for export to Japan.

I am an advocate of both Rudolf Steiner and Glen Atkinson's (BD Max) work and will continue to apply the BD Max range of products to my own orchard. Being a firm believer of organic principles, and in the need to regulate the amount of chemicals being applied to New Zealand orchards and farms, any system that can aid in the control of pests that does not rely of chemical controls is worth investigation.

I personally hope that the work and effort that has been undertaken to complete this thesis will go someway to helping future researcher's, and interested persons in this field to better understand the complexity of the topic, and aid them in their own research work.

References

Anon[1], 1986a. The Fuller rose beetle: The battleground is now in the groves but no one is certain about the weapons. *Citrograph, 71(7)*: 174-175

Anon[2], 1986b. Fuller rose beetle: Industry inspection program revives export shipping. *Citrograph, 71(5)*: 142

Anon[3], 1990. Target zero at Saticoy. *Citrograph 75(4)*: 86

Atkinson, G. 2002. *Gyroscopic Astrology.* Garuda Trust. 229p.

Badgley, M. 2000. www.ipm.ucdavis.edu photos

Berry, J.A. 1983. Aspects of the ecology and control of the greedy scale (*Hemiberlesia rapax* (Comstock)). MSc thesis, University of Auckland, New Zealand. 112p.

Berry, J.A., Morales, C.F., Hill, M.G., Loforth, B.J. and Allan, D.J., 1989. The incidence of three diaspidid scales on kiwifruit in New Zealand. *Proceedings of the 42nd N.Z. Weed and Pest Control Conference*: 182-186

Blake, G and Bacchus, P. 2000. Possum peppering trial on the Thames Coast. *Harvests 53(1)*: 22-25

Blank, R.H., Olson, M.H. and Waller, J.E. 1985. Screening pesticides for control of greedy scale on kiwifruit leaves. *Proceedings of the 38th N.Z Weed and Pest Control Conference*: 219-222

Blank, R.H., Olson, M.H. and Bell, D.S. 1987. Invasion of greedy scale crawlers (*Hemiberlesia rapax*) onto kiwifruit from taraire trees. *N.Z Entomologist 10*: 127-130

Blank, R.H., Olson, M.H. and Lo, P.L., 1990. Armoured scale (Hemiptera: Diaspididae) aerial invasion into kiwifruit orchards from adjacent host plants. *N.Z. Journal of Crop Horticultural Science 18*: 81-87

Blank, R.H., Gill, G.S. and Olson, M.H. 1994. Relationship between armoured scale infestations on kiwifruit leaves and fruit. *Proceedings of the 47th New Zealand Plant Protection Conference*: 304-309

Blank, R.H., Gill, G.S.C. and Olson, M.H., 1995. Seasonal abundance of greedy scale (Homoptera: Diaspididae) and associated parasitoids on taraire (*Beilschmiedia tarairi*). *Journal of Economic Entomology. 88:* 1634-1640

Blank, R.H., Gill, G.S. and Dow, B.W. 1997. Determining armoured scale distribution within kiwifruit blocks. *Proceedings of the 50th New Zealand Plant Protection Conference*: 293-297

Blank, R.H., Gill, G.S., McKenna, C.E. and Stevens, P.S. 2000. Enumerative and binomial sampling plans for armoured scale (Homoptera:Diaspididae) on kiwifruit leaves. *Journal of Economic Entomology 93 (6)*: 1752-1759

Clark, J.K. 2000. www.ipm.ucdavis.edu photos

Coats, S.A. and McCoy, C.W. 1989. Fuller rose beetle: Ovipositional preference on citrus. *Citrograph 74(11)*: 275-279

de Vaus, D.A. 2001. *Research design in social research*. London, Sage.

Edwards, M.E., Buchanan, G.A., Predebon, S., Pywell, M. and Hawtin, J.M. 1992. Evaluation of cold temperature and hot water dipping for postharvest disinfestation of citrus from Fuller's rose weevil (*Asynonychus cervinus* (Boheman)) eggs (Coleoptera:Curculionidae). *Plant Protection Quarterly, 7(4)*: 183-185

Fellows, S. 1998. Autumn pest control – tricky but necessary. *N.Z Kiwifruit Journal 126*:17-18

Ferguson, A.M. 1998. Greedy scale lifecycle. www.hortnet.co.nz

Ferguson, C.M., Barratt, B.I.P., Jones, P.A. and Garnham, M.L. 1990. Control of black vine weevil (*Otiorhynchus sulcatus*) larvae with different rates of a parasitic nematode (*Heterorhabditis bacteriophora)*. *Proceedings of the 43rd N.Z. Weed and Pest Control Conference*: 67-69

Griffiths, H., Hardison, A., Morse, J.G. and Luck, R.F. 1986. Fuller rose beetle: A practical solution. *Citrograph 71(5)*: 139-140

Harley, L. and Kay, S. 2001. Managing the risk of Fuller's rose weevil egg masses. *NZ Kiwifruit Journal 144*:13-15

HortFACT 1998. www.hortnet.co.nz

Jackson, T.A., Pearson, J.F. and Barrow, T.H. 1985. Control of the black vine weevil on strawberries with the nematode *Steinernema glaseri. Proceedings of the 38th N.Z. Weed and Pest Control Conference*: 158-161

James, D.G. 1991. An evaluation of chemical and physical treatments to prevent Fuller's rose weevil oviposition on citrus fruit. *Plant Protection Quarterly, 6(2)*: 79-81

Jamieson, L.E., Dobson, S., Cave, J. and Stevens, P. S. 2002. A survey of armoured scale insects on kiwifruit shelter. *N.Z Plant Protection. 55*:354-360

Johnson, J.A., Soderstrom, E.L., Brandl, D.G., Houck, L.G. and Wofford, P.L. 1990. Gamma radiation as a quarantine treatment for Fuller rose beetle eggs (Coleoptera: Curculionidae) on citrus fruit. *Journal of Economic Entomology. 83(3)*: 905-909

Kay, S. 2002. Armoured scales. Zespri™ KiwiTech bulletin.

Kemp, C. 2003. Biodynamic AgriCulture Australia. www.biodynamics.net.au

KiwiGreen pest monitoring manual 1994 and 1998.

Kolisko, E. 1936. *The twelve groups of animals*. Reprinted 1977. England, Clunies Ross Press.

Kolisko, E & L. 1939. *Agriculture of tomorrow*. England, John Jennings (Gloucester) Ltd.

Larkin K. R. and Morse J. G. 1987. A degree-day model for Fuller's rose beetle, *Pantomorus cervinus* (Boheman) (Col., Curculionidae) egg hatch. *Journal of Applied Entomology 107 (1)*: 102-106

Larkin, K. 2000. www.ipm.ucdavis.edu photos

Lievegoed, B.C.J. 1950. *The working of the planets and the life processes in man and earth*. England, Broome Farm, Clent, Stourbridge, Worcs.

Lo, P.L. and Blank, R.H., 1989. A survey of armoured scale species (Hemiptera: Diaspididae) in Kiwifruit orchards. *N.Z Entomologist 12*: 1-14

Madge, D.G., Clarke, K., Buchanan, G.A. and Wilkins, B. 1992. Seasonal abundance and distribution of Fuller's rose weevil, *Asynonychus cervinus* (Boheman) (Coleoptera:Curculionidae) in Sunraysia citrus groves. *Plant Protection Quarterly, 7(1)*: 3-6

MAF New Zealand 2003. www.maf.govt.nz

Magarey, R.D., Clarke, K., Madge, D.G. and Buchanan, G.A. 1992. Comparative efficacy of trunk treatments for control of Fuller's rose weevil, *Asynonychus cervinus* (Boheman) (Coleoptera:Curculionidae), on citrus. *Plant Protection Quarterly, 7(1)*: 7-9

Magarey, R.D., Buchanan, G.A., Franz, P.R. and Roberts, G.S. 1993. Evaluation of lambdacyhalothrin and deltamethrin trunk treatments for control of Fuller's rose weevil, *Asynonychus cervinus* (Boheman) (Coleoptera:Curculionidae), on citrus. *Plant Protection Quarterly, 8(4)*: 123-126

Martin, B. 2003. Zespri September grower newsletter.

Max, S. 2002. Successful pest management seminar. *NZ Kiwifruit Journal, 154*: 17-19

May, B. 1998. Fuller's rose weevil lifecycle. www.hortnet.co.nz/publications/hortfacts

McCoy, C.W., Terranova, A.C., Miller, W.R., Ismail, M.A. and Carroll, C.C. 1994. Vapor heat treatment for the eradication of Fuller rose beetle eggs on grapefruit and its effect on fruit quality. *Proceedings of the Florida State Horticultural Society. 107*: 235-240

McKenna, C. E., Stevens, P. S. and Steven, D. 1997. Phytotoxicity to kiwifruit from sprays of mineral oil. *Acta Horticulturae 444*: 779-784

McKenna, C. E. 1999. Evaluation of vegetable oils for armoured scale control in kiwifruit orchards. *Acta Horticulturae 498*: 365-370

McKenna, C. and Maher, B. 2000. The effectiveness of nylon covers in preventing insect contamination of kiwifruit. Research report commissioned by Zespri Innovation Ltd, Project no. 316. Conducted by HortResearch.

McKenna, C., Maher, B. and Dobson, S. 2001a. Fuller's rose weevil: Population studies in Hort16A plantings, 2000-01. Research report commissioned by Zespri Innovation Ltd, Project no. 402. Conducted by HortResearch.

McKenna, C., Maher, B. and Dobson, S. 2001b. Control of Fuller's rose weevil in kiwifruit orchards. Research report commissioned by Zespri Innovation Ltd, Project no. 406. Conducted by HortResearch.

McKenna, C., Dobson, S., Maher, B. and Connolly, P. 2001c. Sampling parameters for monitoring Fuller's rose weevil in Hort16A blocks. Research report commissioned by Zespri Innovation Ltd, Project no. 396. Conducted by HortResearch.

McKenna, C. 2002. A review of Fuller's rose weevil biology and control. Research report commissioned by Zespri Innovation Ltd, Project no. 495 component 1, and 496 component 1. Conducted by HortResearch.

McKenna, C., Maher, B., and Dobson, S. 2002. Armoured scale control on Hayward vines using mineral oil. Research report commissioned by Zespri Innovation Ltd, Project no. 504. Conducted by HortResearch.

McKenna, C., Maher, B., Dobson, S. and Allison, P. 2003. Fuller's rose weevil emergence in Hort16A blocks. Research report commissioned by Zespri Innovation Ltd, Project no. 495. Conducted by HortResearch.

Morse, J.G., Phillips, P.A., Goodell, P.B., Flaherty, D.L., Adams, C.J. and Frommer, S.I. 1987. Monitoring Fuller's rose beetle populations in citrus groves and egg mass levels on fruit. *The Pest Control Circular 547*: 1-8

Morse, J.G. and Larkin, K.R. 1987. The battle to control fuller rose beetle. *California Grower 11*: 34-40

Morse, J.G., DeMason, D.A., Arpaia, M.S., Phillips, P.A., Goodell, P.B., Urena, A.A., Haney, P.B. and Smith, D.J. 1988. Options in controlling the Fuller rose beetle. *Citrograph, 73(7)*: 135-140

New Zealand map. www.backpack-newzealand.com/mapofnewzealand

Pearce, A.N. 1993. *A bio-dynamic farmer's handbook*. Revised edition. New Zealand, A.N. Pearce.

Prestidge, R.A. and Willoughby, B. 1990. Control of garden weevil (*Phlyctinus callosus*) larvae and pupae with a parasitic nematode and a fungal pathogen. *Proceedings of the 43rd N.Z. Weed and Pest Control Conference, 1990*: 63-66

Sale, P.R., and Ferguson, A.M. 1975. A further insecticide trial on kiwifruit. *The Orchardist of New Zealand 48(9)*: 313

Sale, P. 1980. The history of pest and disease control of kiwifruit. *Proceedings of the 33rd N.Z. Weed and Pest Control Conference, 1980*: 110-113

Sale, P.R., and Steven, D. 1984. Insect control trials in kiwifruit 1980-82. *Proceedings of the 37rd N.Z. Weed and Pest Control Conference, 1984*: 125-129

Sale, P. 1993. Monitoring of Fuller's rose weevil in citrus orchards. *The Orchardist of New Zealand. 66(11)*: 38-40

Sale, P. 1997. An effective chemical trunk treatment for Fuller's rose weevil control. *The Orchardist. 70(11)*: 63-66

Soderstrom, E.L., Brandl, D.G. and MacKey, B.E. 1993. High temperature for control of *Asynonychus godmani* (Coleoptera: Curculionidae) eggs on lemon fruit. *Journal of Economic Entomology. 86(6)*: 1773-1780

Statistics New Zealand 2003. www.stats.govt.nz

Steiner, R. 1993. *Agriculture* (7th Edition). *ed* Gardener, M. Bio-Dynamic Farming and Gardening Association, Inc. Kimberton, Pennsylvania, U.S.A.

Stephen, D. 1991. Citrus growers beware – weevil about. *The Orchardist of New Zealand, 64(11)*: 30-31

Steven, D. 1990. Entomology and kiwifruit *In. Kiwifruit science and management* (Eds) I.J.Warrington & G.C.Weston, for the New Zealand Society for Horticultural Science.

Steven, D., Tomkins, A.R., Blank, R.H. and Charles, J.G., 1994. A first-stage integrated pest management system for kiwifruit. *Proceedings of the Brighton Crop Protection Conference Vol. 1:* 135-142

Steven, D., Barnett, S. W., Stevens, P. S. and McKenna, C. E. 1997. Changing pest control on New Zealand kiwifruit. *Acta Horticulturae 444*: 765-771

Steven, D. 1999. Perceptions and reality in pest control on kiwifruit in New Zealand. *Acta Horticulturae 498*: 359-364

Steven, D. 2005. Japanese change their quarantine system: no more sticky bands! *NZ Kiwifruit Journal, 170*: 40-42

Stevens, P.S., McKenna, C.E., Blank, R.H., Tomkins A.R. and Steven, D. 1997. Comparison of armoured scale spray thresholds in kiwifruit. *Proceedings of the 50th New Zealand Plant Protection Conference*: 288-292

Thun, M. 1990. *Work on the land and the constellations*. The Lanthorn Press, England.

Thun, M. 1999. *Gardening for life – the biodynamic way*. Hawthorn Press, England.

Tomkins, A.R. 1996. Pest control on kiwifruit with an insecticidal soap. *Proceedings of the 49th New Zealand Plant Protection Conference*: 6-11

Tomkins, A.R., Greaves, A.J., Wilson, D.J. and Thomson, C. 1996. Evaluation of a mineral oil for pest control on kiwifruit. *Proceedings of the 49th New Zealand Plant Protection Conference*: 12-16

Worner, S.P. 2002. Advancement of sampling and monitoring plans for pest management in kiwifruit. Zespri client report project number 441.

Zespri™ KiwiTech bulletin. 2001. Fuller's rose weevil.

Zespri™ Group Limited, 2003. Annual report.

Zespri™ crop protection programme 2003.

Appendices

Appendix A: Pepper preparation

1. Collect breeding age samples of the pest to be eradicated. Sufficient quantity of the pest is required to provide at least 1gm of ash after the insects have been burnt; this can amount to large numbers of insects if dealing with small insects such as scale.
2. The insects are placed within a vessel that can withstand heating eg. wok or pot. The vessel is placed over a flame heat source (NOT electric) until all insects are burnt to ash state.
3. Place cooled ash in mortar and grind with pestle until a fine powder.
4. Measure 1gm of ash then return it to a clean mortar, any surplus ash is stored for later use. Add 9gm lactose and mix together by grinding/stirring compounds for 60mins; this is the commencing of the decimal homeopathy potentising procedure. The resultant mixture is considered to be the first potency or 1x (10^1).
5. 1gm of the 1x mixture is weighed off and placed in a 30ml bottle with 9mls distilled water or ethanol. Bottle capped then rhythmically shaken, 1-cycle/sec for 150secs. This results in the 2x (10^2) solution.
6. Contents of the 30ml bottle then transferred into a 200ml bottle with extra 90ml distilled water, or ethanol. Solution again shaken as before for 150secs (3x). This becomes the stock solution for this insect pest pepper.
7. 2ml of 3x solution added to 18ml of distilled water, or alcohol, in a 30ml bottle and again shaken for 150secs (4x). Step 7 repeated until 8x (10^8 or 8^{th} potency) is reached.

Garuda Biodynamics recommends applying a minimum of 250ml/ha of 8x pepper solution, in a minimum of 250l water/ha. The first pepper application should be applied in late winter or early spring, then reapplied at 3-month intervals.

Appendix B: Anecdotal evidence

The following comments are from a selection of NZ Biodynamic association members that were interviewed as part of the literature review for the trial. Some of interviewee's are also kiwifruit orchardists. Not all of the people interviewed had made the peppers themselves, of those that did some have provided details of the procedure they followed to produce the relevant peppers.

Tim Oliver – Passion vine hopper

Tim has a large KiwiGreen orchard in the Waikato with a number of large black walnut trees and other ornamentals growing in the unusable areas. Tim has had a serious problem with Passion-vine hopper (PVH). In 1988-89 Tim lost 40-50% of the fruit in block three to sooty mould (a mould that grows on the honey dew excreted by the PVH). The orchard was sprayed regularly with Attack until it was converted to organics in the 1992-93 season. Tim started applying the PVH pepper made from insects collected off his own orchard the following year. Over the period 1996-2001 he experienced high PHV pressure (50-100 per stem on the black walnut seedlings) on the ornamentals on the property (only the orchard had the pepper applied, not rest of property), but only the occasional fruit with honeydew or sooty mould as a result of PVH activity within the orchard.

In the first two years of applying the pepper there was a dramatic improvement within the orchard (est. 70-80% reduction in fruit loss) but there were still two problem areas in blocks one and three. Tim estimated that without the use of the pepper sprays he has applied, their annual fruit losses from sooty mould would have been 5,000-10,000 trays, and possibly as high as 20,000-25,000 trays based on past experience. Tim believes that the application of the PVH pepper is the primary factor for the reduction in fruit losses over the intervening years. Tim estimated that over the last six years that he has saved over $100,000 from applying the pepper sprays.

Gary Blake - Possums

Gary Blake has a 36ha property in Thames that was being overrun by possums; he had carried out extensive trapping to eradicate as many as possible. In 1998, Gary made a pepper with the help of Peter Bacchus. One hundred possums were caught in

November, the dead animals were skinned, and the skins were dried in the sun prior to burning. The skins were burnt while the planet Venus was in the constellation of Scorpio (22nd November 1998). The resultant 800g of ash was mixed with GAP7 (particle size 7mm maximum) quarry dust, at a ratio of 110g possum skin ash per seven tonnes quarry dust. A total of 42 tonnes of possum pepper was mixed ready for spreading by aeroplane; this took place on the 30th and 31st December 1998 (Blake & Bacchus 2000). This amounted to 210kg/ha, or 3.3g possum skin ash/ha.

Environment Waikato conducted a possum count between 16th and 21st December 1998, and two post drop counts; between 26th January and 2nd February, and between 28th June and 2nd July. Five trap lines were monitored, two within the treatment zone, lines 1 and 5, with lines 2, 3 and 4 outside the treatment zone; all possums caught were released (Blake & Bacchus 2000). The results can be seen in Table 10.

Table 10: Total numbers of possums caught along each trap line over the three monitoring samplings periods (Blake and Bacchus 2000).

	Possums Numbers				
Date	Line 1	Line 2	Line 3	Line 4	Line 5
16 to 21 Dec 98	14	7	24	11	7
26 Jan to 2 Feb 99	13	12	17	23	6
28 Jun to 2 Jul 99	8	20	25	26	6

Gary also spread the pepper around the boundary of his property by depositing 25g of pepper approximately every 20-metres. Four and a half years later the property is still possum free, while possums are still plaguing neighbouring properties.

Peter Bacchus – Various weeds

Peter learnt about biodynamics from his father, and started to take an active interest in working with biodynamics in 1962. Peter spent time working in Europe with some of the top people in the biodynamic field at that time, including Maria Thun. Peters work experience spans dairy farms, glasshouse production, medicinal herbs, and working for Weleda (specialists in making homeopathic remedies) in Havelock North.

Dandelion

While Peter was working in Dornach (1966-67), Switzerland, the property he worked on was having a major problem with dandelion. The dandelion had taken over the entire pastures, so it was decided to try Rudolf Steiner's peppering technique. Dandelion seeds were harvested and burnt at full moon, the ash was spread over the pasture and the following spring almost no dandelion plants germinated.

Ragwort

Peter moved to a 36-hectare farm in Otorohanga in early 1970's, by 1973 the ragwort was so bad he could not walk in the paddocks with out stepping on a ragwort plant. Peter said that the other local farmers were spraying the ragwort with herbicides including 2,4,5-T. Peter proceeded to collect mature seeds and these were burnt in April at full moon to ensure a Virgo full moon (the best time for weed peppers to be made).

Peter then triturated (potentising in dry medium) the seed ash in sand. He started using a mortar and pestle for the first three potencies. Peter started off with one teaspoon of ash to nine of sand, with each potency increasing by 1:9 (ash: sand). Each potency requires mixing for one hour; the fourth potency was carried out in a clean concrete mixer. The resultant mix was spread thinly over a two hectare trial area when the moon was in perigee and descending; this occurred 10-days after trituration completed. Prior to the application of the pepper all existing ragwort plants had been removed from the two-hectare trial area. Result was that not one new plant germinated in the spring; the rest of the 34-hectares still had ragwort growing happily. It is not known how long the trial block remained ragwort-free as Peter left that property that year.

Whitefly

In the Hawke's Bay Peter moved in to glasshouse tomato production, there encountering whitefly. By 1979 the whitefly problem was so bad that he had to wear a cover over his mouth to prevent breathing in the whitefly. All tomatoes had to be polished before being sold or consumed. Peter had been using Bromide emulsion for control but this no longer worked, he was recommended Lannate (methomyl) but chose not to use it due to its toxicity to other soil organisms.

Peter collected the whitefly in late January at the end of his picking season; he used a vacuum cleaner to do this. Peter burnt the whitefly in a small fire. The resultant ash was stirred into five-litres of soil dust from glasshouse floor, this was stirred for one hour; no other potentising was carried out. Before spreading, Peter ensured that the soil was well moistened, and then spread pepper ash in evening. The next season when the temperatures started to increase the whitefly returned, but instead of being on the inside looking out, they were thick on the outside looking in; Peter did not notice any whitefly inside the glasshouse that year. In the following season the whitefly returned to the other side on the boundary fence, over three metres away, none on Peter's property. The season after that the neighbours had no whitefly in their home garden either. Peter believed the effect of the pepper was spreading out from the original source.

Cheryl Kemp – Weeds and pests

Cheryl Kemp of Australia has been working in the field of peppering for a number of years, and conducted a range of different trials during this time. Cheryl completed the New Zealand Biodynamic Agriculture course during the 1990's then moved back to Australia to put her training in to practise, she said there was a lot of demand for this type of treatment in Australia due the higher numbers of animal, plant and insect pests. Cheryl believes that the peppers work best on properties that have been applying the biodynamic preparations as they work on the soil, making it more sensitive, and better connects the soil to the planets. Most of Cheryl's work is with the use of potentised peppers (mainly 12x), rather than the straight pepper ash of insect, weed, bird or mammal.

Thistle

In the region Cheryl lives in they have a thistle problem, and her own property was no exception. During the autumn 2001 she collected thistle seed heads and burnt them, potentised the ash, then sprayed this over her property. The result was that the following year she had no thistles while all her neighbours were still plagued with thistles.

Cockatoo

Some cockatoos were caught and killed, their skins were burnt and the pepper ash spread around the paddock. Cheryl tried a potentised solution first but got longer lasting results from the straight ash. This pepper was applied around a paddock of harvested peanuts that were drying on the soil surface; there was a paddock of maize next to the peanuts left untreated. Although the cockatoos prefer peanuts to maize, they left the peanuts alone until the maize had been eaten and there was no more food elsewhere; even then it was a number of days before the cockatoos returned to the paddock of peanuts to feed on the nuts.

Fruit bats

An orchardist Cheryl knows had problems with fruit bats, they start arriving every evening around 5.00pm and did a lot of damage in a short time around harvest time. Cheryl made the orchardist a potentised fruit bat pepper at 12x; the solution was sprayed around the perimeter of the orchard in the morning. That evening the fruit bats were observed flying up to the perimeter of the orchard, then stopping, screeching madly, then either going around the orchard, or back the other way. Cheryl believes the length of time the effect of the pepper lasts for can depend on a number of factors; weather conditions, rainfall, whether the properties apply the biodynamic preparations or not (Cheryl has found this to have a pronounced affect on the effectiveness of the peppers and the amount of time the effect lasts), and the use of chemical sprays.

One of the orchardists neighbours observed the success of the pepper application and asked to try it on their orchard; it worked as effectively on the neighbour's orchard until they sprayed a fungicide. This seemed to nullify the effect of the pepper, and the fruit bats returned to that orchard that same night, but still left the first orchard alone. Cheryl found that for the pepper to be effective in the conventional orchard she had to increase the potency from 12x to 60x.

Bowerbird

Cheryl applied a potentised Bowerbird pepper to her own small orchard containing apples and peaches, as the Bowerbirds had destroyed the crops the previous year. The result was that while the birds once again devastated her neighbour's trees, she managed to harvest all her fruit crops unscathed by bird damage.

Fig wasp

A friend of Cheryl's made a potentised fig wasp pepper from a collection of adults, larvae and eggs, then applied it to the first of two trees. The second tree was left untreated. The result was that the treated tree remained undamaged from the wasp, while the wasps decimated the fruit on the untreated tree.

Neville Pomara – Rats and mice

Neville was having a major problem with rats and mice in his kumara shed at Nuhaka, northern Hawke's Bay. Neville caught seven rats and fifteen mice, with males and females of both. The dead animals were skinned, and then the skins were dried in the sun. The date was the 16th October 1997, with the Sun in Libra and the Venus in

Scorpio. All the skins were ashed. Neville then mixed the resulted ash with an equal quantity of sand and dynamised (stirred) for 60 minutes. After potentising in water to D8, Neville added 1ml of the D8 solution per litre of water, and sprayed around his 4.5-hectare property. Neville noticed a change from seeing a plague of mice and rats, to not seeing any rats for at least 3 years and never had any mice in our house until 2001. Mice were back out in the paddock and gardens within 2 years. At the time of interview (2003), kumara had not been eaten by rats during storage since the first application, and have just begun to get chewed while they are growing in the fields.

John and Noeline Almond – PVH, FRW and scale

John and Noeline have a three-canopy hectare orchard in Te Puke; approximately half is Zespri™Gold and the rest Hayward. The orchard was purchased in 1990 and they started conversion to organics in 1996 gaining full organic status in 1999. John and Noeline had a problem on part of the orchard with passion vine hopper (PVH), and now as the property was organic they had to look for alternatives to control it. The 1999-2000 season was the first season the PVH pepper was applied; the percentage of sooty mould picked up in the packhouse that season was significantly less than the previous season. In the 2000-01 season John and Noeline continued to apply the PVH and Fuller's rose weevil (FRW) peppers. For the 2002-03 season in addition to the PVH and FRW peppers they also applied a new scale pepper as well.

In the 1999-2000 season the presence of FRW prevented their fruit going in to Japan, and their fruit was classified as being a high risk product. This was the reason for the inclusion of the FRW pepper the next season. During the 2000-01 season HortResearch visited the Almond's property to look at fruit to find FRW egg masses, but found none. HortResearch returned the following season to look at the sward to find signs of FRW eggs on docks, but again found none and so have now reclassified the Almond's orchard as low risk. In the 2001-02 season all the Almond's fruit was sold as pest free and was exported to Japan.

During the 2002-03 season the Trevelyan's packhouse pest monitoring team found no FRW egg masses in the Almond's gold blocks, but found two adults. The pest monitors did find some FRW eggs in the Hayward blocks, but the Almond's put this down to the fact that they had only started to applied the FRW pepper sprays to that block. Noeline said that before they started applying the FRW pepper, they had FRW everywhere; at harvest time the FRW could be seen crawling out of the bins. While working out in the orchard summer pruning, it was common to find FRW in the canopy and on the kiwifruit poles. However, since the application of the FRW pepper it is now a rarity to find any FRW.

Peter Omber - PVH

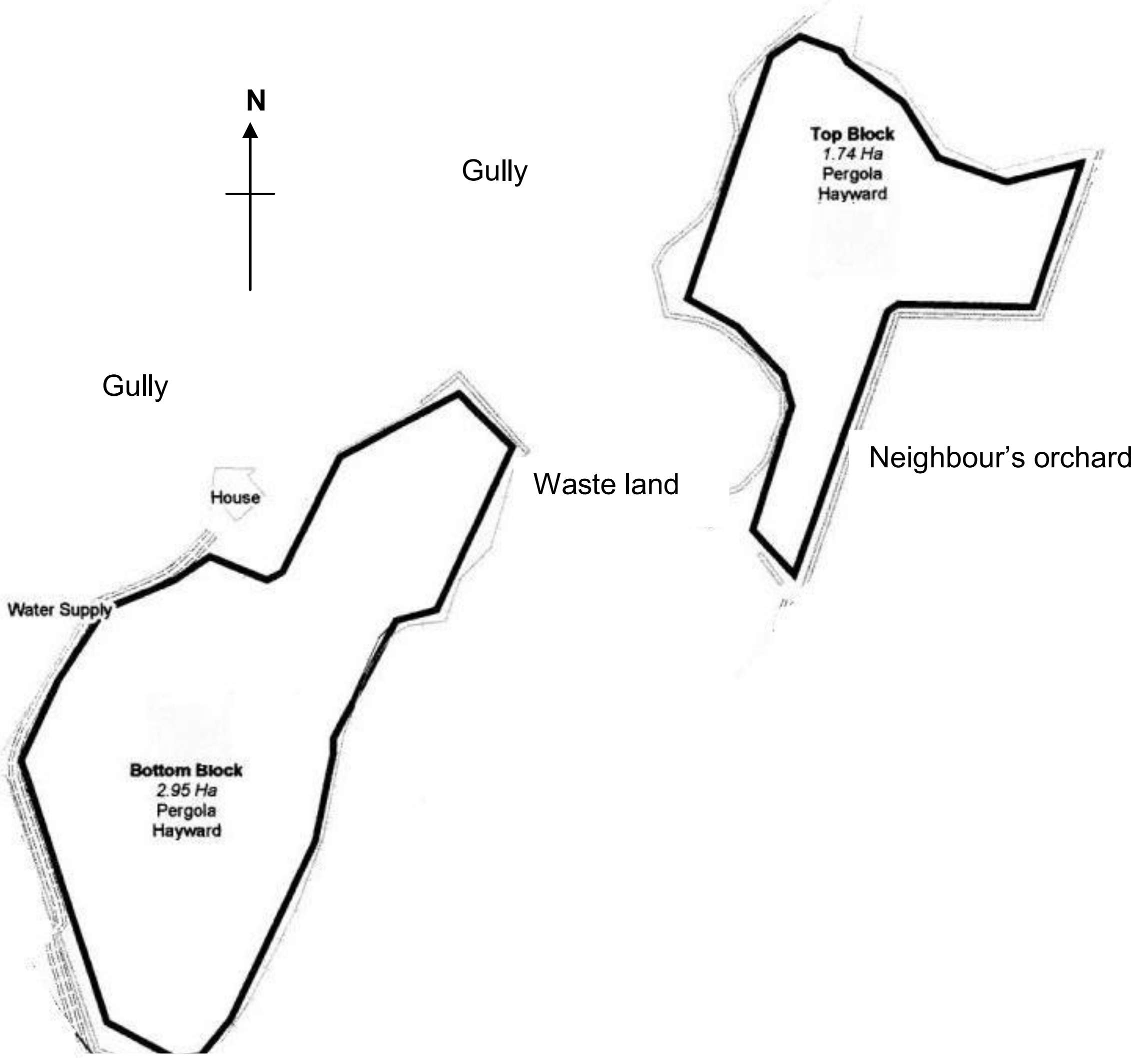
Peter has run his orchard organic for a number of years now and started applying the PVH pepper soon after converting to organics. Peter said we used to lose 2% of his crop annually to sooty mould (this was 20% of their rejects), but since applying the pepper that figure has reduced to 0.2% of the crop, or 2% of their rejects. Peter said he had cleaned up a lot of the nightshade and blackberry around the boundary, and believes this has also contributed to the reduction in the numbers of PVH and sooty mould damage. Peter still believes that the PVH pepper works and will keep applying it.

Geoff Gibbs – PVH and FRW

Geoff is a contract kiwifruit orchard sprayer and presently is applying Garuda Biodynamics triple pepper – PVH, scale and FRW – to 130ha. The pepper is applied approximately every three weeks (total of 6 – 8 applications/year) during the growing season. Geoff has noticed significant reductions in the insect damage related crop reject rates and believes this is due to the application of the pepper sprays.

Appendix C: Scale research property maps

Orchard 'A'

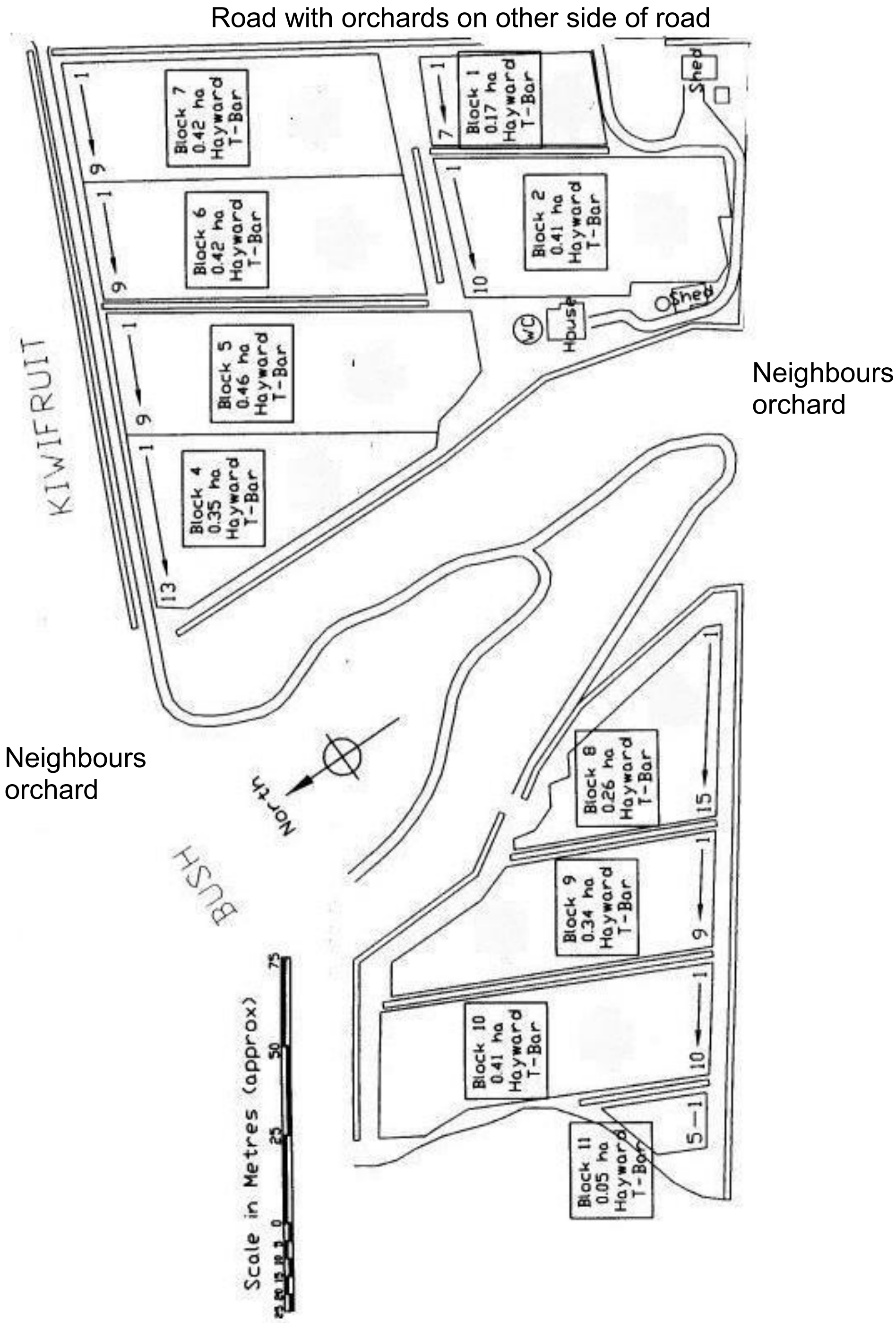


Only the bottom block was used for the trial.

Both the scale and FRW trials were run on this orchard. Top block is surrounded by 5-6m *Cryptomeria japonica*. At the SW end of the Bottom block are 15m+ *Pinus spp.* On the NW side of the block is a 2m high wooden wall, behind this is a vast gully. On the SE side is a high bank that provides shelter from this direction. The NE end is unsheltered.

Map supplied courtesy of Seeka Kiwifruit Industries Ltd.

Orchard 'B'

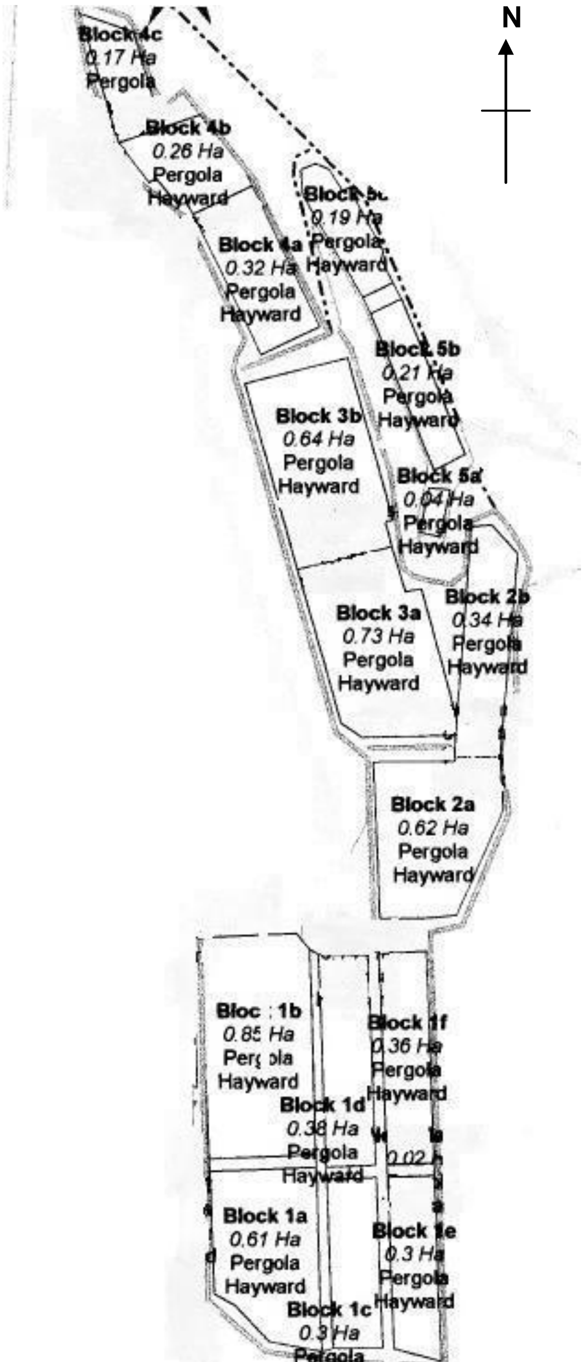


Block 6 was the control block with Block 7 being the treatment block.

Both the scale and FRW trials were run of this orchard. The N side of orchard is sheltered by 10+ *Pinus spp* trees, with the rest of the orchard sheltered by 5-6m *Cryptomeria japonica* trees.

Map supplied courtesy of Trevelyan's Pack and Cool Ltd.

Orchard 'C'

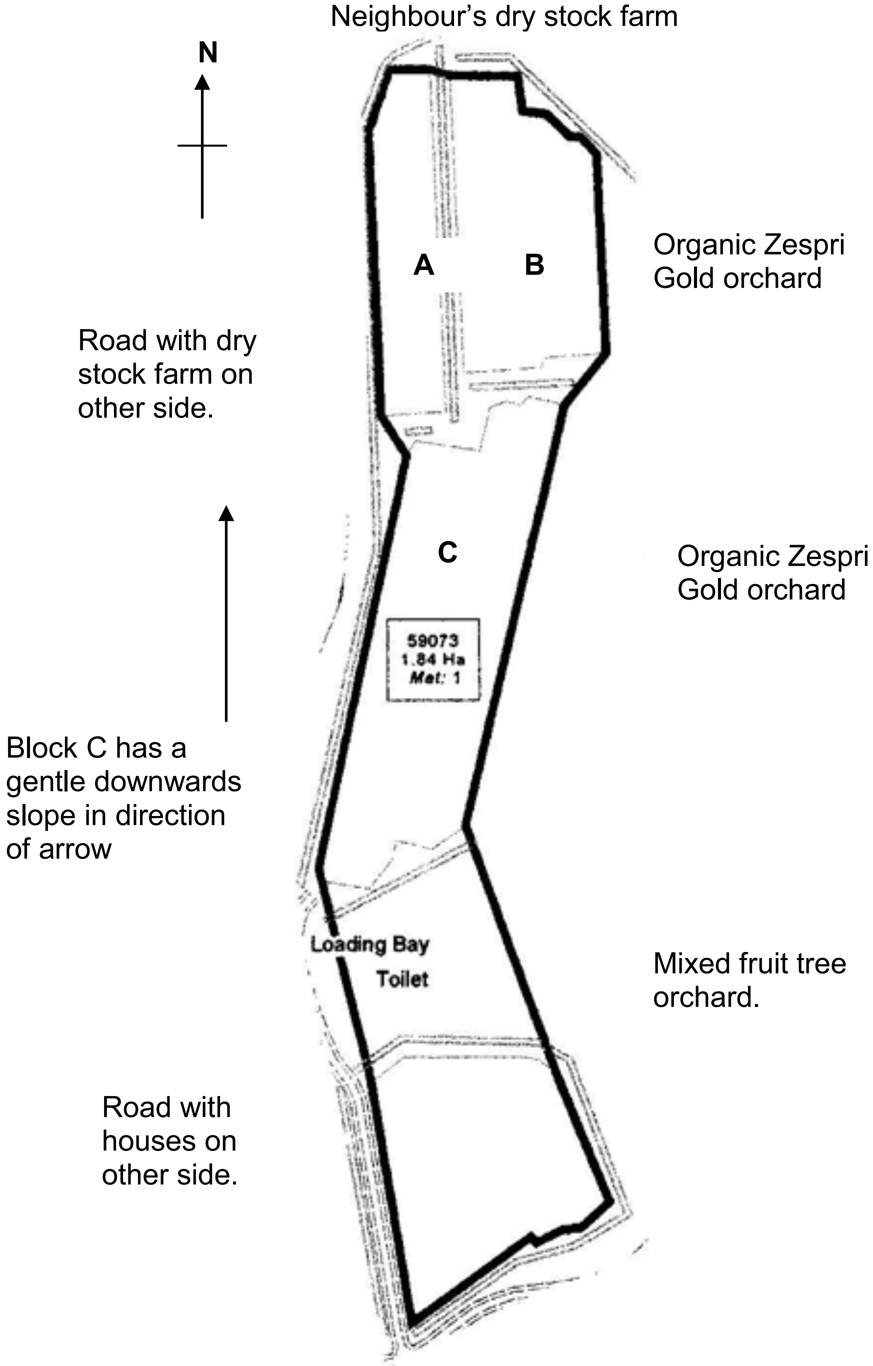


Block 3a was the treatment block with Block 3b the control block in the trial.

The entire orchard is surrounded with 5-6m *Cryptomeria japonica* trees. Along the SW boundary of Blocks 3a and 3b there are 10+m Black walnut trees on the neighbour's side.

Map supplied courtesy of Seeka Kiwifruit Industries Ltd.

Orchard 'D'

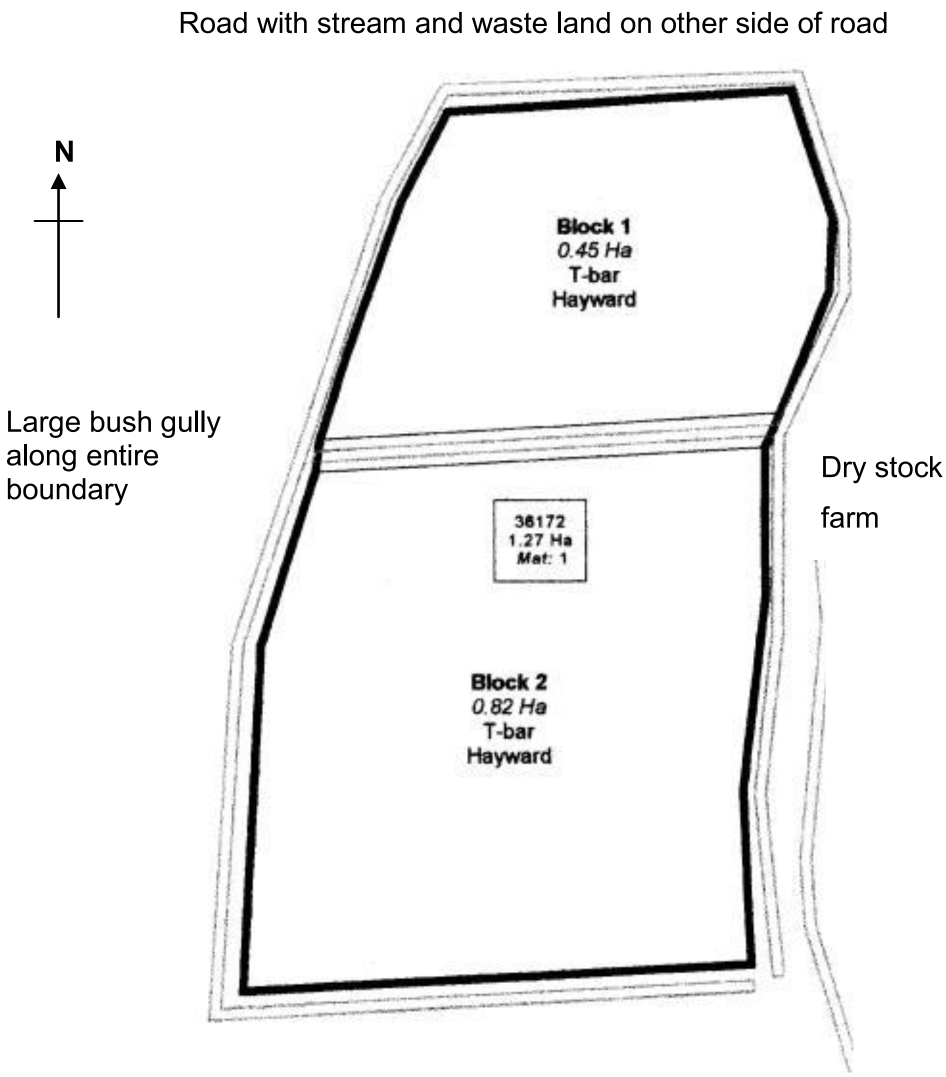


Blocks A & B treatment block and Block C control block.

At the N end of block is a young 2m *Casuarina spp* shelter. Along the E boundary is another organic kiwifruit orchard. At the S end are 10m *Pinus radiata* trees, with 5-10m *Casuarina spp* trees interplanted with 3-5m *Cupressocyparis leylandii* trees along W boundary.

Map supplied courtesy of Seeka Kiwifruit Industries Ltd.

Orchard 'E'



Block 1 treatment block and Block 2 control block in trial.

At N end of block are 5-6m *Salix matsudana* willow trees, with a mixture of 15-20m high *Eucalyptus* and *Pinus spp* trees on the E and W boundaries. At the S end of the block is the orchard owner's house.

Map supplied courtesy of Seeka Kiwifruit Industries Ltd.

Appendix D: ANOVA results of adult live scale with crawlers on individual orchards and combined data

Table 11: ANOVA results of individual orchards of adult scale found with crawlers under their caps per 408-leaves sampled, in relationship to effect of parameters shown.

	Pr > F			
Orchard	trt	shelter	date	trt*date
A	0.1334	0.5000	0.0572	0.1835
B	0.3030	0.2048	0.4063	0.5337
C	0.1987	0.6653	0.2899	0.1734
D	0.5000	0.4311	0.2643	0.3031

Significance Pr > F (0.05)

- Orchard ‘E’ was not included in individual results due to only having shelter-affected results, this did not leave enough parameters to conduct the ANOVA.

Table 12: ANOVA results of combined data of adult live scale found with crawlers under their caps, in relationship to effect of parameters shown.

	All orchards
Significance	Pr > F
orchard	0.1330
shelter	0.8814
trt	0.5077
trt*shelter	0.4446
date	0.3624
shelter*date	0.4238
trt*date	0.2261
trt*shelter*date	0.7407

Significance Pr > F (0.05)

Appendix E: Live and dead scale monitoring results

Orchard	Date	TBAS Live scale	TBAS Dead scale	TBAS Total scale	TBUS Live scale	TBUS Dead scale	TBUS Total scale	CBAS Live scale	CBAS Dead scale	CBAS Total scale	CBUS Live scale	CBUS Dead scale	CBUS Total scale
A	27/12/2002	32	0	32	19	0	19	17	0	17	21	0	21
(Organic)	21/01/2003	30	7	37	24	1	25	12	2	14	17	3	20
	11/02/2003	43	7	50	21	20	41	49	3	52	42	2	44
	8/03/2003	25	9	34	33	5	38	48	14	62	20	9	29
	31/03/2003	42	22	64	24	9	33	49	44	93	42	11	53
	25/04/2003	34	52	86	37	29	66	69	42	111	72	51	123
	26/05/2003	26	33	59	21	16	37	31	26	57	26	24	50
B	27/12/2002	32	0	32	12	0	12	35	0	35	19	0	19
(Organic)	21/01/2003	31	19	50	23	13	36	43	9	52	37	11	48
	11/02/2003	50	14	64	6	4	10	59	20	79	37	3	40
	8/03/2003	31	6	37	27	13	40	27	8	35	27	13	40
	31/03/2003	50	22	72	47	23	70	38	17	55	27	21	48
	25/04/2003	40	15	55	44	12	56	44	19	63	55	8	63
	26/05/2003	60	28	88	47	15	62	33	31	64	41	16	57
C	27/12/2002	230	0	230	154	0	154	70	0	70	43	0	43
(Organic)	21/01/2003	364	14	378	220	15	235	64	4	68	22	17	39
	11/02/2003	365	28	393	286	22	308	81	4	85	59	9	68
	8/03/2003	549	107	656	382	55	437	78	26	104	64	10	74
	31/03/2003	420	158	578	272	172	444	53	26	79	54	31	85
	25/04/2003	277	217	494	241	128	369	89	43	132	71	41	112
	26/05/2003	210	162	372	277	236	513	50	45	95	50	28	78

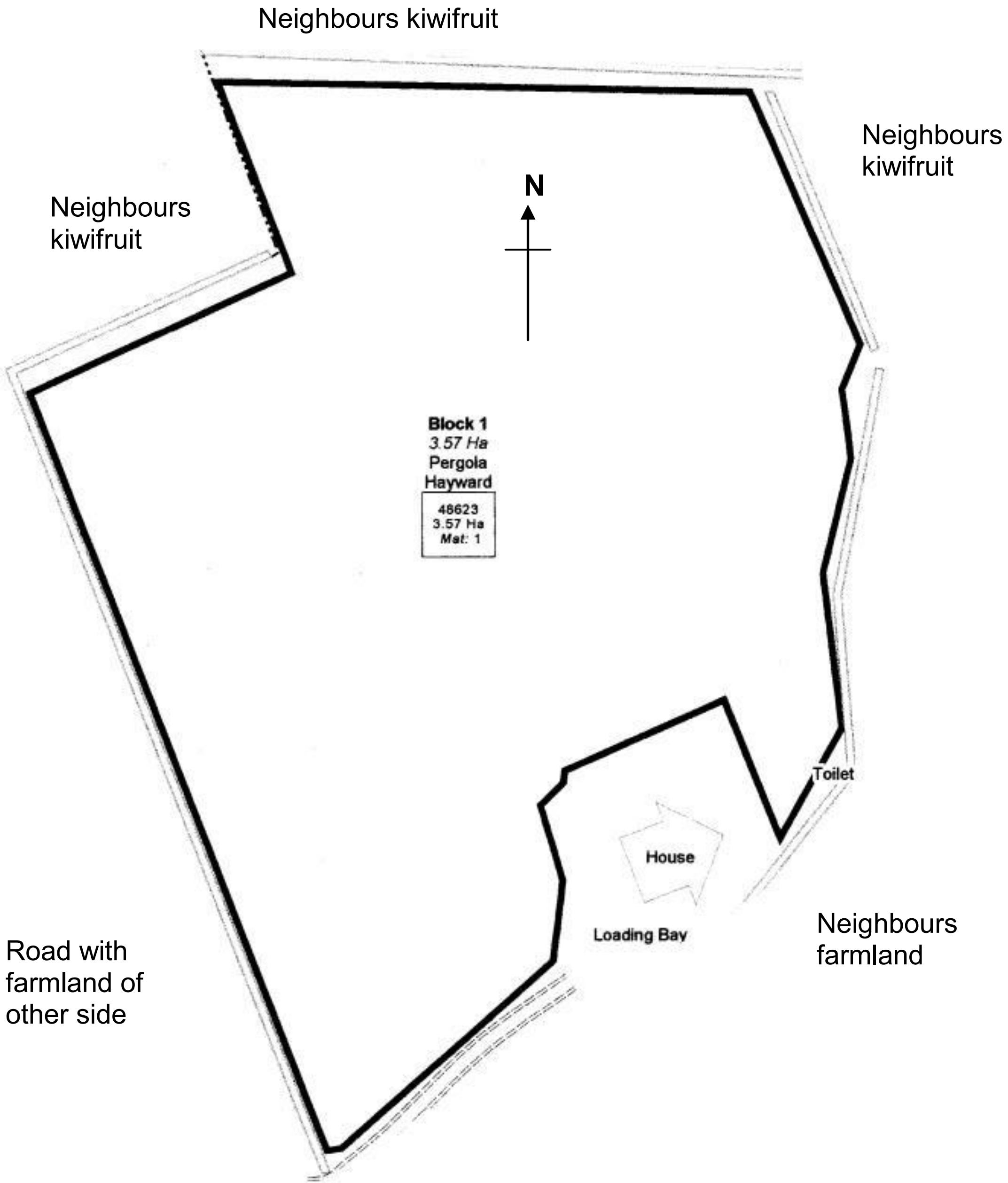
		TBAS			TBUS			CBAS			CBUS		
Orchard	Date	Live scale	Dead scale	Total scale	Live scale	Dead scale	Total scale	Live scale	Dead scale	Total scale	Live scale	Dead scale	Total scale
D	27/12/2002	76	0	76	34	0	34	50	0	50	14	0	14
(Organic)	21/01/2003	28	3	31	12	3	15	9	2	11	9	3	12
	11/02/2003	37	5	42	15	4	19	22	2	24	8	0	8
	8/03/2003	39	17	56	13	4	17	37	13	50	23	9	32
	31/03/2003	52	24	76	26	3	29	57	27	84	21	15	36
	25/04/2003	75	29	104	25	9	34	45	24	69	12	6	18
	26/05/2003	70	15	85	25	21	46	59	30	89	20	13	33
E	27/12/2002	44	28	72				37	27	64			
(KiwiGreen)	21/01/2003	35	10	45				60	16	76			
	11/02/2003	43	25	68				41	30	71			
	8/03/2003	32	14	46				70	29	99			
	31/03/2003	26	32	58				54	33	87			
	25/04/2003	12	23	35				37	65	102			
	26/05/2003	13	21	34				45	48	93			

- TBAS = treatment block affected by shelter
- TBUS = treatment block unaffected by shelter
- CBAS = control block affected by shelter
- CBUS = control block unaffected by shelter

Appendix F: FRW research property maps

Properties that were also part of the scale research trial will not appear again here (Growers ‘A’ & ‘B’), they can been seen in Appendix C, pg 98 & 99.

Orchard ‘F’

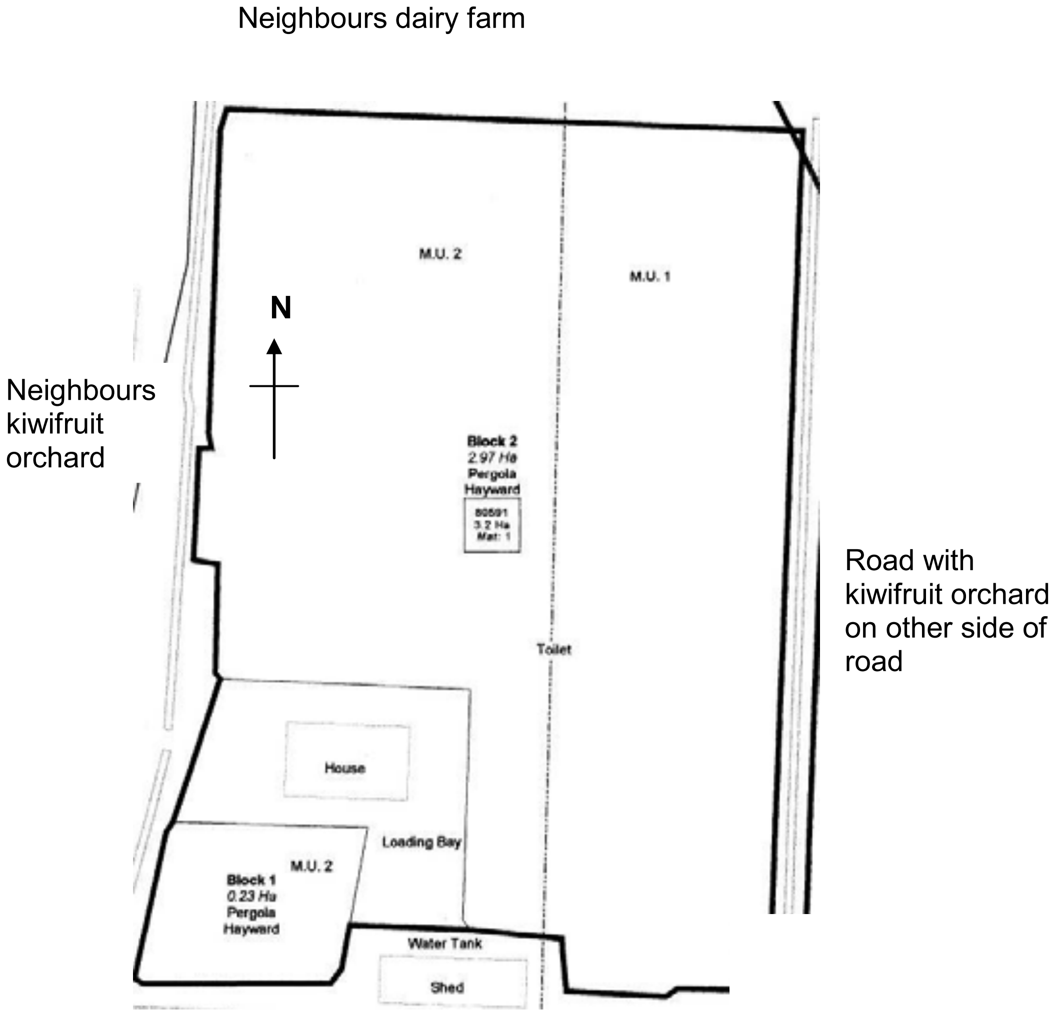


Left side of block used in trial.

All external shelter trees 6m+ *Cryptomeria japonica*.

Map supplied courtesy of Seeka Kiwifruit Industries Ltd.

Orchard 'G'

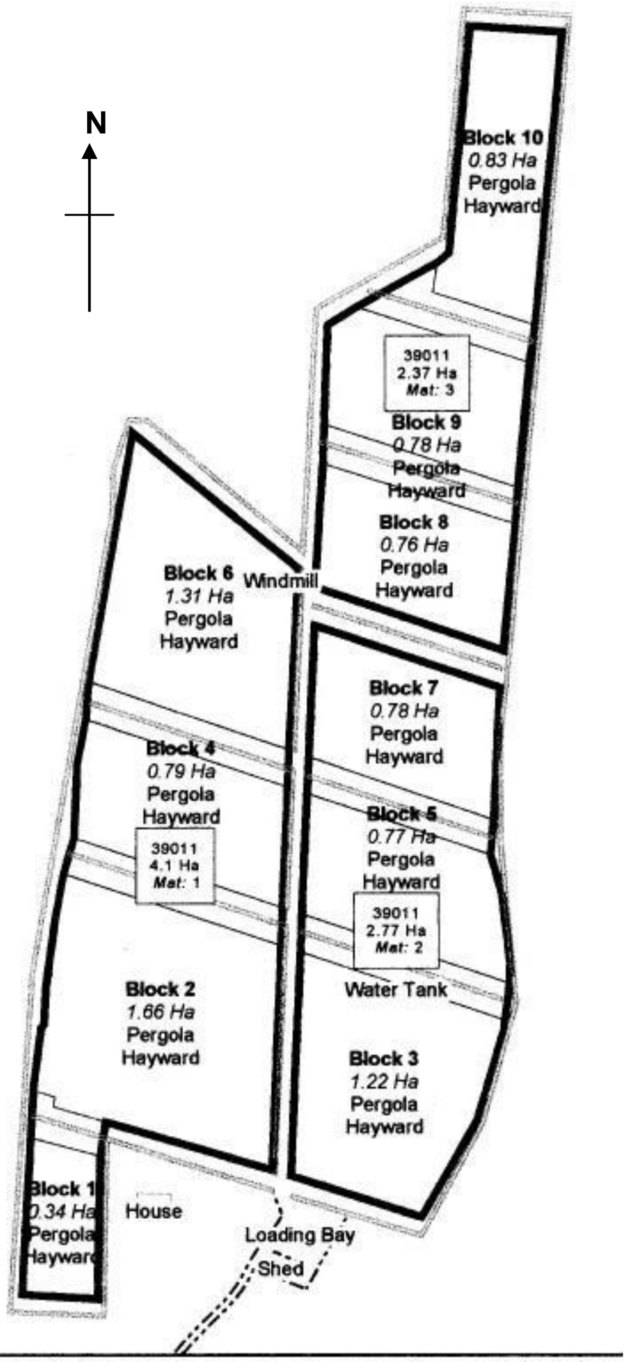


M.U. 1 of Block 2 was used in the trial

Block has been divided into two maturity units for harvesting purposes, M.U.1 and M.U.2. The block is one large pergola canopy with 4-5m *Casuarina spp* trees as external shelter.

Map supplied courtesy of Seeka Kiwifruit Industries Ltd.

Orchard 'H'

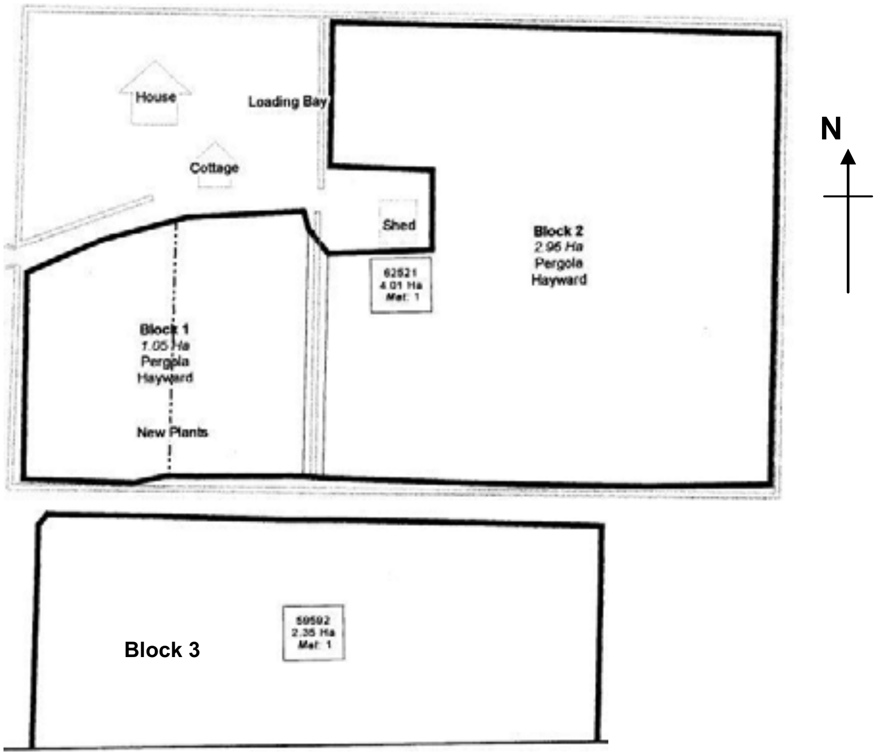


Block 3 used in trial.

The block is surrounded by dairy farms. The external and internal shelter consists of a mixture of *Casuarina spp, Cryptomeria japonica and Salix spp* (willow) trees, all 4-6m in height.

Map supplied courtesy of Seeka Kiwifruit Industries Ltd.

Orchard 'I'



Block 1 treatment block and Block 3 control block in trial.

There is a road on the W side of property with farmland on the other side of road, with farmland on the N and E sides of orchard. At the S side (Block 3) is another organic kiwifruit orchard. Shelter consists of *Cryptomeria japonica* trees all around the block, and between blocks 1,2 and 3. Blocks 1 and 2 are one property, with block 3 being part of the neighbours organic orchard.

Map supplied courtesy of Seeka Kiwifruit Industries Ltd.

Appendix G: FRW monitoring results

Orchard	Date	Treated Blocks		Control Blocks	
		Adults	Egg masses	Adults	Egg masses
‘A’	4\12\2002	0	0	0	0
(Organic)	27/12/2002	0	0	0	0
	21/01/2003	0	0	0	0
	11/02/2003	0	0	0	0
	8/03/2003	0	0	0	0
	31/03/2003	1	0	7	5
	25/04/2003	5	3	4	20
	26/05/2003	4	4	2	29
	21/06/2003	0	4	0	45
‘F’	4\12\2002	0	0	0	0
(Organic)	27/12/2002	0	0	0	0
	21/01/2003	0	0	0	0
	11/02/2003	0	0	0	0
	8/03/2003	0	0	0	0
	31/03/2003	1	0	1	1
	25/04/2003	0	0	0	4
	26/05/2003	1	2	2	9
	21/06/2003	0	2	0	11
‘H’	4\12\2002	0	0	0	0
(KiwiGreen)	27/12/2002	0	0	0	0
	21/01/2003	0	0	0	0
	11/02/2003	0	0	0	0
	8/03/2003	0	0	1	0
	31/03/2003	0	0	0	0
	25/04/2003	0	0	0	0
	26/05/2003	0	0	0	0
	21/06/2003	0	0	0	0

Orchard	Date	Treated Blocks		Control Blocks	
		Adults	Egg masses	Adults	Egg masses
‘B’	4\12\2002	0	0	0	0
(Organic)	27/12/2002	0	0	0	0
	21/01/2003	0	0	0	0
	11/02/2003	0	0	0	0
	8/03/2003	0	0	0	0
	31/03/2003	0	0	0	0
	25/04/2003	0	0	0	0
	26/05/2003	0	0	0	0
	21/06/2003	0	0	0	0
‘G’	4\12\2002	0	0	0	0
(KiwiGreen)	27/12/2002	0	0	0	0
	21/01/2003	0	0	0	0
	11/02/2003	0	0	0	0
	8/03/2003	0	0	0	0
	31/03/2003	0	0	0	0
	25/04/2003	0	0	0	0
	26/05/2003	0	0	0	0
	21/06/2003	0	0	0	0
‘I’	4\12\2002	0	0	0	0
(Organic)	27/12/2002	0	0	0	0
	21/01/2003	0	0	0	0
	11/02/2003	0	0	0	0
	8/03/2003	0	0	0	0
	31/03/2003	4	0	0	0
	25/04/2003	0	0	0	0
	26/05/2003	0	0	0	0
	21/06/2003	0	0	0	0