A pest and disease survey of buttercup squash: towards the development of an IPM programme

A report prepared for the
New Zealand Buttercup Squash Council

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1 EXECUTIVE SUMMARY

An initial survey of the pests and diseases of buttercup squash was carried out in ten crops (five in Hawke's Bay, two each in Gisborne and Pukekohe), to study the feasibility of developing an IPM programme for buttercup squash.

IPM programmes integrate biological, cultural and chemical control methods to maintain pest populations at non-damaging levels. The programmes use spray thresholds to time pesticide applications to periods when crop monitoring indicates that a pest population is at levels where the crop will suffer economic damage. IPM programmes reduce pesticide use, improve quality of yield, improve market image, lessen environmental risk and minimise sprayer operator exposure to pesticides.

The ten crops were inspected weekly or monthly for pests and diseases. Pitfall traps and greasy cutworm pheromone traps were run in some crops. Crop inspections ran from late November until the harvest of each crop.

Three aphid species were found to reside in the buttercup squash crops: melon aphid (*Aphis gossypii*), green peach aphid (*Myzus persicae*) and potato aphid (*Macrosiphum euphorbiae*). Aphid populations were higher in two of the Hawke's Bay crops around Lawn Rd, than in the other three crops in the Maraekakaho area. The association of severity of the aphid infestations and time (date of inspection) were significant ($P<0.05$) for the two Lawn Rd crops but not for the Maraekakaho crops.

Only small aphid populations were recorded in the Gisborne and Pukekohe crops.

Onion thrips (*Thrips tabaci*) was common on the foliage of the three Maraekakaho crops and there was a significant association between severity of infestation and time (date of inspection) for two of these crops. Thrips were rarely found in the two Lawn Rd crops. A late thrips infestation was noted in one of the two Gisborne crops.

New Zealand flower thrips (*Thrips obscuratus*) was occasionally found in buttercup squash flowers, particularly in male flowers protruding through the foliage. This thrips was not considered to be a serious pest.

Zucchini Yellow Mosaic Virus (ZYMV) was recorded in four of the five Hawke's Bay crops. The infestation ranged from 5% to 20-25% and did not appear to be related to the infestation of the three aphid species in the crops. A further five aphid

species, that are not pests of buttercup squash, are known to be vectors of ZYMV. Research is needed to understand the epidemiology of this virus and to develop integrated control strategies.

Powdery mildew appeared late in the growth of most crops (mid to late January). Severity varied from no powdery mildew being recorded to most leaves being severely infested. A forecasting system could be developed to time the application of both protectant and systemic fungicides to periods when buttercup squash is most at risk.

Springtail infestations were sprayed in the two Pukekohe crops and an isolated greasy cutworm problem was noted in one of the Hawke's Bay crops. Otherwise no serious seedling pest problems occurred. Grass grub beetle damage to leaves of buttercup squash was quite common early in the growth of the crops, but not at severe levels.

A wireworm larva and a weevil larva were found under squash fruit. Two-spotted spider mites were at moderate levels in one Hawke's Bay crop at harvest. Whitefly severely infested one Pukekohe crop in which harvesting had been delayed and tomato fruitworm larvae were common, particularly in male flowers protruding through the canopy.

The pitfall traps caught a range of invertebrates, some of which were pests of buttercup squash; others were beneficial natural enemies, and the rest were of little or no consequence to buttercup squash.

The pheromone traps failed to catch any greasy cutworm moths. This was probably because the lure was not the correct chemical or blend of chemicals for this purpose.

Pest management in buttercup squash would benefit immensely from the development of an IPM programme. Populations of pests and diseases could be monitored through crop scouting, and pest management decisions made from the information gathered. Identified pest problems would be controlled with the most suitable pesticide.

It is recommended that the New Zealand Buttercup Squash Council proceed with the development of an IPM programme for buttercup squash. Because there is a wide range of buttercup squash pests and diseases, they should be ranked in order of importance and IPM strategies developed for each one. The following ranking is suggested: ZYMV and the aphid vectors, powdery mildew, greasy cutworm, other seedling pests, other pests. The strategies should be incorporated into a Buttercup Squash IPM Programme as each is developed.

2 INTRODUCTION

Buttercup squash is New Zealand's third largest horticultural export earner with annual exports worth $70 million. While buttercup squash is grown from Northland to Canterbury, the majority of the crop is grown in Hawke's Bay, Poverty Bay and Manawatu.

Over 90% of the buttercup squash exported goes to the Japanese market. Surveys of Japanese consumers indicate that one of their major concerns when buying kabocha (Japanese for buttercup squash) is the use of chemicals pre and post harvest.

The pests and diseases of buttercup squash and the damage they inflict have been described in detail by King & Wishart (1991). Some aspects of the relationship between the pests and buttercup squash host are noted and the reference gives some advice on the timing of pesticide applications.

The pesticides that may be used on export buttercup squash crops are listed in the Export Spray Diary which is produced annually by the NZ Buttercup Squash Council. For the 1994/95 season 4 insecticides, 16 fungicides and a molluscicide are listed. There are restrictions on when many of the listed pesticides may be used on the crops and the NZ Buttercup Squash Council conducts random residue testing to ensure that only the permitted pesticides were used and that the correct withholding periods were observed.

The current recommendations on when to apply pesticides to buttercup squash crops are vague. There is a lack of information indicating when a pest is likely to be a problem and there are no spray thresholds to help growers time their pesticide applications to when they are needed. An Integrated Pest Management (IPM) programme could overcome these deficiencies.

IPM programmes use spray thresholds to time pesticide applications to periods when crop monitoring indicates that a pest population is at a high enough level to cause economic damage to a crop. IPM programmes have been shown to reduce pesticide use by determining the most effective time to apply the pesticide; better pest control also improves quality of yield. Other indirect benefits of IPM programmes include improved market image, less environmental risk and reduced sprayer operator exposure to pesticides (Beck 1991; Beck *et al* 1992; Herman & Cameron 1993). IPM programmes also use biological and cultural methods to help control pest populations and reduce pesticide use.

An initial survey of the pests and diseases of buttercup squash was proposed to study the feasibility of developing an IPM programme for buttercup squash.

3 METHODS

The survey centred on weekly crop inspections in five buttercup squash crops in Hawke's Bay. Three crops were managed by Mike Glazebrook on Te Tua Station, Maraekakaho: "River", "Road" and "Gum", planted 14 October, 28 October and 11 November, respectively. These crops were in an organic farming system. Two crops were managed by David Whitfield, Mill Rd: "Mill" and "Lawn", planted 20 October and 28 October, respectively. These two crops were managed conventionally.

The weekly crop inspections began in late November, at growth stages ranging from small seedlings to 4-5 true leaves. At each inspection 20 plants were examined for the presence of, and the signs and symptoms of, pests and diseases (8-10 leaves/plant, 2-3 fruit and flowers when present). The number of leaves infested and the severity of each infestation (sparse, low, moderate, heavy, severe) were recorded. Crop inspections were not done in the weeks of 30 November, 29 December and 26 January because the scout was out of the Hawke's Bay district. The inspections continued until harvest.

Two crops in Gisborne were inspected once a month. The crops, "Gordons 1" and "Hyland Shirley", were grown by Cedenco Foods and were planted on 19 October and 31 October, respectively. The final inspection of Hyland Shirley was incomplete due to time constraints.

Two crops in Pukekohe were also inspected once a month. The crops were part of the squash breeding programme run by Doug Grant on the Crop & Food Research station at Pukekohe. Both crops were sprayed with an insecticide just prior to the first inspection in November. Bad weather prevented the completion of the second inspection in early January. The third inspection, in late January, was completed.

The latter four crops were all managed conventionally.

The "River" and "Lawn" crops, in Hawke's Bay, each had two pitfall traps set up amongst the buttercup squash plants. These traps are dug into the ground with their rims at soil level and are designed to catch invertebrates moving around the crop. The traps were emptied weekly and the specimens caught were sorted, counted and identified in the lab. Because the traps occasionally dried out or were flooded by rain or irrigation the data were used as indicative information only.

Pheromone traps baited with a commercial lure for greasy cutworm (*Agrotis ipsilon*) were set up in all fields in late November or early December. Most of the traps were dismantled about two weeks later because they failed to catch any greasy cutworm moths.

The data collected were collated on a Quattro Pro spread sheet and analysed using a Chi-square analysis in Minitab. The number of infested leaves per plant in each category of severity was tested for association with time (date of inspection). Severity categories with no records were omitted from the analysis. Where there were only single records in a category, the data were merged into the data of the adjacent category before analysis. Chi-square contingency tables can not have zeroes as data, so tables containing zeroes had each record increased by one to remove the zeroes.

4 RESULTS

4.1 Aphids

Three species of aphid were found in the buttercup squash crops: melon aphid (*Aphis gossypii* Glover), green peach aphid (*Myzus persicae* (Sulzer)) and potato aphid (*Macrosiphum euphorbiae* (Thomas)). These three aphid species are common pests of horticultural crops and could become a serious pest of buttercup squash crops.

4.1.1 Hawke's Bay

There was a distinct difference in the aphid populations of the crops at Maraekakaho and those at Lawn Rd (Fig 1). The Maraekaho crops had low aphid populations with an average of less than 0.5 aphid infested leaves per plant; the Lawn Road crops had a peak of 2 aphid infested leaves per plant. None of the aphid colonies found in the Maraekakaho crops fell into the heavy or severe category of infestation. Chi-square analyses were not significant for the three Maraekakaho crops but were significant ($P<0.05$) for the two Lawn Rd crops.

River (Fig 2) There were a few small aphid colonies in this crop during November and early December. A few low aphid infested leaves were observed in late December crop inspections, but no aphids were recorded in the last two crop inspections before harvest.

Road (Fig 3) The aphid population in this crop started off in a similar manner to that in the River crop, i.e., a few small colonies. Later in the crop there were a number of low aphid infested leaves and moderate aphid infested leaves. These colonies persisted up to harvest.

Gum (Fig 4) Of the three Maraekakaho crops, this crop had the largest aphid population. Early in the crop there was a moderate aphid infested leaf and low and sparse sized aphid infested leaves were common right through to harvest.

Mill (Fig 5) Heavy and severe aphid infested leaves were found in this crop. These did not persist. High numbers of sparse and low aphid infested leaves were present throughout the growth of the crop.

Lawn (Fig 6) There were high numbers of sparse and low aphid infested leaves from the first crop inspection in this crop. Moderate and high aphid infested leaves were also relatively common through December. The

number of aphid infested leaves dropped away in January and rose again, briefly, in early February.

4.1.2 Gisborne

The aphid populations in the two buttercup squash crops were relatively small.

Hyland (Fig 7) — From very few leaves with sparse and low aphid infestations in late November, the aphid population developed to the extent that there were a few leaves with heavy infestations. The mid-January crop inspection was not completed; however, there were not many aphid infested leaves found.

Gordon (Fig 8) — The late November crop inspection recorded a small number of leaves with low or moderate aphid infestations. In mid-December more aphid infested leaves were found but these were in the sparse and low severity categories. A couple of leaves with sparse aphid infestations were found in the mid-January crop inspection.

4.1.3 Pukekohe

The data from the one complete crop inspection (24 January) in the two crops at the Pukekohe Research Station are not presented. A few sparse and low aphid infested leaves were found in each crop.

4.1.4 Zucchini Yellow Mosaic Virus (ZYMV)

The three crops at Maraekakaho were all infested with ZYMV. John Fletcher assessed these crops as being 20-25% infested. Of the two Lawn Rd crops, Mill had no ZYMV, while Lawn was 5% infested (John Fletcher's assessment). All three of the aphid species collected from buttercup squash crops are vectors of ZYMV.

4.2 Thrips

Two species of thrips were commonly found in the squash crops: onion thrips (*Thrips tabaci* Lindeman) was on the leaves and New Zealand flower thrips (*Thrips obscuratus* (Crawford)) was sometimes found in the flowers, particularly the male flowers protruding through the crop canopy.

4.2.1 Hawke's Bay

There was a distinct difference between the thrips populations in the three Maraekakaho crops and the two Lawn Rd crops (Fig 9). The former had large thrips populations and the latter low populations, the reverse situation to that noted with aphid populations (Fig 1). Chi-square analyses were significant ($P<0.05$) for River

and Gum crops and not significant for Road crop. Insufficient numbers of thrips were recorded from the two Lawn Rd crops for Chi-square analysis.

River (Fig 10) — A few sparse thrips infested leaves were recorded during crop inspections in December. The thrips population developed from this to have moderate to high numbers of low thrips infested leaves at the January crop inspections as well as a few moderate and heavy thrips infested leaves.

Road (Fig 11) — There was an established thrips population present throughout the growth of this crop. The thrips infested leaves were mainly in the sparse and low categories, with a smattering of moderate, heavy and severe thrips infested leaves through January and up to harvest in February.

Gum (Fig 12) — The thrips infestation in this crop was similar to that in Road. Thrips infested leaves were primarily in the low category with some occasional leaves being moderately, heavily or severely infested with thrips during January and February.

Mill (Fig 13) and Lawn (Fig 14) — Very few thrips were recorded in these two crops

4.2.2 *Gisborne*

Hyland — No thrips were recorded in the late November or mid-December crop inspections. An observation from the incomplete crop inspection in mid-January noted that thrips infested leaves were common (data not presented).

Gordons (Fig 15) — No thrips were recorded in the first two crop inspections in this crop (late November and mid-December). The mid-January crop inspection frequently found leaves that were sparsely to heavily infested with thrips.

4.2.3 *Pukekohe*

The data from the one complete crop inspection (24 January) in the two crops at the Pukekohe Research Station are not presented. Thrips infested leaves were very rarely found in these two crops.

4.3 Powdery mildew

4.3.1 *Hawke's Bay*

Once again there were obvious differences between the powdery mildew infestations in the three Maraekakaho crops and the two Lawn Rd crops (Fig 16). The powdery mildew infestation started earlier and reached a higher level in the Lawn Road crops and was less of a problem in the Maraekakaho crops.

River No powdery mildew infested leaves were recorded in this crop

Road (Fig 17) Powdery mildew appeared in this crop in February within two weeks of harvest. Only sparsely infested leaves were found.

Gum (Fig 18) As with the previous crop, powdery mildew was not recorded until the February crop inspections. With the longer time to harvest, the infestation was able to develop further and leaves with low powdery mildew infestations predominated in the sample.

Mill (Fig 19) Powdery mildew was only recorded in this crop once, in mid-January immediately before harvest. The infestation appeared to develop rapidly from no observations of powdery mildew the week before to an abundance of low to severely infested leaves.

Lawn (Fig 20) This crop had the worst powdery mildew problem of the nine buttercup squash crops inspected in this survey. Powdery mildew infested leaves were first recorded in mid-January and by the last crop inspection in early February, were severely infested.

4.3.2 *Gisborne*

No powdery mildew infested leaves were found during the first two crop inspections in either of the two Gisborne buttercup squash crops. One sparsely infested leaf was found in Gordons in the mid-January crop inspection and a large infestation was noted in Hyland in an incomplete crop inspection in mid-January (data not presented)

4.3.3 *Pukekohe*

Powdery mildew proved to be the major pest problem in the two crops at Pukekohe. The complete crop inspection on 24 January recorded that there was an overall mean of 2.75 infested leaves/plants. The infestation was mostly of low to moderate severity, but there were some leaves with heavy and severe levels of powdery mildew (data not presented).

4.4 Others pests

A range of other invertebrate pests, or the damage they caused, was recorded in the buttercup squash crop inspections (Table 1). Of the pests listed, springtail in the two Pukekohe crops was the only pest of the young buttercup squash considered to be serious enough to warrant a pesticide application (it is not known if any of the crops had an insecticide included at sowing). Other pests recorded, which are potentially serious pests of young buttercup squash crops, included red-legged earth mites, grass grubs (beetle damage to leaves), cutworms, wireworm and weevil larvae (found under fruit).

Tomato fruitworm larva were common in later crop inspections. They were generally found in male flowers protruding through the foliage. One tomato fruitworm larva was found borrowing into a small buttercup squash fruit.

A considerable population of two-spotted spider mite had developed in the Lawn crop by harvest, but it did not appear to affect the yield of the crop.

Substantial whitefly colonies were observed in the early Pukekohe crop. This pest could have caused a reduction in yield quality through sooty mould establishing in the honey dew deposited by the whitefly on the buttercup squash fruit.

4.5 Pitfall traps

A range of invertebrates were caught in the six pitfall traps that were set up in three buttercup squash crops (Table 2). Those that were of importance to buttercup squash as a pest or beneficial insect are listed by their common names where possible. Invertebrates that were of no known importance to buttercup squash were not identified past the "order" level, e.g., other beetles (Coleoptera order). Insects such as parasitic wasps (Hymenoptera) were not identified to the species level due to the difficulty involved.

The majority of the invertebrates caught can be classed as either beneficial or of no consequence to buttercup squash. Spiders are predators of small invertebrates as are the staphylinid beetles, or rove beetles, and centipedes. Syrphid flies or hover flies,

11-spotted ladybirds, lacewings and nabids are predators of aphids and other small insects. Many of the Hymenoptera (wasps) trapped may be parasites of the aphids.

Collembola were frequently caught in the pitfall traps but the data are not presented here. Many Collembola found on the soil surface feed on soil-inhabiting micro-organisms. Other Collembola include the springtails that are a pest of buttercup squash seedlings but this type was less frequently caught in the traps.

4.6 Pheromone traps

The data from the pheromone traps are not presented because the lure supplied failed to attract any greasy cutworm moths. Two other moth species, *Chrysodeixis eriosoma* (green looper caterpillar) and *Mythimna loreyimima*, a species endemic to New Zealand, were caught in the traps.

5 DISCUSSION

Aphids, thrips and powdery mildew and, to a lesser extent, springtails and ZYMV, were the main pests of the buttercup squash crops that were inspected in this survey. Could they have been controlled more effectively? Did the infestations need to be controlled?

For the aphids and thrips it is hard to determine how effective control was. There were numerous ladybirds, hoverflies and other natural enemies in the crops during the season, which must have had some impact on the population. Without defined thresholds of infestation levels it is hard to determine if insecticides were required. The population levels of aphids and thrips, observed in this survey, did not appear to cause any significant reduction in yield.

The Chi-square analysis showed that, for most of the crops, the severity of the aphid and thrips infestations was not associated with time (date of inspection). This suggests that infestations can not be reliably predicted in relation to time of season. Therefore crop monitoring is needed to compile pest population information for efficient pest management.

ZYMV was worst in the crops that had relatively low aphid populations (Maraekakaho crops). No ZYMV was found in Mill where there had been a relatively high aphid infestation. This shows that regular insecticide applications for control of the aphid vectors of ZYMV is not necessarily going to control the problem. Perring *et al.* (1992) reported that ZYMV aphid vectors could transmit the virus in less than 15 seconds and that insecticides would not kill the aphids within this time.

Perring *et al.* (1992) lists ten aphid species that are known vectors of ZYMV. Cucurbits are host plants for only a few of these species. The remainder are transients that can transmit the virus as they pass across a crop. At least eight of the ten aphid species listed by Perring are present in New Zealand. This survey has identified three aphid species that use buttercup squash as a host; the other five aphid species that are vectors of ZYMV in New Zealand are transients. (A report to the Council by Fletcher and Jermyn outlines research strategies for ZYMV.)

Cool, damp weather is conducive to powdery mildew epidemics (Cheah, pers comm). Powdery mildew appeared in the Hawke's Bay crops 10 to 14 days after a cool wet spell was recorded at nearby Hort Research meterological stations. Periods favourable to the development of powdery mildew epidemics could be predicted using disease forecasting techniques. Control strategies, such as preventative and curative fungicide applications, could then be targeted to these periods.

Many of the other pests noted in the crop inspections were potentially serious pests of young buttercup squash crops. Of those listed, only the springtail populations in the two Pukekohe crops required an insecticide application. The cutworm damage appeared worse than it was because it was concentrated in a small area at one end of the crop where the damage was estimated at 5%. Because the crop was managed organically no insecticide was sprayed to control this pest.

The large population of two-spotted spider mite which was present late in the growth of the Lawn crop did not have any noticeable impact on the yield. However, it may have posed a contamination problem at harvest and could become a serious pest if the next crop planted in that field is a host of two-spotted spider mite.

The whitefly population in the Pukekohe 1 crop did not noticeably affect yield. Harvest was delayed in this crop and this allowed a larger whitefly population to develop. Whitefly produce honey dew that would have been deposited on the surface of the buttercup squash fruit. The honey dew is a substrate for black sooty mould to grow on and this may have lowered the quality of the harvest.

As well as being a potential pest problem for the next crop, whitefly are more mobile than two-spotted spider mite and could migrate out of the deteriorating buttercup squash crop after harvest and infest other nearby host crops.

The pitfall traps give an indication of the invertebrate fauna present in the buttercup squash crops. In general, the traps captured a reasonable range of the natural enemies of the pests that can damage buttercup squash crops. An IPM programme would take advantage of the benefits of this potential biological control. Pesticides would be used more efficiently because a pest would only be sprayed when it was no longer being controlled biologically and selective pesticides would be used where possible.

The pheromone traps set up to capture male greasy cutworm moths failed completely. No greasy cutworms were caught in any of the traps in the three regions. This was probably due to the pheromone lure which was produced in the United Kingdom. New Zealand, Australia and Papua New Guinea have a different sub-species of the greasy cutworm to that found in Europe and the sex pheromone that the females use to attract males probably differs.

Regardless of this result, IPM strategies for greasy cutworm control could be developed for this pest. With the correct pheromone, pheromone traps and crop scouting could be used to time pesticide applications to avoid the considerable losses that this pest can cause. Because greasy cutworm is a pest in a wide range of vegetable crops, a cooperative IPM programme for greasy cutworm could be developed.

Pest management in buttercup squash is complicated by the wide range of pests and diseases that could cause serious problems in this crop. For this reason, pest management in buttercup squash would benefit immensely from the development of an IPM programme. The crops would only be sprayed if a pest population identified as a potential cause of damage, exceeded a defined threshold level. The most appropriate pesticide would then be selected to control that pest. This would lead to more efficient pest control through encouraging biological control methods and using cultural control methods to reduce the need for pesticide applications.

6 RECOMMENDATIONS

It is recommended that the New Zealand Buttercup Squash Council proceed with the development of an IPM programme for buttercup squash. Currently, pest management in buttercup squash is on a calendar spray basis. If growers do monitor their crops, they use 'gut feeling' rather than scientifically defined spray thresholds to determine when to spray a pest population.

The wide range of buttercup squash pests and diseases should be ranked in order of importance and IPM strategies developed sequentially for each one. The strategies should be incorporated into a Buttercup Squash IPM Programme as each is developed. The programme would include the most appropriate response to a particular pest or disease problem, i.e., one that would maximise the impact of control on the particular pest or disease and have minimal impact on other fauna in the crop, thereby minimising the disruption of biological controls.

The following ranking of pest importance is suggested: ZYMV and the aphid vectors, powdery mildew, greasy cutworm, other seedling pests, other pests.

ZYMV is currently the major pest problem facing the industry. Research into the control of ZYMV should be broad based and include studies on disease epidemiology, vaccination with weak ZYMV strains, breeding of resistant cultivars, and control of the aphid vectors (biological and cultural control, improved chemical control and spray thresholds). Efforts to restrict the spread of the virus from Hawke's Bay to other regions should be associated with this research.

A disease forecasting system for powdery mildew should be developed after IPM strategies for ZYMV have been defined and implemented.

The IPM strategies for greasy cutworm should be produced in collaboration with other companies in the vegetable industry as it is also a pest of other vegetable crops.

As the programme evolves it should be broadened to include seedling pests and other pests.

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9 APPENDIX I - TABLES AND FIGURES

Table 1: Other invertebrate pests observed in buttercup squash crop inspections

Date	Hawke's Bay				
	River	Road	Gum	Mill	Lawn
23.11	10x dark mite 2x red (predatory) mite	1x leaf roller 2x dark mites	-		
24.11				-	-
8.12	2x grass grub	3x grass grub 6x springtail 1x weevil larvae	1x grass grub 1x springtail	1x grass grub	5x grass grub
14.12				3x grass grub	11x grass grub
15.12	2x grass grub	4x grass grub	-		
22.12	-	cutworm damage, at one end	-	-	6x grass grub 1x springtail
5.1	2x grass grub 1x flower rot	1x springtail	-	-	1x twospotted spider mite
12.1	1x wireworm larvae	-	-	-	-
19.1	2x tomato fruitworm	-	-	-	-
2.2		1x tomato fruitworm	-		4x twospotted spider mite
8.2		5x tomato fruitworm	4x tomato fruitworm 1x wireworm larvae		17x twospotted spider mite
16.2			1x whitefly colony 1x tomato fruitworm		

Date	Gisborne		Date	Pukekohe	
	Hyland	Gordon		Pukekohe 1	Pukekohe 2
25.11	2x springtail 5x grass grub	-	28.11	damaged by: grass grub springtail	springtail damage
19.12	1x whitefly	6x grass grub 1x springtail 1x leaf hopper	3.1	-	-
17.1	-	1x leaf rust 1x red mite	24.1	1x psyllid 1x tomato fruitworm 1x looper 1x rotten fruit	-
			16.3	whitefly and aphid abundant	-

Table 2: Invertebrates caught in pitfall traps in three buttercup squash crops

Date	River	Road	Lawn
22.12.94		3 spiders	12 spiders
		6 hemiptera	1 grass grub beetle
		3 hymenoptera	3 11-spotted ladybirds
		2 11-spotted ladybirds	6 Staphylinids
		3 other beetles	1 aphid
		10 syrphids	6 other flies
		6 other flies	1 honey bee
		1 thrips	20 wheat bugs
		14 mites	
5.1.95	5 spiders	6 spiders	24 aphids
	7 11-spotted ladybirds	11 11-spotted ladybirds	2 spiders
	1 wireworm beetle	9 other beetles	1 grass grub beetle
	7 other beetles	16 other flies	1 wireworm beetle
	18 wheat bugs	2 wheat bugs	1 other flies
	1 syrphid	10 aphids	1 hymenoptera
	4 other flies	1 hymenoptera	3 moths
	1 nabid	1 centipede	1 hemiptera
	3 aphids		
12.1.95	2 crickets		
	11 spiders		
	7 wheat bugs		
	1 hemiptera		
	8 11-spotted ladybirds		
	1 wireworm beetle		
	1 staphylinid		
	13 other flies		
19.1.95	2 spiders	11 spiders	1 11-spotted ladybirds
	2 other flies	14 11-spotted ladybirds	7 staphylinids
	1 moth	2 staphylinids	2 other beetles
	5 11-spotted ladybirds	1 other beetles	1 wheat bug
	4 wireworm beetles	1 hemiptera	1 mirid
	4 Tasmanian grass grub beetles	9 wheat bugs	1 cricket
	7 wheat bugs	4 hymenoptera	9 other flies
		12 other flies	7 thrips
		3 thrips	8 aphids
			2 hymenoptera
2.2.95	9 spiders		
	39 Tasmanian grass grub beetles		
	58 other flies		
	5 11-spotted ladybirds		
	1 lacewing		
	1 thrips		
	1 aphid		
	4 staphylinids		
	4 other beetles		
	6 wheat bugs		
	1 hemiptera		
	1 nabid		

Date	River	Road	Lawn
3.2.95		17 spiders	
		2 Tasmanian grass grub beetles	
		1 wireworm beetle	
		2 other beetles	
		27 11-spotted ladybirds	
		8 wheat bugs	
		15 other flies	
		2 hymenoptera	
		2 aphids	
		8 thrips	
		2 nabids	
		1 Heliothis larvae	
		1 centipede	
8.2.95		14 spiders	2 spiders
		1 11-spotted ladybird	21 other flies
		2 nabids	3 stapylinids
		2 other beetles	1 other beetles
		1 hemiptera	3 hymenoptera
		6 other flies	1 Heliothis larvae
		5 hymenoptera	1 hemiptera
		4 thrips	9 aphids
		1 mite	1 thrips
15.2.95			7 spiders
			5 other flies
			3 other beetles
			1 hemiptera
			1 lacewing larvae
			1 caterpillar
16.2.95		6 spiders	
		1 nabid	
		3 hemiptera	
		1 other beetles	
		2 hymenoptera	
		6 other flies	
		1 moth	
		1 centipede	

Fig 1: Aphids on HB squash

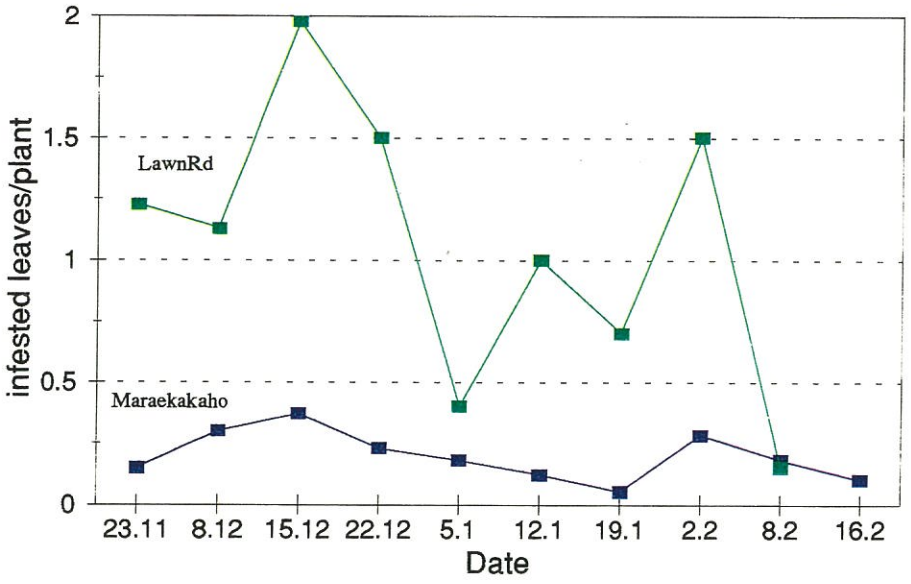

Fig 2: Aphid infestation in "River"

Maraekakaho, Hawke's Bay

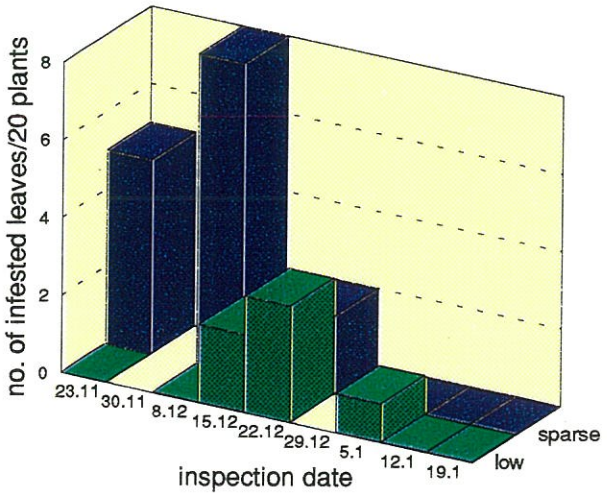

Fig 3: Aphid infestation in "Road"

Maraekakaho, Hawke's Bay

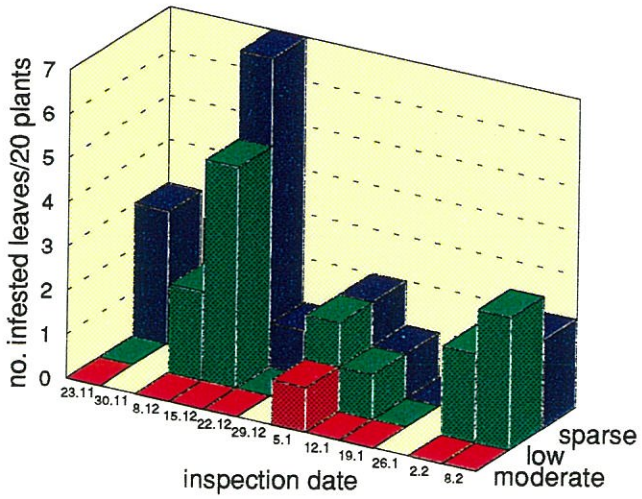

Fig 4: Aphid infestation in "Gum"

Maraekakaho, Hawke's Bay

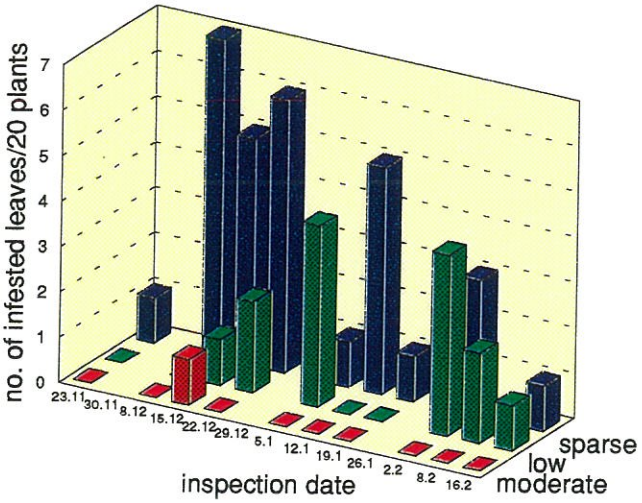

Fig 5: Aphid infestation in "Mill"

Lawn Rd, Hawke's Bay

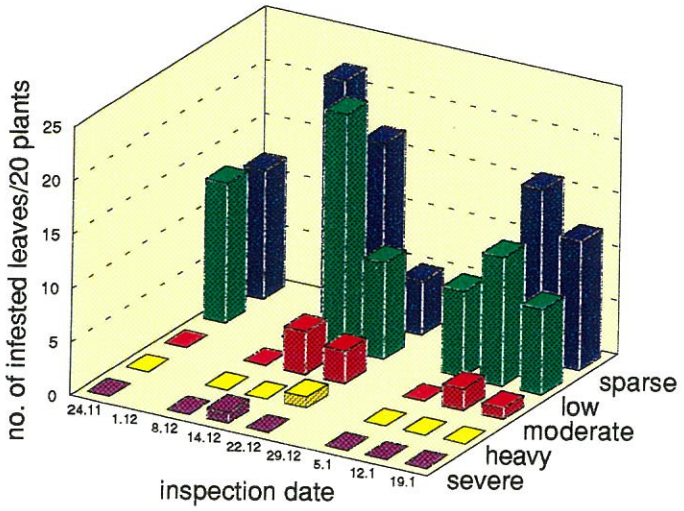

Fig 6: Aphid infestation in "Lawn"

Lawn Rd, Hawke's Bay

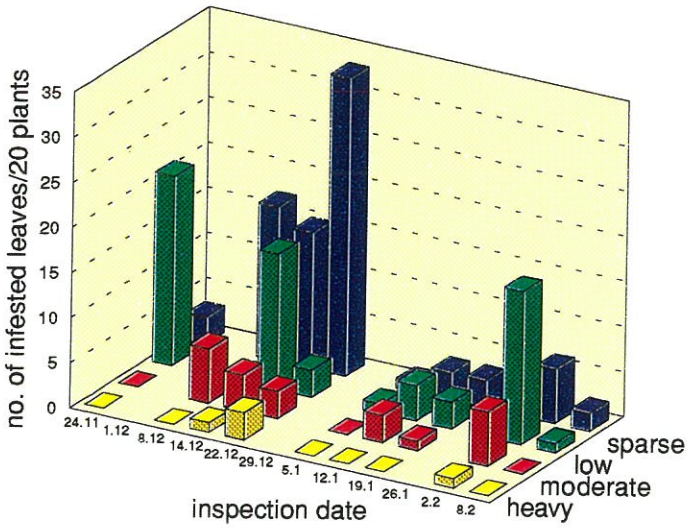

Fig 7: Aphid infestation in "Hyland"
Gisborne

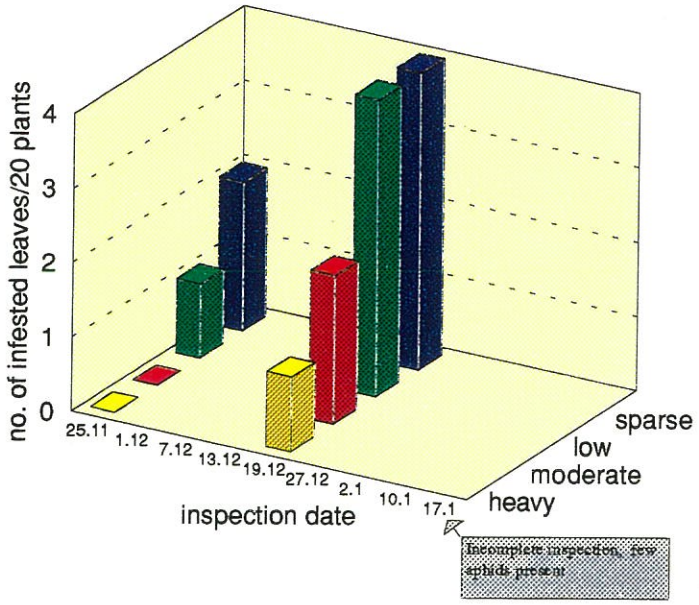

Fig 8: Aphid infestation in "Gordon"
Gisborne

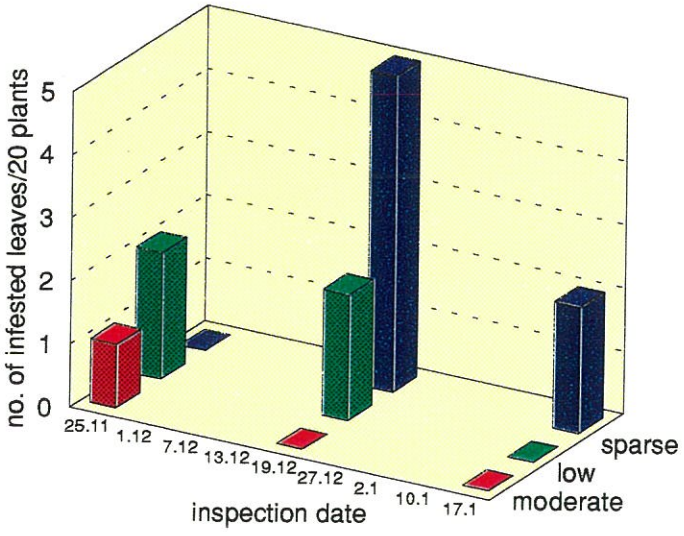

Fig 9: Infestation in"Mill"
Lawn Rd, HB

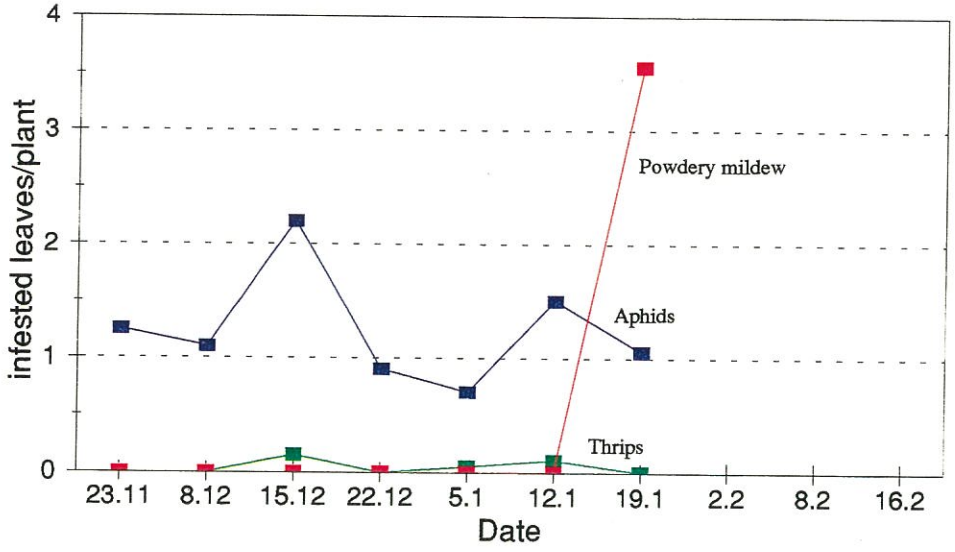

Fig 10: Thrips infestation in "River"
Maraekakaho, Hawke's Bay

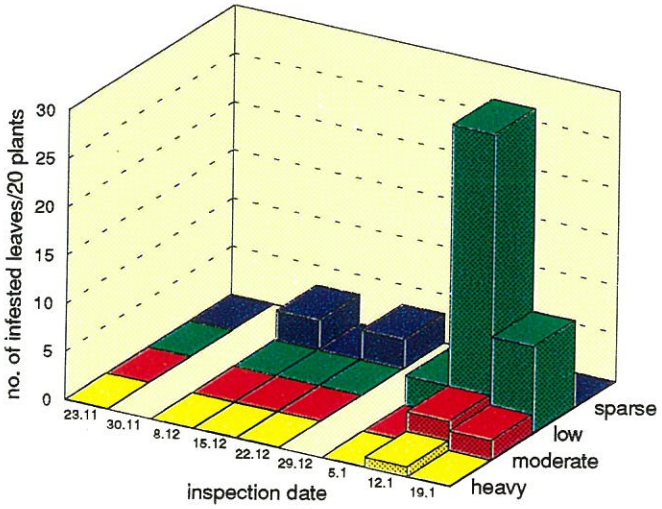

Fig 11: Thrips infestation in "Road"

Maraekakaho, Hawke's Bay

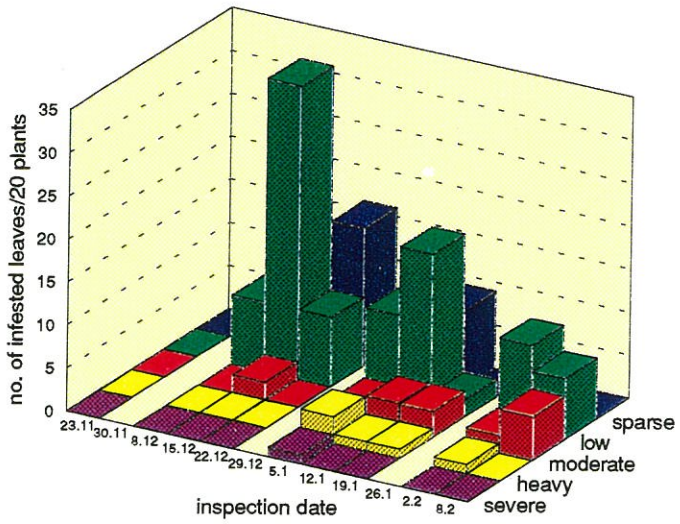

Fig 12: Thrips infestation in "Gum"

Maraekakaho, Hawke's Bay

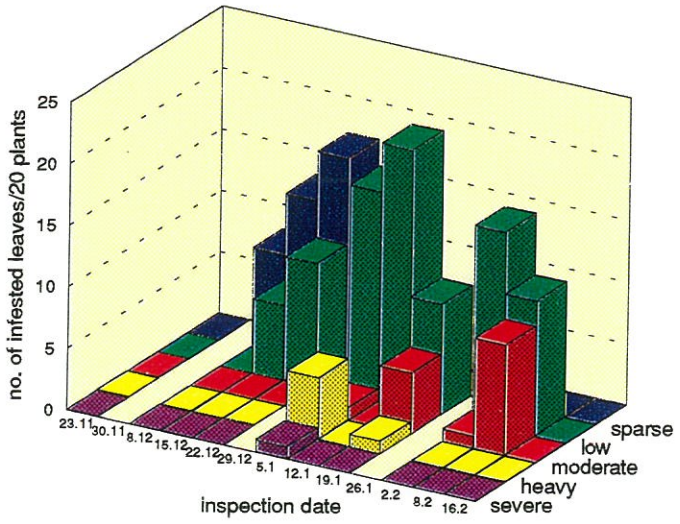

Fig 13: Thrips infestation in "Mill"

Lawn Rd, Hawke's Bay

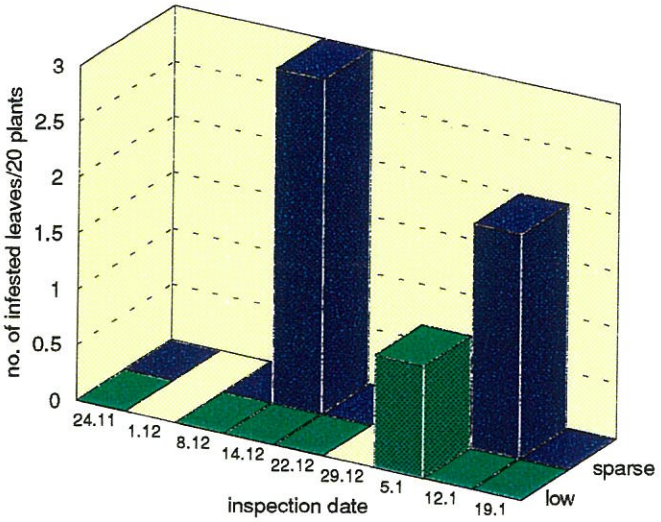

Fig 14: Thrips infestation in "Lawn"

Lawn Rd, Hawke's Bay

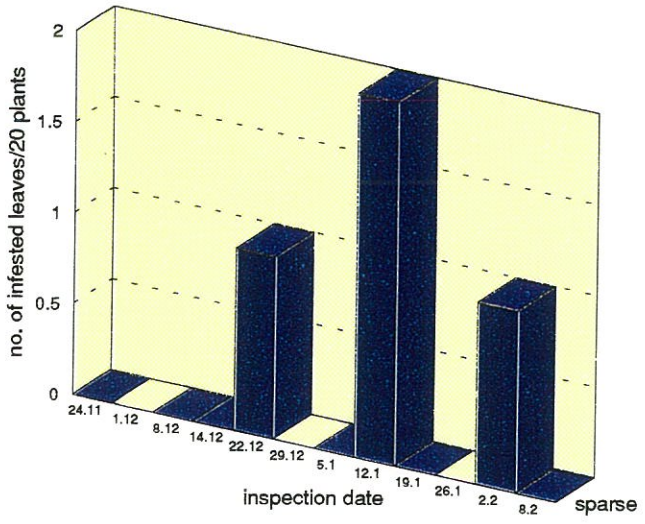

Fig 15: Thrips infestation in "Gordon"
Gisborne

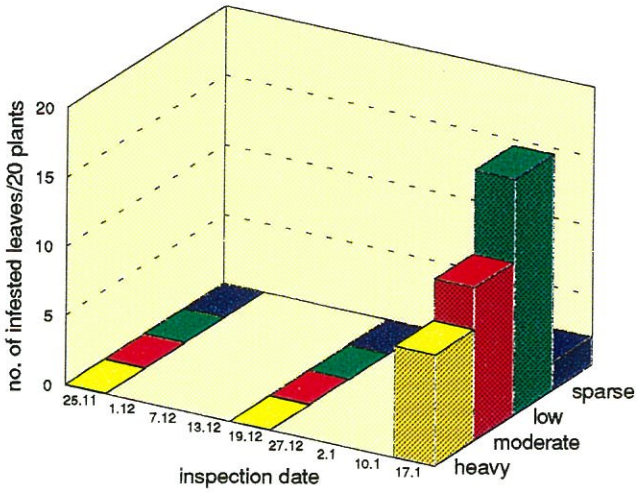

Fig 16: Powdery Mildew on HB squash

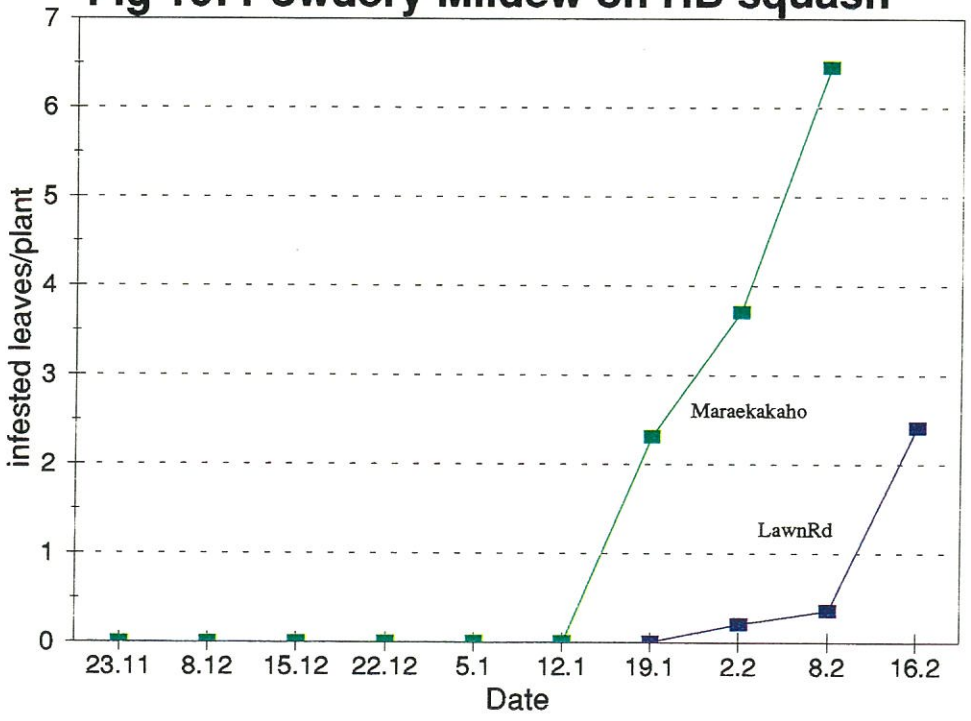

Fig 17: Powdery mildew infestation in "Road", Maraekakaho, Hawke's Bay

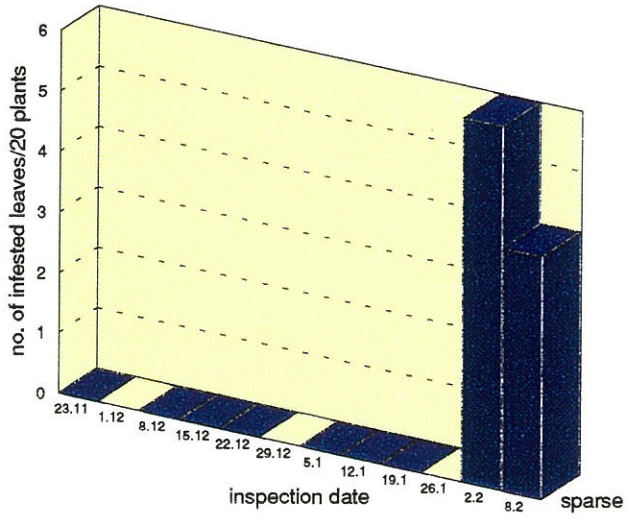

Fig 18: Powdery mildew infestation in "Gum", Maraekakaho, Hawke's Bay

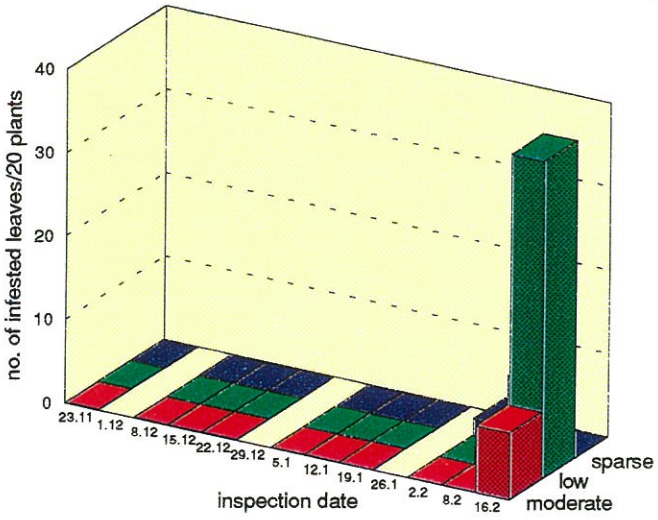

Fig 19: Powdery mildew infestation in "Mill", Lawn Rd, Hawke's Bay

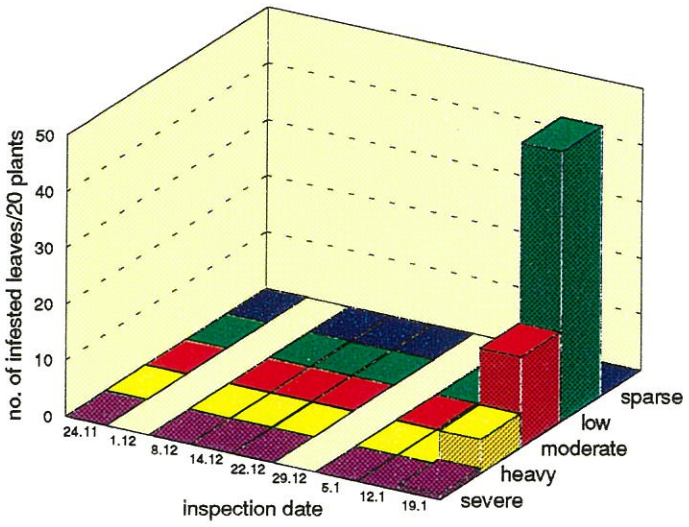

Fig 20: Powdery mildew infestation in "Lawn", Lawn Rd, Gisborne