Buttercup squash—virus disease report 1997/98

A report prepared for the
New Zealand Buttercup Squash Council

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CONTENTS

1 EXECUTIVE SUMMARY

This report summarises research on the management of squash virus diseases funded both by the Public Good Science Fund and the Squash Council during 1997/98. Once again, mosaic virus disease was only found in and around Hawke's Bay. Disease incidence was higher in mid and late-sown crops in which levels of up to 70% were recorded. WMV was most prevalent and ZYMV was recorded on four crops. Some fruit blister symptoms were noted but no significant losses were recorded.

Five new weed hosts were found to be carrying viruses, and various aphid vector species were confirmed colonising or feeding on these hosts. Aphid numbers trapped at Lawn Road were higher than those in the previous season, with vector flights commencing later and continuing longer. Four squash crops were closely monitored and, as expected, aphids were found on squash plants soon after traps signalled their arrival. In addition to the primary squash colonisers (melon aphid and potato aphid), pea aphid was a minor coloniser. Aphid numbers tended to increase from colonies within the crop, even when flights stopped. In spite of high vector numbers, disease development was no more than 6%. Field samples of leaf and fruit material were collected and assessed in the laboratory. Disease incidence was estimated to be low. This method was more accurate than visual estimates of disease incidence.

It is recommended that we monitor disease in districts other than Hawke's Bay only if disease outbreaks are detected in these districts. We also recommend that we continue, with grower collaboration, to develop plans to implement a vector warning programme in Hawke's Bay. It is important that we still monitor aphid thresholds in some crops in this district as a reference for this work. We propose that research funded by the Public Good Science Fund continues on seed-borne virus transmission, resistance breeding and disease epidemiology.

2 INTRODUCTION

This report summarises research on virus disease management funded both by the Public Good Science Fund (PGSF 6 CRF-04-4937 Diseases of arable and vegetable crops) and the New Zealand Buttercup Squash Council during 1997/98. The work is a continuation of that commenced in 1995 (Fletcher & Jermyn) and furthered in 1996 (Fletcher 1996) and 1997 (Fletcher et al. 1997). Research this season covered disease epidemiology, aphid flight patterns, and disease loss effects. It exemplifies the integral collaboration necessary between research and industry to study and resolve the problem of virus management in buttercup squash.

3 METHODS

3.1 National squash virus disease survey

A national survey of squash crops representing the main regions was undertaken from December 1997 through to February 1998. In consultation with Squash Council National Delegates, local contacts were established and samples of squash crops were surveyed. As in previous seasons, eight regions were covered: Northland (Dargaville), Auckland (Pukekohe, Mangatangi), Bay of Plenty (Te Kaha), East Coast (Gisborne), Hawke's Bay (Hastings), Manawatu (Palmerston North), Marlborough (Blenheim) and Canterbury (Ashburton, Christchurch).

3.2 Hawke's Bay squash virus monitoring

Thirty-four early, mid, and late-sown squash crops were routinely visited throughout the season to estimate the development of virus infection over the growing period. A visual estimate of virus incidence was made in the field, and leaf and fruit samples were taken to the laboratory where virus identity was confirmed.

3.3 Disease epidemiology

3.3.1 Weed survey

Overwintering weeds in and around the previous season's diseased squash crops in Hawke's Bay were collected and assayed for possible virus infections. Aphids feeding on these weeds were also trapped and identified as potential virus vectors.

3.3.2 Site monitoring

A block in Pakohai Rd, Hastings, regularly cropped with squash, pumpkin, and other vegetables, was again monitored during the season for virus disease development. Virus infections in weeds and crops were recorded in order to detect any seasonal infection pattern.

3.3.3 Aphid vectors and virus disease development

Aphid flight patterns continued to be monitored at Lawn Rd, Hastings, throughout 1997 and 1998. A wind trap set at 2.5 m was emptied weekly and the aphids counted and identified.

Four similar wind traps were established in squash crops at four sites around Hastings: two at Ngatarawa (Lawson), and one each at Pakipaki (Speers) and Pukekura (Brownrigg). These sites were monitored weekly for aphid catches and fortnightly for virus incidence in the squash crops. Aphid numbers and species were derived from a random sampling of 30 plants and a count of aphids on up to 10 leaves/plant. Virus incidence was estimated both visually, by the examination of 100 plants, and by random sampling and testing of 50 leaves.

4 RESULTS

4.1 National squash virus disease survey

In total, 155 crops of squash, zucchini, pumpkin and other cucurbits were surveyed. No sign of either WMV or ZYMV was recorded in most regions. Only in Hawke's Bay did virus disease develop during the season. WMV was most commonly identified although ZYMV was also detected in some crops this season.

4.2 Hawke's Bay squash virus monitoring

Mosaic symptom was more widespread in early, mid and late-sown Hawke's Bay crops this season than in the previous two. Results are summarised in Figure 1 (with 1995-97 comparisons). Early-sown crops developed up to 5% mosaic. All mid-sown crops developed disease fairly rapidly. Disease incidence ranged from 1 to 50%. Fewer late-sown crops were affected but those with disease had the highest incidences of between 40 and 70%. In later crops, blistered fruit were more evident. However, no serious quality losses due to virus were reported. Once again WMV prevailed with ZYMV recorded at four crop sites.

4.3 Disease epidemiology

4.3.1 Weed surveys

A number of weed species were found to be carrying WMV, and this season new hosts of ZYMV (Table 1) were found. Some host species were quite widespread early in the spring (wild carrot, speedwell, stagger weed, cleavers, twin cress, clovers and red root) both around crop margins and as seedlings within an old crop. New virus hosts, in addition to those identified in previous surveys, included: rayless chamomile (ZYMV), redroot (ZYMV), lily of the valley vine (WMV), sub-clover (WMV) and white clover (ZYMV). Aphid species associated with some of these weeds included the established cucurbit virus vectors: *Myzus persicae, Aphis craccivora, Macrosiphum euphorbiae, Capitophorus eleagni, Acythosiphon pisum* and *A. kondoi.*

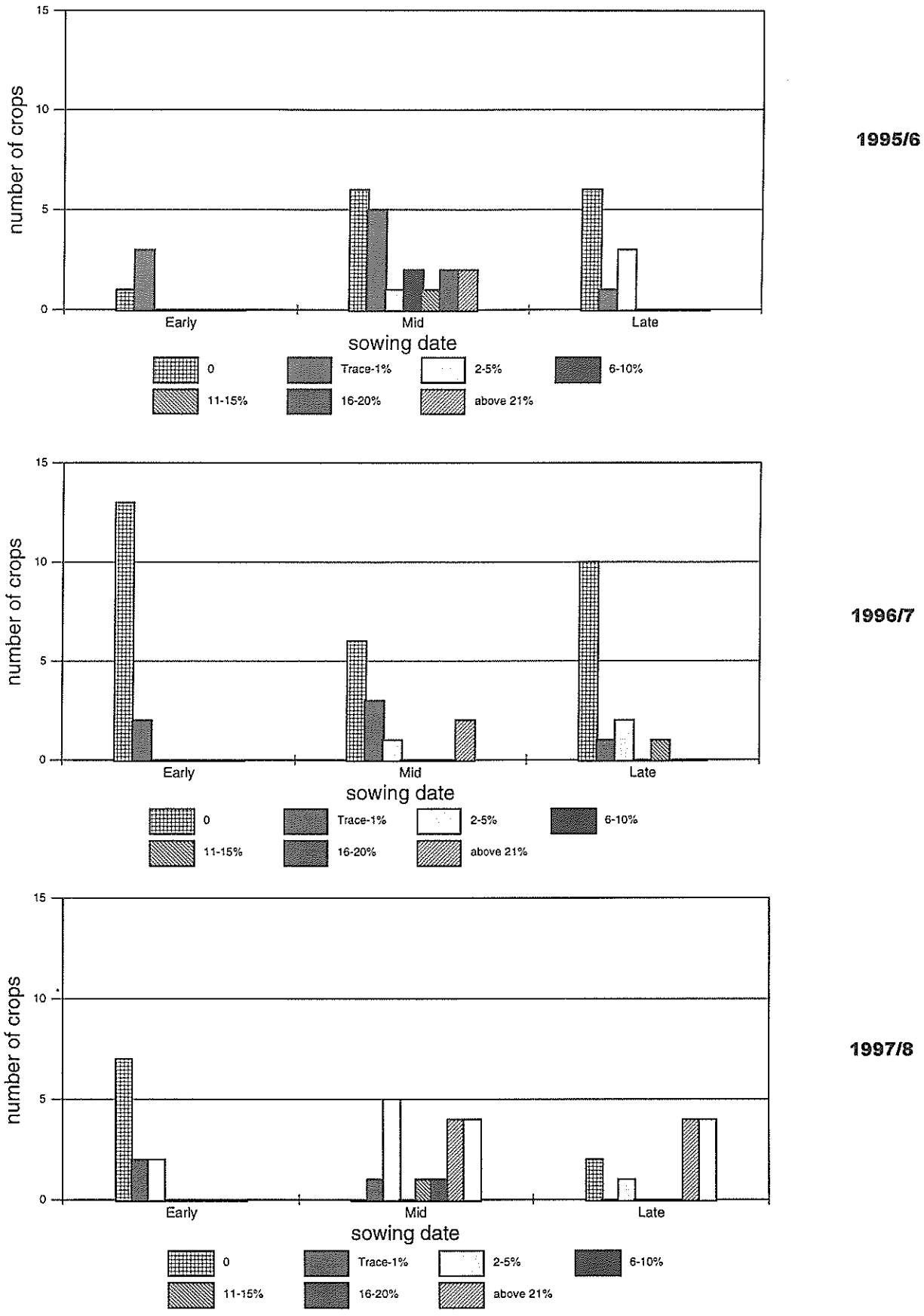
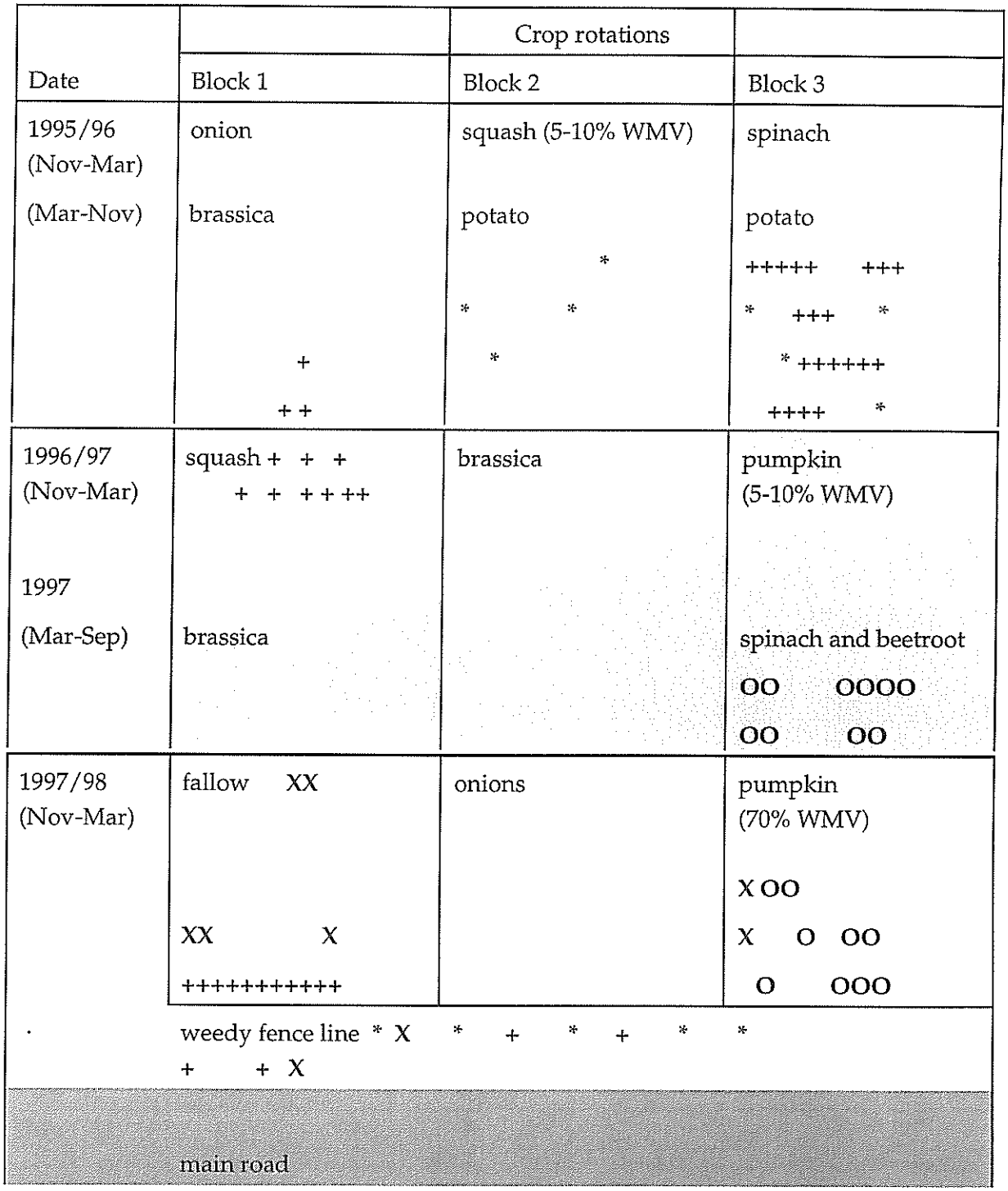


Figure 1: Numbers of squash crops with different levels of visual virus symptoms in Hawke's Bay during 1995/96, 1996/97, 1997/98.

Table 1: The incidence of WMV, ZYMV and associated aphids in weeds in and around squash crops, Central Hawke's Bay, 1996/97.

Weeds		Virus	Associated aphids
Black nightshade	*Solanum nigrum*	WMV	
Broad-leaved dock	*Rumex obtusifolius*	WMV	
Broad-leaved plantain	*Plantago major*	WMV	
Chickweed	*Stellaria media*	WMV, ZYMV	
Cleavers	*Galium aparine*	WMV, ZYMV	*Macrosiphum euphorbiae, Acythosiphon pisum, Acythosiphon kondoi, Aphis gossypii*
Fat hen	*Chenopodium album*	WMV, ZYMV	*M. euphorbiae, Cavariella aegopodii, Myzus persicae, Brachycaudus helichrysi, Aulacorthum solani, Aphis craccivora*
Fennel	*Foeniculum vulgare*	WMV	
Field madder	*Sheradia arvensis*	WMV	
Hawks' beard	*Crepis* sp.	WMV	
Hemlock	*Conium maculatum*	WMV	
Horehound	*Marrubium vulgare*	WMV	
[1]Lily of the valley vine	*Salpichroa organifolia*	WMV	
Oxtongue	*Picris echioides*	WMV	M. euphorbiae
[1]Rayless chamomile	*Matricaria dioscoidea*	WMV, ZYMV	
[1]Redroot	*Amaranthus* sp.	WMV, ZYMV	*A. pisum, M. euphorbiae, M. persicae*
Sow thistle	*Sonchus oleraceus*	WMV	*Hyperomyzus lactucae, Macrosiphum rosae*
Speedwell	*Veronica* sp.	WMV	
Stagger weed	*Stachys arvensis*	WMV, ZYMV	
Subterranean clover	*Trifolium subterraneum*	WMV	
Twin cress	*Cheiranthus didymus*	WMV	*Brevicoryne brassicae, A. kondoi, A. craccivora, Lipaphis erysimi*
Vetch	*Vicia sativa*	WMV	*A. gossypii*
[1]White clover	*Trifolium repens*	WMV, ZYMV	*M. euphorbiae, A. pisum, Capitophorus eleagnii, M. persicae*
Wild carrot	*Daucus carota*	WMV	

[1]Additional hosts first recorded 1997/98.



WMV disease development : November-January 1997 ********
March 1997 ++++++++ September-January 1998 XXXXXX
February 1998 OOOOO

Figure 2: Spatial occurrence of WMV infection in squash and pumpkin crops 1996-98 in Pakohai Rd, Hawke's Bay, over three growing seasons.

Disease development history at Pakohai Rd:

October 1996	WMV found in cleavers, vetch, white clover, rayless chamomile, twin cress, and chick weed, along fence line and in old squash crop. Aphids present: *Macrosiphum euphorbiae, Acyrthosiphon kondoi, A. pisum, Hyperomyzus lactucae*
November 1996	WMV found in sow thistle and ox tongue.
March 1997	WMV found in ox tongue.
September 1997	WMV found in white clover along fence line and in old squash crop.
November 1997	Aphids present: *M. euphorbiae, Cavariella aegapodii, Aphis craccivora, Myzus persicae.*
January 1998	Aphids still present (*M. euphorbiae, A. craccivora, M. persicae*). WMV in pumpkin (12%) and squash (24%).
February 1998	ZYMV found in red root and fat hen. WMV in pumpkin (70%) and squash (80%).

4.3.2 Site monitoring—Pakohai Rd, Hastings

Figure 2 illustrates the progression of disease from virus-infected weeds within the crop and from weeds on the roadside fence line over the past three seasons.

This year, virus ZYMV was detected early in the season in rayless chamomile, and later on in red root and fat hen, within the crop. As illustrated in previous seasons (1995/96 and 1996/97) disease also arose from infected weeds along the fence line. In January 1998, winged aphids (*Macrosiphum euphorbiae, Myzus persicae* and *Aphis gosypii*) were found on young pumpkin and squash crops. Disease incidence of WMV at this stage was estimated to be 12 and 24% on these crops respectively. A month later, in February, it was 70 and 80%, leading to some fruit blister on squash and skin discoloration in the pumpkin fruit. No ZYMV was found on these squash or pumpkins.

4.3.3 Aphids trapped at Lawn Road, Hastings

Wind trap catches of aphids from 1996 to 1998 at Lawn Road are summarised in Figure 3a. Highest total aphid flight numbers for 1997/98 were recorded in a spring flight peak in mid December. Numbers were much higher than in the previous season. Autumn flights commenced in mid February, peaking in late March.

The numbers of known virus vector aphids (*Myzus persicae, Aphis craccivora, A. gossypii, Aulacorthum solani, Macrosiphum euphorbiae, Cavariella aegopodii* and *Rhopalosiphum padi*) (Fig. 3b), peaked in late November 1997. In the 1996/97 season the peak occurred in late September 1996. Once again, virus vectors peaked (Fig. 3b) a little earlier than the main aphid flights (Fig. 3a). Vector flight activity did not drop off until late January/February 1998 in response to the warm temperatures. In the previous season activity dropped from December. Most of this vector activity was confined to *C. aegopodii*, an aphid we have found landing on squash but not noted colonising the crop.

4.3.4 Aphids trapped at the four crop sites

Three of the monitored sites ran east to west from Ngatarawa (organic and non-organic), to Pakipaki, about 8 km to the east. The fourth site was 17 km to the south at Pukekura (Fig. 4a, b, c, d).

Total numbers of aphids trapped at each site largely followed the pattern recorded at Lawn Rd. At each site a distinct peak in the number of aphids trapped occurred soon after plant emergence, around 25-28 November. Smaller peaks were recorded at Ngatarawa, Pakipaki and Lawn Rd between 5 and 15 January and to some degree at Pukekura around 28 January. Autumn flights commenced around 17 February at Lawn Rd and Pukekura and slightly later, around 25 February, at the other sites.

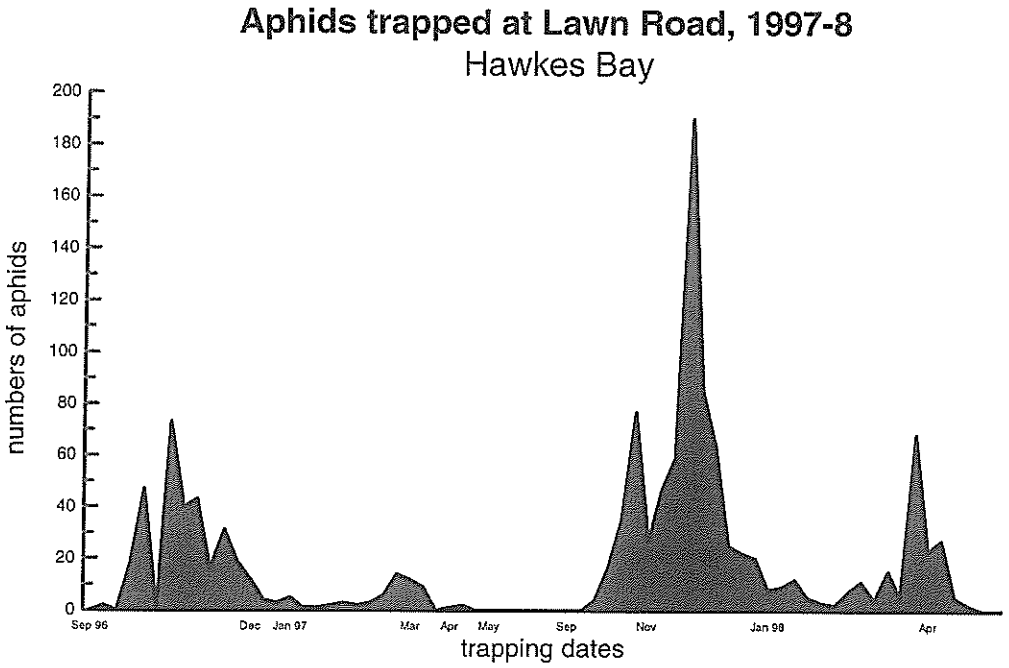


Figure 3a: Numbers of aphids trapped at Lawn Rd, Hastings, 1996-98.

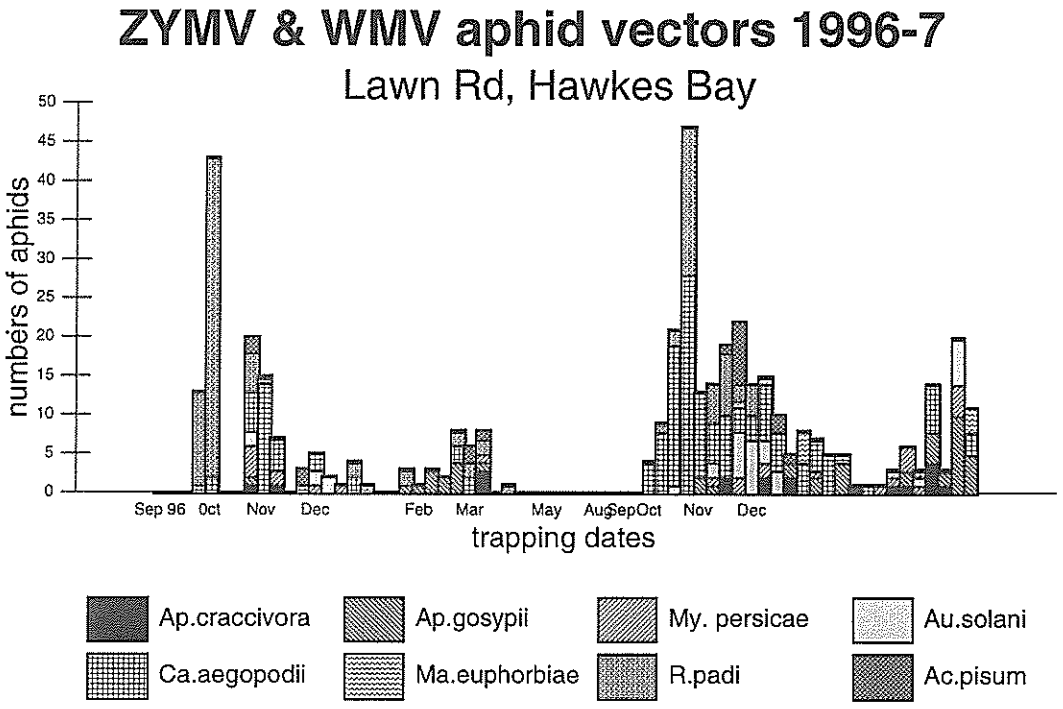


Figure 3b: Numbers of ZYMV and WMV aphid vectors trapped at Lawn Rd, Hastings, 1996-98.

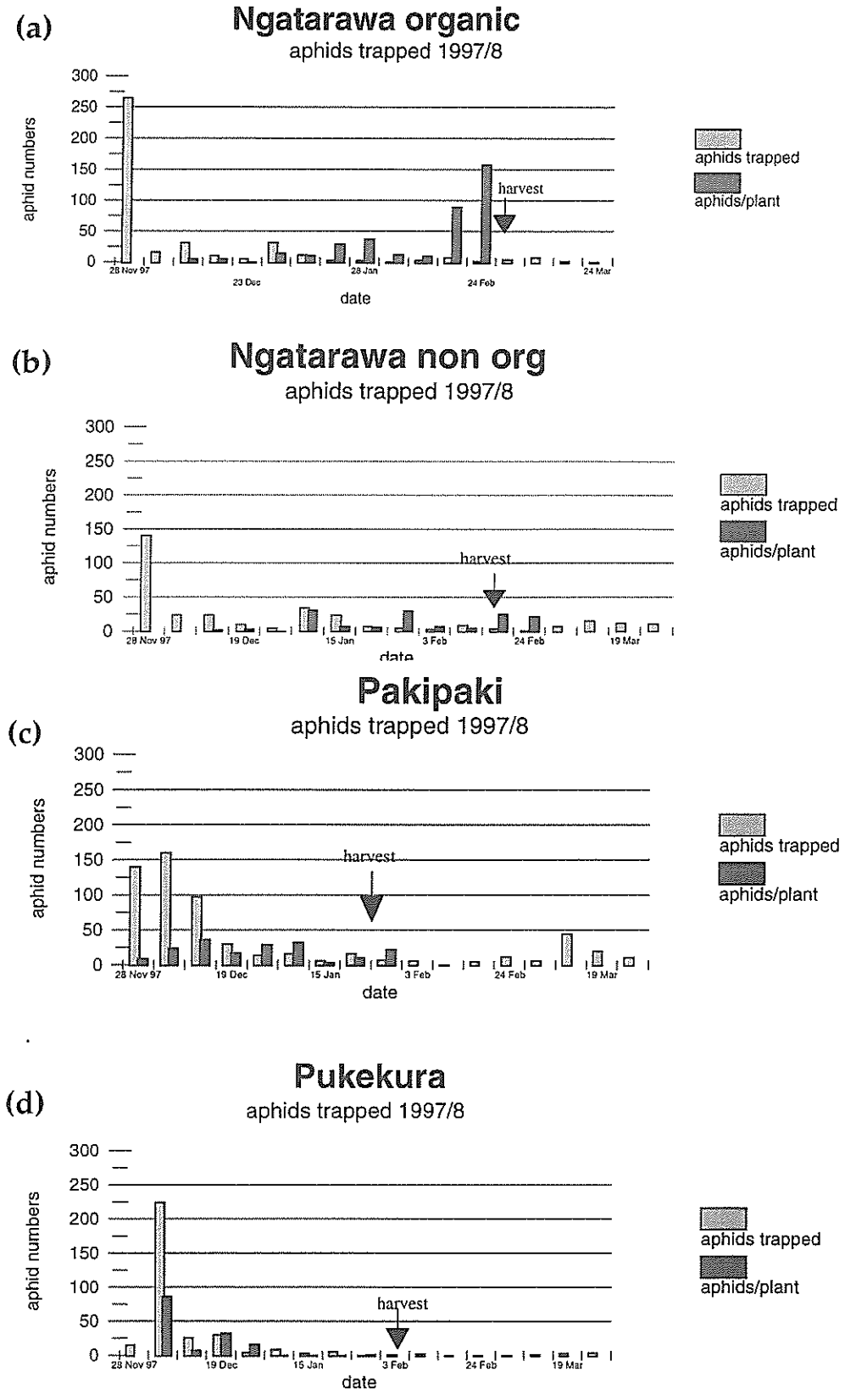


Figure 4: Numbers of aphids trapped in four monitored squash crops, Hastings, 1997/98.

4.3.5 *Vectors on squash plants*

As expected, most aphids were found on plants following a flight peak which was signalled by counts in the wind traps (Fig. 4). Early season trap figures were the highest. Most aphids found on plants were wingless. Colony numbers are recorded in Table 2 and Fig. 5a, b, c and d. Colonisation appeared to start when aphids reached a mean of around 0.2 aphids/leaf. Through the season aphids established and their numbers increased within the crops, even though numbers of aphids caught in traps declined. This trend was observed particularly at Ngatarawa, possibly because seed had been treated with the recommended insecticide Gaucho.

The main vectors found colonising squash included: *Macrosiphon euphorbiae* and *Aphis gossypii*, as primary colonisers and *A. pisum* as a minor coloniser. Other winged species trapped on plants included recorded vectors: *A. craccivora, Lipaphis erysimi, Myzus persicae, Cavariella aegopodii,* and *Rhopalosiphum maidis.* Further species, *Aulacorthum solani, Brachycaudus helichrysi, Brevicoryne brassicae, Capitophorus eleagni* and *Therioaphis trifolii,* not recorded in the literature as vectors, were also trapped and may be casual virus vectors.

4.3.6 *Virus disease development at four crop sites*

In spite of relatively high aphid numbers disease development at the four sites was modest and did not lead to any detectable crop loss (Fig. 5). Field sampling estimated WMV at a maximum each of 1% and ZYMV at 6%. There was no sign of fruit damage.

4.3.7 *Disease estimation—comparison of methods*

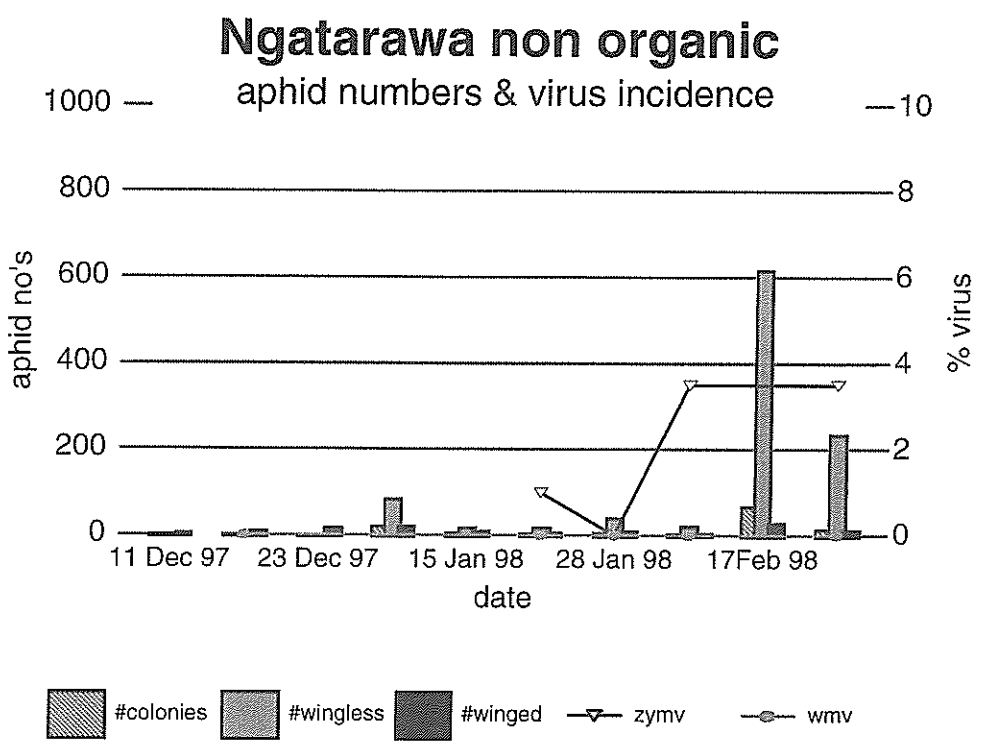
Table 3 compares the accuracy of visually estimating the disease incidence on 100 leaves in the field with sampling and testing 50 leaves for analysis in the laboratory.

At low disease incidence, field sampling with laboratory follow-up appears to be more sensitive than visual estimation. Comparisons of the two methods at higher visual disease incidence did not produce distinctly different estimates.

Table 2: Mean counts of aphids and colonies at four buttercup squash trial sites, Hawke's Bay, 1997/98.

	Ngatarawa organic		Ngatarawa		Pakipaki		Pukekura	
Date	Aphids/ leaf	Colonies	Aphids/ leaf	Colonies	Aphids/ leaf	Colonies	Aphids/ leaf	Colonies
28/11/97					0.26	0		
4/12/97	0.2	0			0.42	2	0.75	0
11/12/97	0.2	0	0.13	0	0.46	10	0.05	0
19/12/97	0.2	1	0.14	0	0.09	1	0.12	0
23/12/97	0.14	1	0.15	0	0.29	4	0.06	0
5/1/98	0.57	21	0.76	19	0.73	41	0	0
15/1/98	0.08	2	0.09	5	0.09	5	0	0
21/1/98	0.26	13	0.08	3	0.04	2	0.003	0
28/1/98	0.76	18	0.15	5	0.14	6	0.003	0
3/2/98	0.16	4	-	-				
10/2/98	0.07	4	0.08	2				
17/2/98	2.4	81	2.14	66				
25/2/98	11.5	145	0.81	233				

(a)



(b)

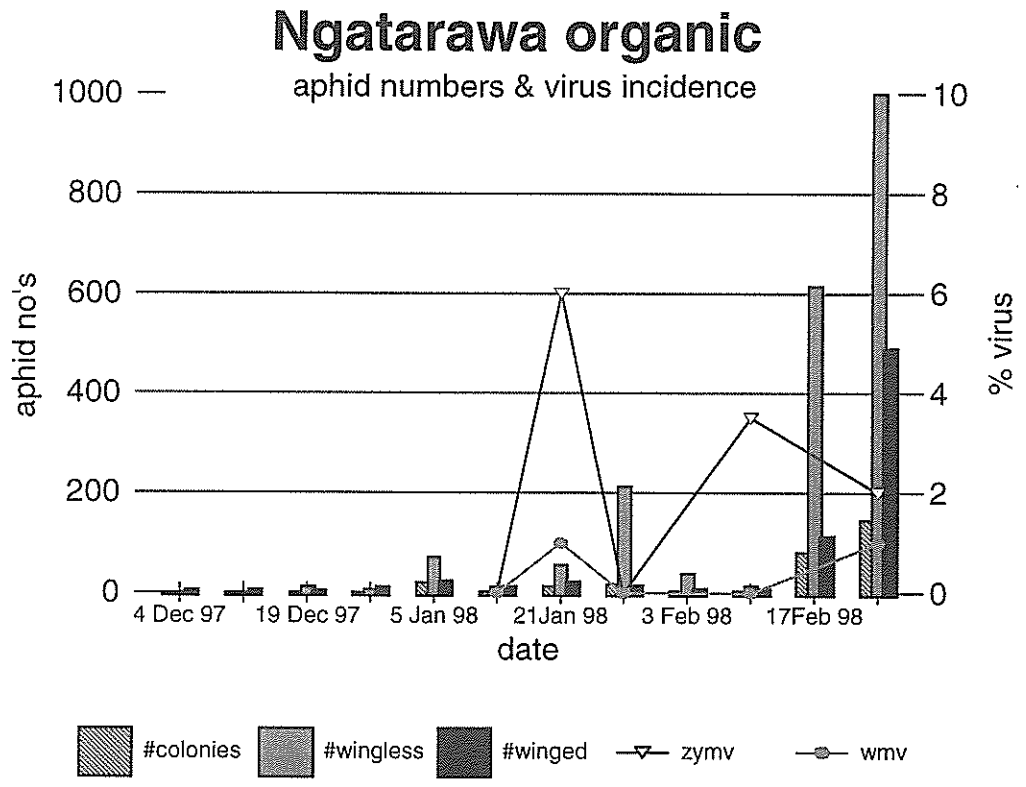


Figure 5: Aphid numbers and virus incidence in four monitored squash crops, Hastings 1997-98.

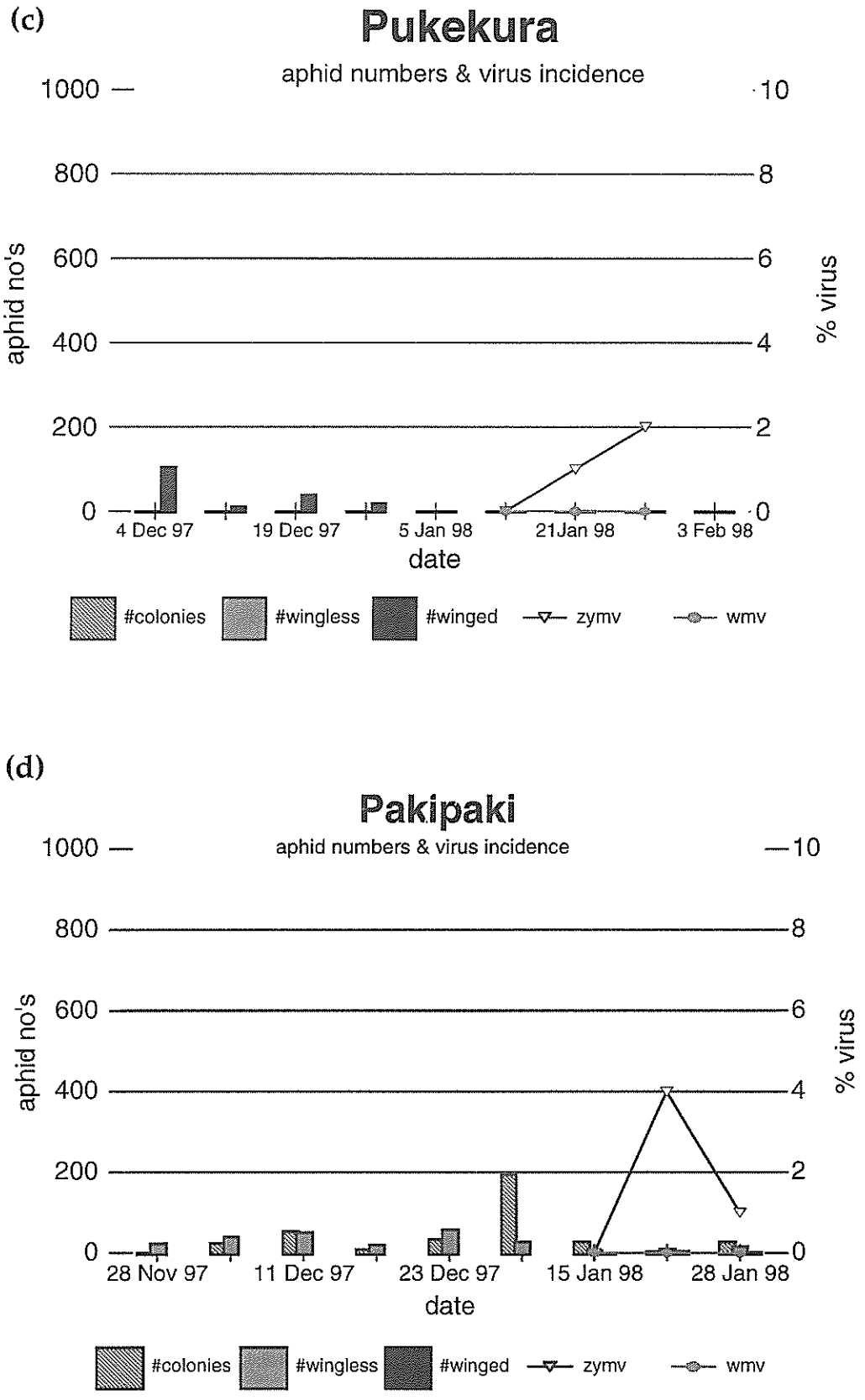


Figure 5: Aphid numbers and virus incidence in four monitored squash crops, Hastings 1997-98.

5 DISCUSSION

Currently, the significant viruses of buttercup squash are still confined to the Hawke's Bay, and WMV remains the most widespread squash virus disease. Site sampling confirms that, unlike the previous two seasons, ZYMV is still infecting some squash crops.

During the 1997/98 season disease developed in mid and late crops to a higher level than in the past two seasons. This is probably attributable to high early season aphid numbers. Their survival was enhanced by warm, mild conditions, particularly within the crop. Both diseases appear to be moving from infected weeds back into nearby squash crops. This was clearly shown at the Pakohai site where many weeds acted as virus hosts while there were no crop hosts available. This allowed infection of new season crops early in their growth which, in turn, led to the development of fruit symptoms and yield loss. Fewer infected weed hosts around the four crops were monitored during the season. Viruses were carried into these crops by aphid vectors, which infected the crops later, after flowering. Consequently, no fruit symptoms were seen.

We have also confirmed that a number of aphid species found on weeds are also landing on, and sometimes establishing in, squash. They are, therefore, implicated in disease initiation and spread. This appears to be the first time that *A. pisum* has been confirmed as a coloniser of squash in New Zealand. There is also evidence of other aphid species casually feeding on squash. They only probe the plant to assess its suitability as a host. These aphids will reject the squash plant as a suitable host for colonising and then move on. However, by probing the plant those aphids carrying virus may have infected the plant. After initial flights aphid vectors that do recognise squash as a suitable host will colonise and spread within the crop throughout the growing season.

Our figure of one aphid/five leaves may be useful as an action threshold, but further work should be done to confirm this figure since this is based on only one season of work. The importance of an aphid monitoring programme to warn growers of flight activity was further confirmed by these observations. We are now working with local Hawke's Bay growers on the possibility of setting up a monitoring system to forecast aphid and virus risk periods.

We know from our previous work that virus infection of squash before the end of flowering causes the most fruit damage. Field sampling helps to give good estimates of low level early virus infection. This will be useful in helping to determine the nature of the relationship between aphid numbers and actual disease incidence, and thus the risk of infection.

6 RECOMMENDATIONS

The current research programme has further funding from the Public Good Science Fund and will continue for the next two seasons. We believe the Squash Council should continue to support the following areas of research:

- assisting with the preparation of an application for an AGMART Progressive Farming Grant to fund an aphid monitoring programme in Hawke's Bay,
- continuing to support research on aphid flight patterns,
- continuing to determine appropriate aphid scouting thresholds,
- exploring alternate disease management methods.

Research funded by the Public Good Science Fund will continue to: monitor the spread of disease, as required through the season; understand the processes of seed transmission; and screen virus-resistant squash crosses as they become available. It will also continue to determine alternate disease hosts.

7 ACKNOWLEDGEMENTS

We wish to acknowledge the scientific and technical collaboration of Brian Rogers, Phillipa Page, Kerry Sanders (aphid traps and field sampling), Heather Nott, Stan Ebdon (lab and glasshouse experiments), and David Teulon (aphid identifications). We also wish to thank the squash growers who have actively supported this work with access to their properties, useful comments, information and their precious time.

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