VG201
Introduction of integrated pest management programs for fruit and vegetable crops in Bowen

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Bowen Crop Monitoring Services Pty Ltd

Know-how for Horticulture™

VG201

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During the course of this project a number of growers have given their valuable support in allowing the researchers to trial alternative pest control strategies in their crops. In some instances this resulted in considerable loss in production. Without these contributors this research could not have progressed. We wish to thank the following Bowen growers.

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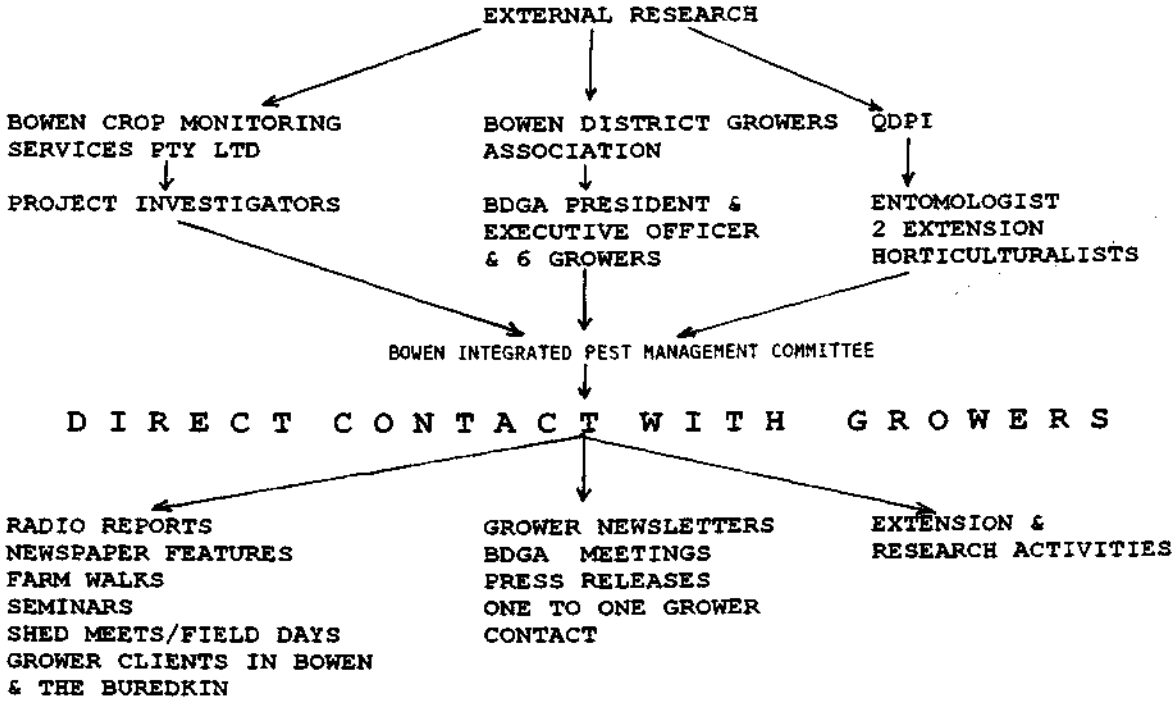
CONTENTS

TECHNICAL SUMMARY

The major research findings that have resulted from this project are:

1. **The leafminer monitoring system that has been established in the Bowen district has been effective due in part to the compactness of the growing area. This monitoring system could be adapted to other potential insect problems if specific pheromone lures and trapping devices are available. The trap counts collated has provided data for further research to develop a computerised population model for leafminer.**
2. **Growers were able to relate leafminer moth trap counts to crop damage.**
3. **Peer pressure was an important tool in policing farm hygiene practices.**
4. **The influence of food source and development of leafminer populations convinced growers of the importance of a summer break in production with a progression of no seasonal break to 4 weeks with a further extension to 6 weeks.**
5. **There is a definite need to further investigate the efficacy and viability of biocontrol agents in fruit and vegetable crops in the Dry Tropics.**
6. **There is a definite need for further research into heliothis control in sweetcorn using alternative control measures to O.P. and carbamate insecticides in the Dry Tropics.**
7. **This research was conducted by a private crop consultancy business who communicate daily with over 30 fruit and vegetable growers in Bowen and the Burdekin regions. Information gained from the research was conveyed personally to growers. This immediate transfer of research findings to the end user was a very positive aspect of this project.**
8. **In this major horticultural producing region. effective lines of communication were vital to the success of this project. There was daily grower liaison from all members of the IPM Committee. The infrastructure is represented below:**



INDUSTRY SUMMARY

This project has been very successful in achieving its commercial outcome in terms of reduced tomato leafminer damage and increased production. This success was achieved by:

1. A district tomato leafminer monitoring system.
2. A seasonal break in production.
3. Investigation into alternative pest management strategies. namely biological and chemical methods.

This research has assisted Bowen tomato producers to remain at the forefront of winter tomato production. Integrated pest management of tomato leafminer has resulted in reduced insecticide usage, reduced labour costs associated with picking and sorting and consequently improvement in marketable yield.

Over the duration of this project, growers have become aware of sustainable pest management and IPM techniques. The extension infrastructure that has become established over the last few years in this region is able to react quickly to advances and changes in pest management and farming technology. This is evident by recent examples such as Papaya fruit fly and heliothis resistance strategies. It has taken the full duration of this project to achieve grower acceptance of the benefits of an IPM strategy to reduce the tomato leafminer problem.

The project investigators are now in the first year of another 3 year project directed specifically at tomato leafminer. District maintenance of sound crop and farm hygiene practices and the district monitoring system is essential to the continued success of the IPM strategy for leafminer control. The 1996 season, has to date, benefited from a six (6) week break in production, with minimal tomato leafminer damage to crops. The next two seasons will prove the value of a consistent seasonal break.

INTRODUCTION

In 1992 the Bowen district fruit and vegetable industry represented $70 million of which $50 million was attributed to tomato production (Meurant pers.comm.). In the Bowen district it was estimated that *Phthorimaea operculella* (Zeller), potato tuber moth, also known as tomato leafminer, could reduce gross returns by 10-60% (Meurant pers.comm.). That represented a loss of $5-30 million in horticultural production in a growing season. The major crops grown in this region are fresh market tomatoes, sweetcorn, beans, capsicums, cucurbits and eggfruit. Planting of a number of these crops, namely tomatoes, commences in February with harvesting generally completed by late December.

Bowen Crop Monitoring Services Pty Ltd is a private consultancy business which has serviced growers in the Bowen and Burdekin districts of North Queensland for the past 16 years. The services of this company are primarily employed by growers to conduct routine field monitoring of insects and diseases in horticultural crops and to recommend pest management measures and strategies. In 1992 we became very concerned with the gradual increase in insect activity and the apparent decrease in control with insecticides, in particular, concern with tomato leafminer. This increase in pest activity over the last 10 years in the Bowen district can be explained by an extended growing season, the adoption of trickle irrigation systems and suspected insect resistance. Conditions which have favoured the increase of tomato leafminer are large monocultural areas under constant cropping, a very short seasonal break in production and minimal alteration of insecticide groups. Grower awareness of farm hygiene and appropriate field management practices in order to control pests needed to be addressed.

With the support of the Bowen District Growers Association the main focus of this project was to establish a tomato leafminer monitoring system for the farming district and to routinely alert growers of the leafminer status at a district level. Pheromone trapping of male leafminer moths was established using vertical water traps to monitor the leafminer population (See Plate 1). Tomato leafminer only attacks plants of the Solanaceae family of which tomatoes, capsicums, and eggplant belong(Hassan,1977). The solanaceous weed host species are Blackberry nightshade, *Solanum nigrum*, Apple of Peru, *Nicandra physalodes and* Thornapple, *Datura* spp. (Hargreaves, 1992). These weeds are common to cultivation areas of Bowen and the Burdekin. Appropriate pest management techniques and strategies were introduced for fruit and vegetable crops in this region, primarily targeting tomato leafminer, but many of the management strategies had application to other pest problems.

The research undertaken in this project was 'grower based' or may be referred to as 'on farm research'. All trials were conducted in commercial plantings due to the prevailing pest threat posed by tomato leafminer with immediate commercial application necessary as research proceeded.

MATERIALS and METHODS

1. *Bowen district tomato leafminer monitoring system*

Vertical water traps (See Plate 1) were manufactured and fitted with lures impregnated with the female leafminer pheromone. The traps were located at 48 sites throughout the farming area on a 2 kilometre grid pattern (See Figure 1). All traps were secured to a fence post, fixture or tree adjacent to cropping areas, with none located in-crop. The 48 traps were monitored on a weekly schedule, 52 weeks of the year for 3 years. Weekly trap counts of male leafminer moths for each trap were recorded, published in the local newspaper(See Figure 1) and broadcast on the ABC Rural Radio report every week. To assist growers in identifying potential problem areas, the traps recording high leafminer trap activity were highlighted and these 'hot spot' areas targeted and inspected by the researchers. Crop management and field sanitation practices were recommended in response to weekly trap counts which were also published and broadcast on radio weekly.

2. *Weather station*

A weather station was installed at a central location of the farming district. Correlations between leafminer activity and weather data were attempted.

3. *Extension and Education*

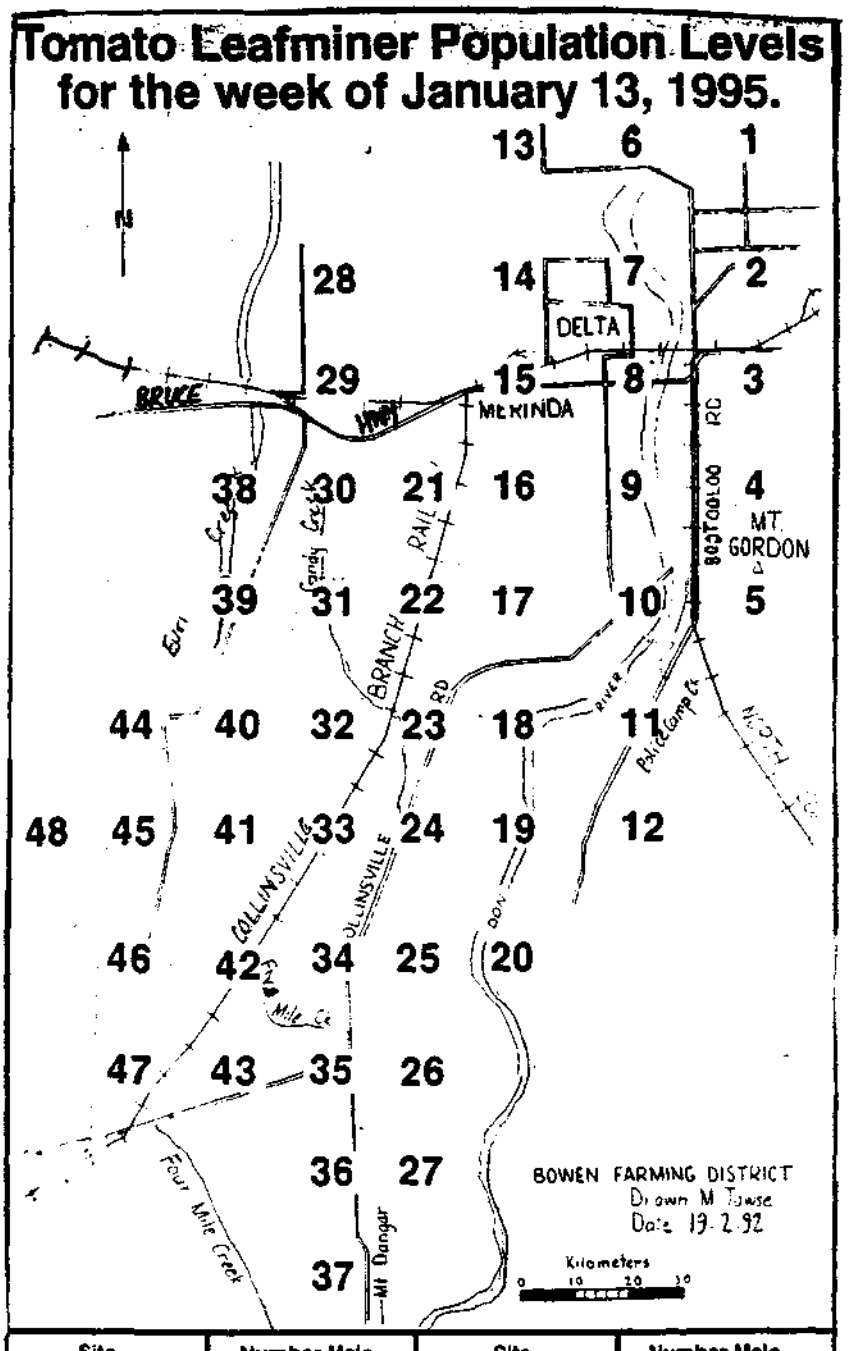
All data collected from the leafminer monitoring system and the 'on farm' research conducted on a number of grower's properties throughout the 1992-1995 growing seasons was communicated to the Bowen and Burdekin farming sector by various extension methods. These methods included:

(i) Local print media - The bi-weekly newspaper *The Bowen Independent* - featured a weekly report with editorials submitted when current research findings, information from other growing areas relevant to the research and appropriate pest management techniques came to hand.

(ii) ABC Radio - A weekly broadcast was established with the ABC announcer, Bruce Reynolds in Townsville, conducted live by telephone each Thursday morning at 6.25 am. This report was entitled ' The Bowen/Burdekin Integrated Pest Management Report ' which went to air for 4-5 minutes. This report included the weekly leafminer activity, current 'hot spot' areas, recommendations on chemical usage, field sanitation and cropping practices, along with a current report on the prevailing insect and disease problems in other major horticultural crops grown in the region. This media opportunity was also made use of to advertise guest speakers, industry events and pertinent information to the introduction of integrated pest management in horticulture. This report was given by the principal researcher every week for 10 months of the year for the 3 years of this project.

Figure 1

Map of Bowen farming district with trap sites indicated. The map, trap counts and relevant information was published every week in the *Bowen Independent*



Site	Number Male Moths per Week		Site	Number Male Moths per Week	
1	63	(65)	25	78	(337)
2	215*	(44)	26	89	(324)
3	158	(64)	27	898+#*	(373)
4	107*	(71)	28	42*	(72)
5	29	(58)	29	34	(63)
6	89	(87)	30	18	(127)
7	39	(48)	31	480*	(159)
8	67	(56)	32	190*	(71)
9	76	(105)	33	210#*	(265)
10	19	(98)	34	105*	(381)
11	68*	(53)	35	72	(270)
12	42*	(88)	36	111*	(188)
13	134	(69)	37	56	(164)
14	53*	(83)	38	73	(53)
15	102	(107)	39	620*	(112)
16	19	(130)	40	83*	(62)
17	245	(345)	41	142	(268)
18	189	(221)	42	54	(228)
19	220#	(449)	43	25	(59)
20	36	(72)	44	78*	(34)
21	63*	(214)	45	69	(186)
22	n/a	(308)	46	85	(108)
23	79*	(152)	47	45*	(71)
24	33*	(70)	48	198*	(152)

* denotes an increase in numbers from previous week.
\# ground recently ploughed adjacent to trap site. + trap adjacent to old plastic mulch.
( ) denotes 1994 figures.

COMMENTS - 99% of traps are recording leafminer male moth activity, with 26 trap sites recording above threshold. Growers in all areas should be disposing of old tomato crops immediately after final harvest. In 1994, at this same week, the average L.M. COUNT/TRAP was 149. This year it is 125 L.M./trap/week. Please refer to the 1994 figures in brackets above. THE AIM IS NOT TO HAVE ANY TOMATO PLANTS GROWING IN THE DISTRICT IN JANUARY. Last season it required the four weeks between December 31 and February 1 to show a reduction in the leafminer population. If we are to repeat this in 1995 we need the full co-operation of all growers. MAKE SURE YOUR FARM IS CLEAN OF VOLUNTEER TOMATOES AND CROP RESIDUES NOW.

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Phone 851066 - Fax 851107

(iii) Growers newsletters - Monthly newsletters are circulated to growers by the Executive Officer of the local Growers Association. On request or when new research and information came to hand growers were quickly informed via this avenue.

(iv) Grower notes/Newsflashes - Condensed information advice sheets were provided to reseller outlets for dissemination to growers and industry personnel.

(v) Seminars - 4 seminars were presented to growers and industry personnel, 2 in 1993, 1 in 1994 and 1 in 1995. These seminars were reasonably well attended and included speakers from Crop Tech of Bundaberg, QDPI personnel, and scientists from the Cooperative Research Centre for Tropical Pest Management.

(vi) Field days and shed meetings - 3 grower orientated meetings were conducted by the principal investigator to show growers how to inspect their crops for early leafminer detection, the use and location of pheromone trapping, to advise on farm hygiene practices and to inform growers on the best management of pesticides.

(vii) Establishment of the Bowen Integrated Pest Management (IPM) Committee. This committee was formed in the first year of the project and consisted of the principal investigator, 2 QDPI Horticulturalists and 1 Entomologist, 6 grower representatives and the Executive officer of the Bowen District Growers Association. Meetings were regularly held, approximately at monthly intervals, to discuss the research progress and initiatives which were then communicated to growers by the above mentioned avenues.

(viii) Liaison with QDPI personnel - Excellent co-operation between the principal investigator and the QDPI Extension Horticulturalists resulted in 20 grower complaints relating to poor crop hygiene being investigated in the 1992-1993 season with satisfactory results.

(ix) This project provided the opportunity for the principal investigator to be a participant at two workshops coordinated by the Cooperative Research Centre for Tropical Pest Management. The workshops attended were: 'Use of *Trichogramma* as a Biocontrol Agent in Australia', Brisbane, February 1994 and 'Tomato Pest Management', Brisbane, April 1994.

4. *Grower field trials - 'on farm research'*

New and alternative pest management techniques to control leafminer were pursued from other horticultural growing areas such as Bundaberg (J.Hall, pers. comm.1992, 1993,1994), Toowoomba (D.Murray, pers. comm.1994,1995) and the potato growing areas of Victoria (P.Horne,pers. comm.1993, 1994). As information came to hand whether it was anecdotal experience from growers or consultants or scientific research from Government departments or chemical companies, these techniques were quickly incorporated into a number of growers pest management strategies, trialled and monitored. Time was a critical factor as leafminer was a constant threat to production and applied research was the best approach to this problem.

The pest management techniques that were introduced can be divided into 3 main areas:

(i) Agronomic or cultural practices
(ii) Biological control methods
(iii) Alternative pesticide strategies

(i) Agronomic or cultural practices

(a) The removal of crop residues immediately after final harvest. This included the removal of plastic mulch and soil incorporation of trash.

(b) The identification of alternative host plant species in the farming district.

(c) The detection and removal of volunteer crop and weed host plants in fallow ground. This included regrowth of slashed crop residues.

(d) The importance of a seasonal break in production with a district adherence to a specified length of time.

(ii) The introduction of biological control methods

(a) In 1993, field releases into crops of the parasitic wasp, *Trichogramma* spp. were investigated. The wasps were obtained from 2 sources, one at Warwick(Bio-Protection) and one at Moree (Biological Alternatives). Field trials were established in tomatoes, corn and capsicums. These commercial plantings were monitored on a bi-weekly basis.

(b) Parasitic wasps,*Trichogramma* , were released into speedling tomato plants in farm nurseries in order to reduce leafminer infestation prior to plantout.

(c) In 1994 large scale grower trials were undertaken with the inundation of *Trichogramma* into tomato crops. High rates, 494,000/hectare/week, of these wasps were released in conjunction with a 5-7 day spray interval with a biological insecticide. The insecticide applied was Delphin, *Bacillus thuringiensis* (Bt) applied at a rate of 1 kg/hectare. This program was pursued under moderate leafminer activity and low to moderate heliothis activity.

(d) Lacewing larvae, *Chrysopa* spp., were released into capsicum crops to investigate green peach aphid, *Myzus persicae* (Sulzer) and heliothis, *Helicoverpa* spp., control.

(e) Larval parasitoids supplied by QDPI Entomologists, Toowoomba, were released into commercial sweetcorn plantings. Their fecundity and effect on heliothis in sweetcorn was monitored.

(iii) Alternative pesticide strategies

(a) Mixtures of registered organophosphate insecticides and Bt's were applied to crops and assessed.

(b) Mixtures of the registered carbamate insecticide Larvin and Bt's were applied to crops and assessed.

(c) Bt's alone were applied to crops and assessed.

(d) Assessment of pesticide application equipment used for leafminer control was undertaken using water sensitive paper in crop situations.

RESULTS and DISCUSSION

1. *Bowen District Tomato Leafminer Monitoring System*

Male tomato leafminer moth trap counts (See Appendix I) commenced in February 1992. This was prior to the project's approval by the HRDC and the QFVG due to the urgency of the problem and grower demand. Leafminer moth counts were recorded every week from 48 traps sites with an average weekly trap count calculated. Subsequently an average trap count per week for each month was available for comparison (See Table 1 & Graph 1). In order to communicate population changes and trends to the farming community on a weekly basis this mode of reference was considered to be simple and effective.

In the first year of the project, June 1992 to July 1993, there was no seasonal break in production, with tomato crops growing throughout December 1992 and January 1993. Male leafminer moth numbers were higher in the 1993 season with the highest counts recorded in September 1993, 344 moths(See Table 1). The economic threshold level of 70 male moths per week per trap (J.Hall,pers.comm.1992) was the accepted district standard. These high counts were reflected in widespread fruit damage throughout the Bowen district. At the end of the 1993 season, as a direct result of the IPM program and the district monitoring system, growers were convinced of the economic losses associated with continued production throughout the summer months, specifically December and January. This sustained production provided a constant food source for leafminer.

A summer break in production was voluntarily agreed upon by growers, to be approximately 1 month from December 25th, 1993 to February 1st, 1994. This seasonal break was widely publicised using all media opportunities and local industry platforms. As a direct result of this seasonal break, leafminer levels were substantially reduced. The 1994 February average trap count was 6 compared to the February 1993 average of 91.

At the end of the 1994 season a further increase in the length of the seasonal break was advised to extend from December 15th, 1994 to February 15th, 1995. However, a

Table 1

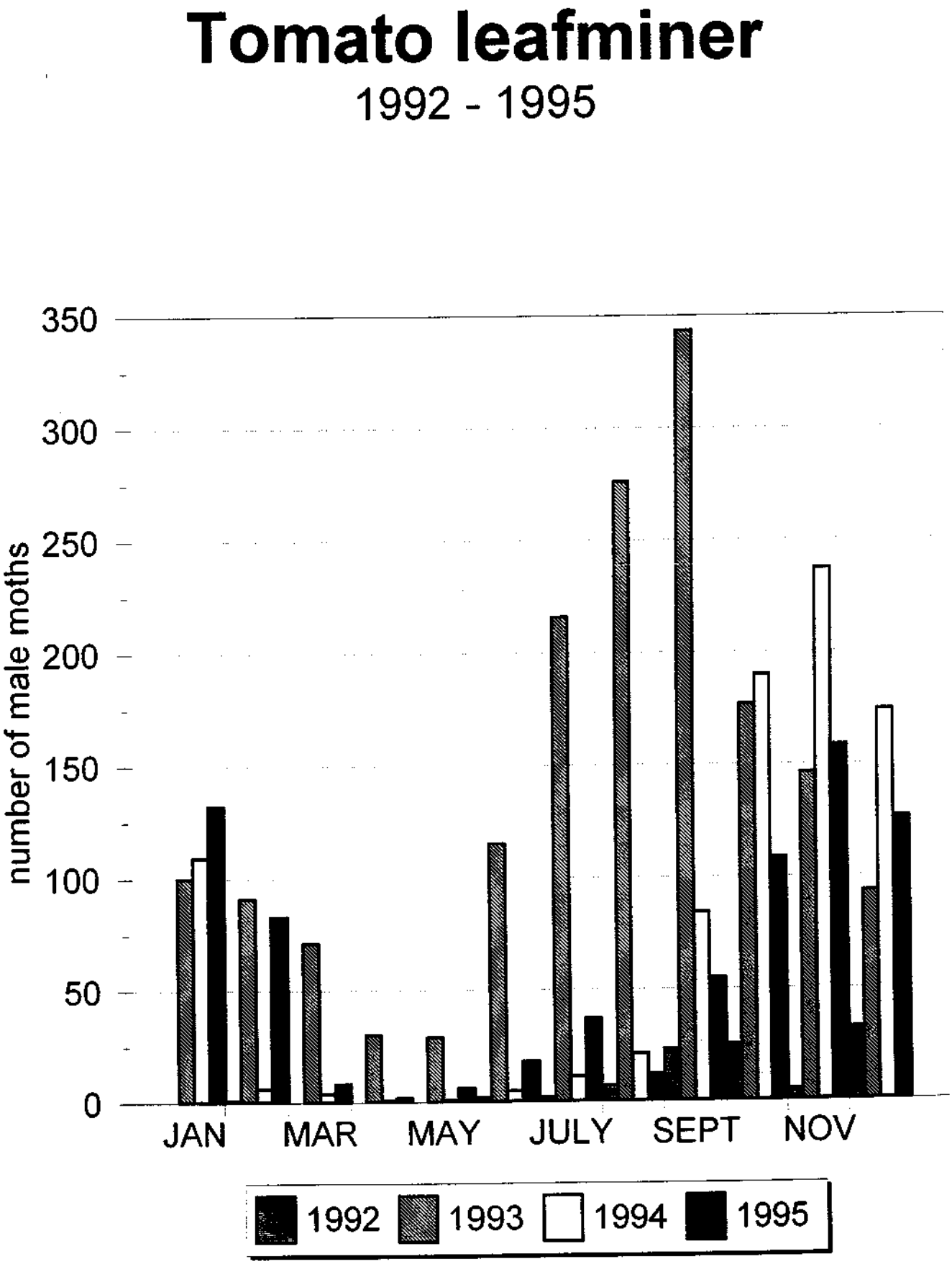
Average number of male leafminer moths per trap per week for 1992 - 1995

	JAN	FEB	MAR	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
1992		<1	<1	0	<1	2	2	7	23	26	5	33*
1993	100	91	71	30	29	115	216	276	344	178	146	93**
1994	110	6	4	1	1	5	11	21	84	190	237	174***
1995	132	83	8	2	6	18	37	12	55	108	158	126
1996~	33	3	<1	<1	<1							

* No seasonal break in 1992/1993 - 12 months production
** Seasonal break 1993/1994 - December 30th to February 1st
*** Seasonal break 1994/1995 - January 1st to February 1st

~ Leafminer trapping has continued in Bowen with recordings to date shown in this table.

Graph 1 **Average no. male tomato leafminer moths per trap per week**



minimum period of 4 weeks only was achieved. Leafminer numbers remained high. The benefit of a longer seasonal break appeared to be necessary in order to dilute the leafminer population. Extending beyond the term of this 3 year project, a longer seasonal break was achieved from December 25th, 1995 to February 5th, 1996, a period of 6 weeks. The 1996 trap counts (See Table 1) indicate a reduced leafminer population with a 6 week break in production.

The entire life cycle of tomato leafminer can be completed in 3-4 weeks in summer (Hassan, 1977), therefore a number of generations can occur in an infected summer crop. By extending the seasonal break to 6 weeks whereby no food source is available, namely tomatoes, the life cycle of tomato leafminer can be disrupted.

The seasonal pattern of leafminer in Bowen has been the same for the past 4 years (See Graph 1). Leafminer are active from June onwards. As temperature increases and cropping area expands the leafminer population increases which peaks between September and November . Leafminer will remain active as long as there is an available food source, which was the case in the December and January periods of 1992 -1993.

The trap and field monitoring of tomato leafminer conducted by the researchers in Bowen over the past 4 years has clearly shown that when the leafminer population is reduced by a seasonal break the carry-over population at the start of the following season is decreased and the spring build-up is reduced. The length of the seasonal break determines the extent to which the leafminer population is reduced. The 1996 trap counts support this conclusion. A 6 week break in production resulted in the lowest moth counts in 4 years.

2. *Climate*

Climatic conditions, namely temperature and humidity effect both general development and distribution of insect species. In general, humidity is important but not so critical a factor as temperature (Ross,1964). The rate of development (of tomato leafminer) is dependent upon temperature. At higher temperatures (up to 40 degrees C in constant temperature experiments) development from egg to adult may be as short as 2 weeks. At lower temperatures (to a minimum of about 11 degrees C) development will take several months (Horne, 1994).

In Bowen, during the winter months of June, July and August of 1992 to 1995, leafminer trap counts increased. Although the life cycle of tomato leafminer may have taken longer to complete(this was not a component of study in this project) due to the cooler temperatures, the population was seen to increase (See Table 1 and Graph 1) as the food source increased. Food is one of the most important factors influencing the distribution and abundance of insects (Ross,1964). This influence of a favourable food source on leafminer population is discussed under agronomic and cultural practices.

3. *Extension and Education*

All data collected was communicated to the Bowen and Burdekin farming areas by the following extension methods:

(i) Local print media
(ii) ABC Rural Radio - these reports were given by the principal researcher every week for 10 months of each year of the project. This broadcast went to North, Far North and North Western Queensland. The value and impact of these regular reports were not only to the benefit of all growers but also to the horticultural service industries and to the general public. These reports have continued to date.
(iii) Monthly newsletters
(iv) Fact sheets
(v) Seminars
(vi) Field days and shed meetings
(vii) IPM Committee
(viii) Liaison with QDPI

All the above methods were co-ordinated by the researchers culminating in the Bowen District Integrated Pest Management Committee establishing a Voluntary Code of Practice in 1995.

4. *Grower field trials - ' on farm research'*

(i) Agronomic or cultural practices

It was found from regular monitoring of tomato crops and pheromone traps that a rapid increase in trap numbers of tomato leafminer will be seen as visible damage in crops approximately 1 month after the trap increase.

By the end of the 1995 season, the value of sound crop hygiene practices based on the slashing of crop residues,rapid removal of plastic mulch and deep ploughing ground post-harvest was accepted by district growers as the best cultural method to reduce leafminer. The onus placed on these cultural methods was extensive, the benefits of which were gleaned from trial work conducted in Bundaberg by local consultants (J.Hall, pers. comm. 1992). Failure to clean-up crops, regrowth, volunteer crops or weed hosts resulted in a rapid increase in the leafminer population.

Planting schedules and layout in relation to neighbouring crops and potential pest problems coupled with consideration of prevailing winds was a pest management technique that was addressed and emphasised to growers of all fruit and vegetable crops. In relation to tomato leafminer, it was found that to plant upwind of high activity areas resulted in a reduced crop infestation of leafminer. Leafminer are weak fliers,though they can be transported long distances with wind assistance (Hargreaves,1992).

The value of planting upwind of pest infested crops is significant. Whether it be tomato leafminer or powdery mildew in rockmelons, the influence of the prevailing south-easterly winds of up to 25 knots during the winter production period in Bowen, is considerable. Wind direction and sites of infestation are directly associated with each other(J.Hall, pers.comm. 1992).

A seasonal break for a minimum period of 4-6 weeks between December and February accompanied by growers ensuring rapid clean-up procedures after final harvest of crops has resulted in substantially reduced pesticide usage and less fruit damage from leafminer.

In July 1995, a Code of Practice was formulated by the IPM Committee and Bowen District Growers, for the control of agricultural pests and diseases in the district. The Code covered crop hygiene, planting patterns, a production break and pest monitoring. The Code is based on self-regulation by the farming community.

For the Bowen growing season there have been 3 periods identified with respect to leafminer development. They are:
Critical Period 1: February to April = early season
Critical Period 2: May to July = mid season
Critical Period 3: August to December = late season

(ii) Biological control methods and (iii) Alternative pesticide strategies

In 1992 and 1993, it was found in tomatoes that under very high leafminer activity there was no difference in control between (1) alternating organophosphates (O.P's) on a 3-4 day spray interval (2) mixtures of O.P.'s and Bt's and (3) Bt's alone.

Commercial supplies of *Trichogramma* were not available in adequate quantities for large scale grower trials until October 1993. Late season trials involving endosulfan (Thiodan) plus Bt's, at registered rates, plus a release rate of 494.000 per hectare of *Trichogramma* resulted in reasonable heliothis control in tomatoes.

Sweetcorn trials with *Trichogramma* releases did not produce any differences in control of heliothis. Release rates of 50,000, 125,000 and 250,000 wasps per hectare were applied weekly with no reduction to cob damage at harvest.

It was seen from regular crop monitoring that predators, particularly native spiders found in Bowen tomato crops, were not eliminated by regular organophosphate insecticide applications. In ground grown tomatoes, once the bush had developed a canopy, spiders were able to seek refuge and avoid insecticide contact.

Beneficial insect activity was promoted with increased humidity in early and late season crops.

In 1994 early season trials with Bt's and the release of *Trichogramma* had to be abandoned due to a high level of tomato spotted wilt virus in the tomato crop. This virus which is transmitted by thrips cannot be controlled with Bt's.

Many observations were made on the use of *Trichogramma* in Bowen crops during the course of this project. These observations constitute the first made on commercial application of these biological control agents in this farming district.

* It was noted by the researchers that the wasps are host-specific and will remain in one area until all host eggs are parasitised.

* *Trichogramma* prefer high humidity. The low humidity and dry conditions, typical of the Bowen winter growing season, is not favourable to their survival.

* Organophosphate insecticides did not kill all *Trichogramma*.

* Two sweetcorn trials produced a 30% and 50% reduction in heliothis larvae at flowering with weekly releases of *Trichogramma*, lacewing eggs and larvae, and the larval parasitoids *Cotesia* sp. and *Microplitis* sp. with no pesticides applied. However, at harvest, cob damage was higher in these unsprayed blocks compared to sprayed blocks.

* In 1994 a late season grower trial was conducted in tomatoes using high release rates of *Trichogramma*, 500,000 per hectare per week with an application of a Bt on a 5-7 day spray interval. The heliothis egg pressure was low and tomato leafminer activity was low to moderate. Reasonable control of heliothis resulted with good control of leafminer. However, the pinholing of fruit caused by heliothis neonates prior to death was very high, resulting in an estimated 50% of fruit being culled at the packing shed for this damage.

CONCLUSIONS

This project has been very successful in achieving commercial outcomes in terms of reduced leafminer damage and subsequent increased production. This research has confirmed the following:

1. **In Bowen, late season cropping, later than December 25th, extends the period of leafminer activity, coupled with early season plantings in early February, results in high leafminer populations prevailing at the commencement of the growing season.**

2. **In Bowen, climatic conditions are not a major factor affecting leafminer development. An available food source (host crops, weeds and volunteer host plants) is the main contributing factor to population increase.**

3. **There needs to be a minimum of 4 weeks break in production with no available food source for leafminer. This will ensure a reduction in the population.**

4. **Cropping areas need to be slashed, plastic mulch lifted and deep ploughed immediately following harvest to minimise the food source and reduce pupal viability. Double cropping on old tomato plastic mulch increases the risk of tomato leafminer development due to the survival of volunteer tomato plants. The importance of farm and crop hygiene cannot be underrated as a major pest management tool.**

5. **The information and data disseminated to growers for the past 3 years has encouraged Bowen growers to adopt a Voluntary Code of Practice whereby there is a 4-6 week seasonal break in production.**

6. **More research needs to target biological control alternatives which are compatible with the conditions of the Dry Tropics Region.**

7. **In order for integrated pest management systems to operate in fruit and vegetable crops routine crop monitoring is essential.**

Grower adoption of sound farm hygiene practices on a district basis has been excellent. Adherence to the Code of Practice saw a 6 week seasonal break from December 25th, 1995 to February 5th, 1996. This pest management strategy has resulted in the leafminer population being the lowest in 4 years. The optimal seasonal break would extend from December 15th to February 15th to completely dilute the leafminer population for every season.

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Plate 1

Vertical water traps with pheremone lures were located throughout the Bowen farming district