Alternative fruit fly management for market access for apples

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Department of Employment, Economic Development & Innovation

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15 August 2010

This report shows the results of using an experimental technique that had previously been used in citrus crops in Queensland for fruit fly, to see if similar results could be obtained for apples, in terms of market access

Acknowledgements
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Table of Contents

Media Summary

Difficulty with control of Queensland fruit fly with four cultivars of apples on the Granite Belt, Qld

Warnings that the insecticides dimethoate & fenthion might be removed from the market for apples, had been current for several years. Dimethoate was widely used as a post harvest control measure as well as an in-field treatment. Fenthion also had and still has in-field usage. The project attempted to find a replacement for these control measures.

In citrus an approach of combining control measures (a systems approach), avoided the use of these insecticides. Instead protein hydrolysate bait spraying pre-harvest & pack-out inspection had been used. This was so successful that it obtained Interstate Certification Assurance for Victorian markets, (ICA-28).

A similar approach was taken on the Granite Belt to try this approach on apples. Trial work over five seasons attempted to show if such protein baiting would give sufficient control of Queensland fruit fly that the generated data might be used in an application for an Interstate Certification Assurance to enter Victorian markets.
Although four apple cultivars were tested, none reached the required standard of 99.99% clean fruits, that was (at the time of writing), required for an ICA. The cultivar Granny Smith performed the best with 99.6% clean fruit for four consecutive seasons. Red Delicious, Royal Gala & Pink Lady were less consistent with fruits lightly infested only in some years. While this data is disappointing, it points the way for further work.

So if individual importing states stand firm on the need for a 99.99% threshold level of an ICA; protein baiting will need to be supplemented with additional control measures, (such as the use of spinetoram or exclusion netting in addition to protein baiting) to strengthen a systems approach for apples.

However, if this extremely high level of control is reduced in the future, especially with the ramifications of the removal of dimethoate from the apple market*, this project's data would be crucial in obtaining rapid acceptance and clearance especially for Granny Smith apples.

* In Canberra, during this time period, the ultimate findings of the review of dimethoate in terms of residues & dietary risk; conducted by the Australian Pesticides & Veterinary Medicines Authority (APVMA) issued in August 2011. Dimethoate usage on apples was suspended as of 6th October 2011.

Technical Summary

Queensland fruit fly [*Bactrocera tryoni* (Froggatt)] is a serious pest of apples necessitating the application of control measures particularly as the crop matures before harvest. This is important especially to access markets in non-endemic areas of Queensland fruit fly e.g. Melbourne. Entry conditions into such markets require the use of a pre-approved disinfestation treatment.

Dimethoate was widely used as either a pre-harvest cover spray treatment for marketing into endemic areas or as a post-harvest flood spray or dip as an approved disinfestation treatment for non-endemic markets.

Fenthion is used only as a pre-harvest spray for marketing into endemic areas. However the uses of both fenthion and dimethoate have been under review by the APVMA since 1994. It was strongly suspected that the usages of both insecticides would be severely curtailed when the ultimate review report issued for each chemical. Dimethoate's review report issued in 2011and usage is presently effectively banned in apples as of 6 October 2011.

As programmes of pre-harvest protein baiting coupled with packing line inspections had been used effectively to obtain approval for marketing of citrus into Melbourne; this approach was tried on apple orchards in the Granite Belt. At present, to obtain such new approvals, data showing a 99.99% level of uninfested fruit has to be presented.

Over the period of the five harvests, none of the cultivars achieved this level consistently. Granny Smiths performed best with 99.6% clean fruit for four consecutive seasons. Red Delicious, Royal Gala & Pink Lady had lighter infestations only in some years. Cultivar differences were detected between the four in terms of susceptibility to Queensland fruit fly with Granny Smiths the most antagonistic to fly development & Royal Gala; the least.

While none of the data would reach the standard required for an Interstate Certification Assurance (ICA), which is disappointing, it points up the direction in which to go.

Further work is predicated on what future threshold level of damaged fruits individual states will accept. If there is a reduction, even slightly, from the present 99.99% threshold, cultivars such as Granny Smith should gain acceptance. For other, more susceptible apple cultivars such as Royal Gala; the systems approach of bait spraying needs to be strengthened. The incorporation of such chemicals as spinetoram, with an existing place in the apple spray program, but with a side benefit of also having an effect on fruit flies, is one path. The incorporation of exclusion /hail netting is another.

The fruit flies caught in cuelure baited traps in the district were almost exclusively *B.tryoni*. There appeared to be little relationship between trap numbers and fruit

damage in commercial orchards throughout the seasons studied. Trap catches were greater in the town areas and persisted there longer than in the surrounding cultivated areas or associated bushland. Further work needs to be done on cuelue traps if they are to be of greater use in prediction of bad fruit fly seasons.

Introduction

The Queensland apple & pear industry is centred on the Granite Belt where 99.2% of the apples and 96.6% of the state's pears are produced (Anon.2004, 2008) The industry is unique in having a strong domestic focus with minimal export or import of product (Ashton 2007).

Nationally Queensland produces 11.9% of the Australian apple harvest from 12.8% of the national orchard (Apples & Pears Australia Limited 2008). More than half of the Australian crop is consumed domestically as fresh apples with 35% being processed, principally as juice. Exports constitute only 10% of production (Australian Bureau of Agricultural Resource Economics 1997)

Agronomically, the Granite Belt utilises its advantage, of an earlier start to the production season, than southern states. The harvest is consequently spread to take advantage of these early & late parts of the season (February - June).

Queensland fruit fly [*Bactrocera tryoni* (Froggatt)] & to a much smaller extent the lesser Queensland fruit fly [*Bactrocera neohumeralis* (Hardy)] are part of the suite of major apple pests on the Granite Belt. They cause direct crop damage necessitating pre-harvest control measures. For pome fruit in endemic areas, cover spray treatments of two successive sprays of either dimethoate or fenthion, at 7& 4 weeks or 6 & 4weeks before harvest respectively; are available. In addition, trichlorfon can be applied as a cover spray, from the first sign of oviposition at 7-10 day spray intervals, with a 2 day withholding period (Anon 2011). However trichlorfon is not widely used and there is growing acceptance amongst orchardists of bait spraying for fruit fly with protein autolysate formulations plus either maldison or chlorpyrifos (C.McGrath, personal communication 2011).

In addition, to access markets in non-endemic areas, principally Melbourne, specific post harvest treatments must be applied e.g. Interstate Certification Assurances (*ICA-01 Dipping with dimethoate; ICA-02 Flood spraying with dimethoate; ICA-07 Cold treatment*)

In 1994 fenthion and in 1995 dimethoate were nominated for review by the Australian Pesticide and Veterinary Medicines Authority (APVMA). The nominations followed concerns for the toxicology & food residues for a range of registered pesticides that had been on the market for some time.

While the food use recommendations for fenthion have yet to be made public; the recommendations for dimethoate issued in 2011. As a consequence dimethoate usage on apples was forbidden. In anticipation of such a proscription of dimethoate usage and following one of the recommendations of the Department of Agriculture, Forestry & Fisheries (DAFF) national action plan, we proposed to adapt and use the techniques of the systems approach that had been successfully used in citrus to produce ICA-28 *Pre-harvest treatment (bait spraying) & inspection of citrus.*

Materials & Methods

Evaluation of the protein baiting and pack-house inspection of ICA28 as a quarantine treatment for apples.
The techniques used followed the lead given by the Horticultural Research & Development (HRDC) project CT970 that was to obtain data that might be used for interstate access to Victoria without the need for chemical post harvest treatment. As Dr Lloyd and her colleagues found, no guidelines were available as to what data was required, except for the Standing Committee on Agriculture & Resource Management (SCARM) Code of Practice for Management of Qld Fruit Fly of an efficacy level of 99.6% mortality. We adopted Dr Lloyd's practice of measuring efficacy in terms of the numbers of infested fruits, although larval numbers in fruits were also recorded. We were to find out much later that the efficacy level had been raised to 99.99%

Bait efficacy trials 2007 – 2011

For the 2006-2007 trial, blocks of the cultivars Granny Smith and Pink Lady were selected from the commercial orchard plantings of Mr M. Mattiazzi at Cottonvale. Again in 2008, blocks of Royal Gala and Red Delicious were sourced from the same property, as well as Granny Smith and Pink Lady from Mrs. L. Carniel's at Pozieres. For 2009, we sourced from the property of Mr G. Rizzato at Pozieres. For 2010 we used the same cultivars save that no Royal Gala fruit were assessed.

For 2011, to husband the funds, the Applethorpe Research Station was used to supply blocks of Red Delicious as well as Royal Gala.

Bait formulations

The bait formulations used followed local grower practices. Yeast autolysate (Fruit Fly Lure® - Bugs for Bugs, Mundubbera) was used at 2L product/100L water plus chlorpyrifos (Lorsban 750 WG®) 267g product as the bait components in both trials in 2007 & 2008.

Consequent trials in 2009-2011 used the formulated, pre-mixed bait lure Naturalure® (protein autolysate and sugar as the lure plus spinosad 0.24g/L as a toxicant – Dow AgroSciences, Aust.) at the rate of 1 part Naturalure® to 6.5 parts water. This change of experimental product was to mimic a growing grower trend to utilise the convenience of the formulated lure.

Bait application

For trials 1 and 2 the baits were applied by ourselves, using a hand powered 20L knapsack sprayer (Hardi BP20) delivering about 2 bar of pressure at the outlet nozzle. The nozzles delivered a coarse droplet as a spot spray at the application

rate of 15-20L/ha. Timed squirts were applied to the lower skirt of each tree of each row. The next week, the sides were alternated. For the grower applications, a range of application would be typified by a small all-terrain vehicle fitted with 100L tank and delivering a band of spray via a 12V 1-1.4 bar diaphragm pump. Application could be adjusted to either one or both sides of the row. Swivel nozzles directed the spray application.

Timing of bait applications

In general the baiting of individual blocks started around twelve weeks prior to harvest. The early varieties such as Royal Gala and Red Delicious, sprays started in late September. Later cultivars such as Granny Smith and Pink Lady had started by early November.

The field samples were harvested just prior to commercial harvest. Fruits were picked according to a statistically developed, systematic sampling plan based on the numbers of rows in each block; the numbers of trees in each row and ten designated positions on the tree. North, south, east and west inside; ditto outside; top centre and tree skirt were the designated positions on the selected tree.

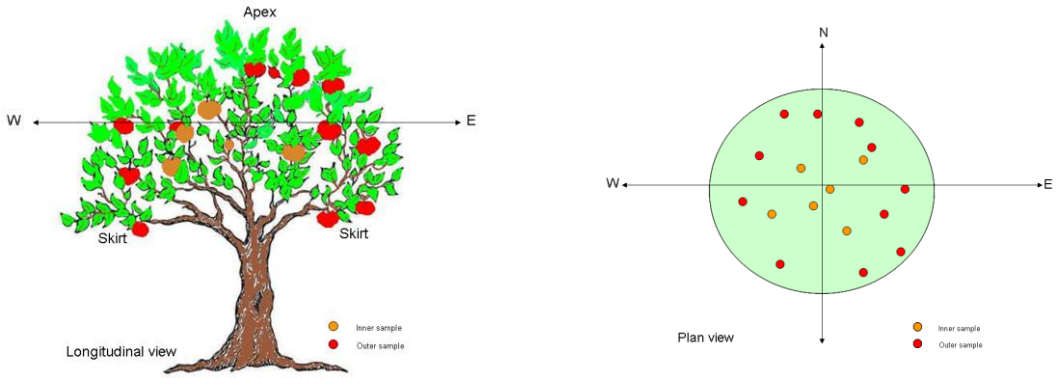

Figure 1 Apple sampling positions used in treatment blocks

Fruits of harvest size only, irrespective of quality (except obviously damaged, e.g. bird damaged or rotting fruit), were picked. Fruits were transported to the Applethorpe Research Station and either packed directly into our constant temperature room's holding containers or into commercial bulk bins for transport to the research station's sheds and subsequent repackaging the next day.

The packed holding boxes were stacked in two control temperature rooms running at 26oC and 60-70% relative humidity. These growing conditions assisted eggs and larvae to develop.

Fruit examination started 10 days after the loading of the control temperature room; examination could take up to 6 days depending on the load in the chamber.

Plate 1 Interior of controlled temperature room

Plate 2 Holding box for apple incubation

Fruit were held in 30L plastic containers, vented with organdie or muslin gauze lids. Layers of holding boxes were separated by 25 x 50mm battens, to assist air-flow.

Fruit examination

After 10 days in the growth chamber, boxed fruits were removed successively and the contents examined. The boxes were checked for emergent pupae before the fruits were scanned for obvious entry or exit sites. Each piece of fruit was cut along the core before each half was sectioned into at least six slices. Slices were carefully examined visually for any evidence of fruit fly infestation. The numbers of infested fruit and the larval loads were recorded.

Plate 4 Infested fruit with larval tracking

Plate 3 Dissected fruit just prior to inspection

Analysis of results

The analysis was performed by departmental biometricians, It is understood that they utilised programmes adapted on the methods described by Couey and Chew (1986).

Determination of apple Host Susceptibility Index for Queensland fruit fly

The Host Susceptibility index (HSI) was developed by QPIF Market Access researchers to quantify varietal differences in host susceptibility to Queensland fruit fly (Qfly), *Bactrocera tryoni*. It is determined by undertaking a controlled laboratory infestation test based on the host status testing procedures defined in the *New Zealand Ministry of Agriculture & Fisheries Regulatory Standard for Host Status 155.02.02.*

The HSI for a particular variety is determined by the number of flies per gram of fruit that complete development when the variety is exposed to a potential infestation rate of one egg per gram of fruit under controlled laboratory conditions.

In this trial, tests were conducted on four apple cultivars – Royal Gala, Red Delicious, Granny Smith and Pink Lady.

To determine the number of female flies required to achieve the infestation rate of one egg per gram of fruit, an oviposition test using mature, protein fed females from the QPIF laboratory colony was conducted 24 hours immediately prior to the susceptibility test. Fifty female flies were allowed to oviposit into a small plastic cup punctured and coated with apple juice for 24 hours. At the end of this period the total number of eggs was counted and the mean number of eggs laid by each female calculated.

Pesticide free, unblemished fruit, at harvest maturity for each variety was used for all susceptibility tests. Fruit was washed thoroughly and six replicated samples each weighing approximately 650g (usually 4-5 fruit) were prepared. A pricked, hollowed out apple dome, made from an organic, pesticide-free "Red Delicious" apple was used as a "control". Based on the results of the oviposition test, the number of female flies required to oviposit one egg per gram in the test sample was calculated and this number of flies, from the same cohort used for the egg test, was counted into each of seven gauzed cages (30x30x30cm). The cages were placed in a controlled temperature room at 26°C and 70% relative humidity and the prepared fruit samples were introduced into the cages. After 24 hours, the fruit samples were removed and placed in gauze-topped plastic containers containing moist vermiculite and were then held at 26°C and 70% relative humidity for fruit fly development. The "control" was cut into sections and placed with the inner surface in contact with a tray of artificial diet and held as above.

Test samples were examined for pupae twice a week up to 44 days after infestation. Days to first, maximum and last pupal recovery were recorded. Pupae were held until flies emerged. The "control" sample was used to confirm the fertility of the female flies but the number of flies recovered had no relevance in the determination of susceptibility for each variety. The HSI is calculated based on results from the test replicates only.

Fruit Fly Monitoring

Fruit fly populations in and around the trial sites were monitored with Lynfield style traps. The traps were baited with commercial cuelure /maldison wicks and were replaced at three-monthly intervals. Four traps were placed within the trial blocks

spaced at 25m centres and four additional traps throughout the remainder of the orchard at 50m centres.
For the 2007 harvest, around half of our pick was bulk binned and placed in the hands of the grower to be passed over his packing line. The fruit that was passed as marketable from our bulk bins, was collected and packed into our incubation boxes, then transported to Applethorpe research station for incubation and assessment.

District wide trapping

Fruit fly trapping across the Granite Belt aimed at estimating fruit fly abundance outside of the main orchards. Lynfield traps baited with Cuelure were placed in feral host trees (commercial fruit trees growing wild – generally as seedling fruits). While these trees were naturally more abundant in drainage areas near main roadways, shady trees were used in their absence.

As a generalisation, the traps ran on a north-south axis, pivoting on the town of Stanthorpe. Five traps were also placed within the town to record urban fly activity as were two traps in Warwick. Traps were also placed to the east and west, such that to the east the furthest trap was below the scarp of the Granite Belt and into the headwaters of the Clarence River. To the north, traps generally followed the north flowing creeks off the Granite Belt plateau to ultimately join the Condamine River at a lower elevation than the general Granite Belt. Because they were more accessible, sixteen of the northern traps that were closer to the roads were serviced weekly. The remaining seventeen traps in less accessible sites were checked every 2-3 weeks. Trap data was expressed in counts/day/trap.

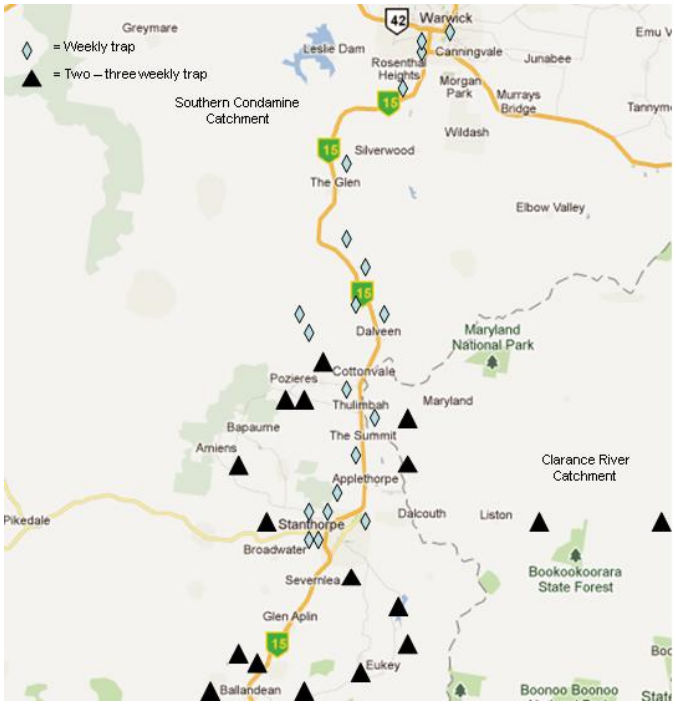

Figure 2 Layout of non-orchard traps used in the study

Results

Evaluation of protein baiting and inspection as a quarantine treatment.

Table 1. Infestation levels & fruits sampled for all harvests

Harvest year	Cultivar	Treatment	No. fruit sampled	No. fruit infested	Upper % infested (95% confidence)
2007	granny smith	direct incubation	5452	0	0.0549
		packhouse then incubation	4875	0	0.0615
	pink lady	direct incubation	4943	9	0.3180
		packhouse then incubation	5469	5	0.1920
2008	royal gala	direct incubation	7765	0	0.0386
	red delicious	direct incubation	7456	0	0.0402
	granny smith	direct incubation	8425	2	0.0747
	pink lady	direct incubation	7887	18	0.3384
2009	royal gala	direct incubation	10170	151	nc
	red delicious	direct incubation	9540	652	nc
	granny smith	direct incubation	7750	19	0.3597
	pink lady	direct incubation	5040	65	1.5855
2010	red delicious	direct incubation	4350	1	0.1090
		cold then incubation	4500	0	0.0666
	granny smith	direct incubation	3220	1	0.1473
		cold then incubation	3360	0	0.0892
	pink lady	direct incubation	3500	1	0.1355
		cold then incubation	2880	0	0.1040
2011	red delicious	direct incubation	8000	27	0.4654
		direct incubation	7360	44	0.7687
		(bulked)	15360	71	0.5632
	royal gala	direct incubation	8000	250	nc

nc = values too large & not able to be calculated

Table 2. Numbers of fruits discarded for each harvest

Harvest year	**Cultivar**	**No. sampled**	**No. discarded**	**No. trees / block**
2007	granny smith	5069	194	113
	pink lady	5099	156	420
2008	royal gala	7967	202	137
	red delicious	7598	142	489
	granny smith	8677	252	113
	pink lady	8047	160	420
2009	royal gala	10393	223	137
	red delicious	9788	248	489
	granny smith	7913	163	113
	pink lady	5151	111	420
2010	red delicious	9018	168	406
	granny smith	6776	196	415
	pink lady	6507	127	436
2011	royal gala	8192	190	50
	red delicious	8168	168	65
		7544	184	65

Table 3. Calculated upper % infestation levels (95% confidence) for all four cultivars

Cultivar	Total no. fruit*	No. infested	Upper % infestation level (95% confidence)
Granny smith	24847	22	0.1264
Pink lady	21370	83	0.4662
Red delicious	29346	680	>0.5453
Royal gala	25935	401	>0.6167
All cultivars	101499		

* Only fruit directly incubated

Table 4. Results of standard test using calculated infestation rate of 1 egg per g of fruit.

Variety	Mean flies per g fruit ± SE (HSI)	Mean days to first pupa	Mean days to last pupa
Granny Smith	0.003 ± 0.001	24	30
Red Delicious	0.082 ± 0.024	16	35
Pink Lady	0.127 ± 0.017	17	33
Royal Gala	0.197 ± 0.040	13	34

Table 5. Comparison HSI for other crops.

Variety	Mean flies per g fruit ± SE (HSI)	Mean days to first pupa	Mean days to last pupa
Eureka Lemon	0.002 ± 0.002	14	22
Murcott Mandarin	0.083 ± 0.014	15	29
Capsicum	0.17 ± 0.06	11	16
Nectarine cv. Sundowner	0.59 ± 0.05	8	16

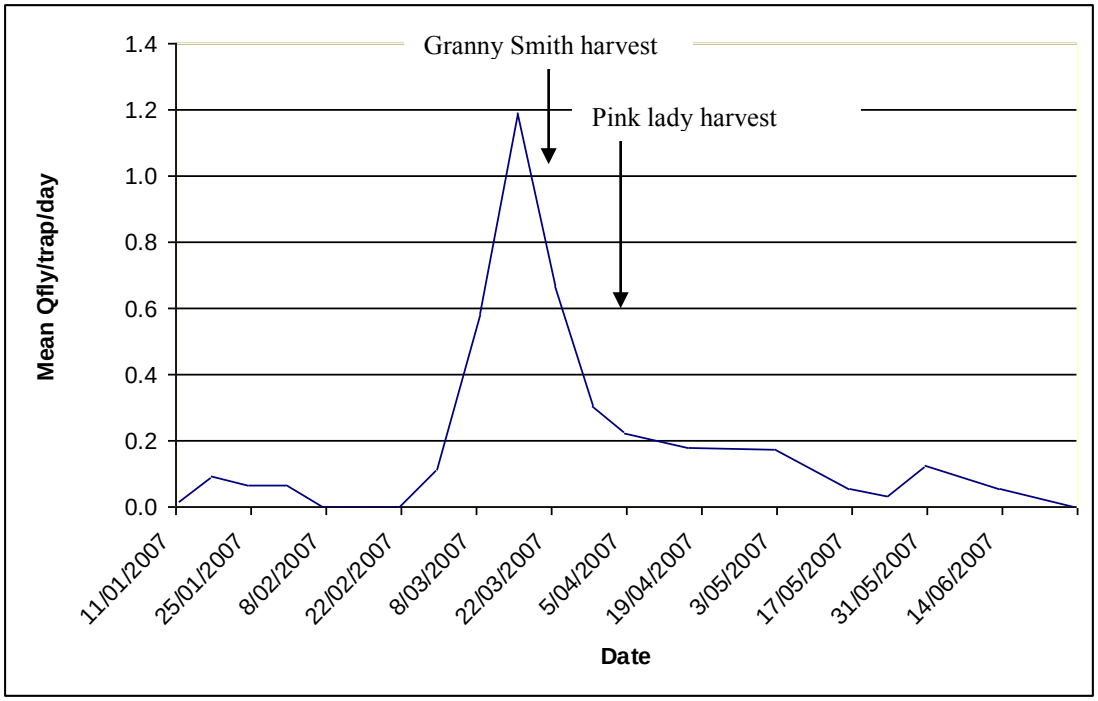

Figure 3 Mean number of *B. tryoni* per trap per day at Mattiazzi's

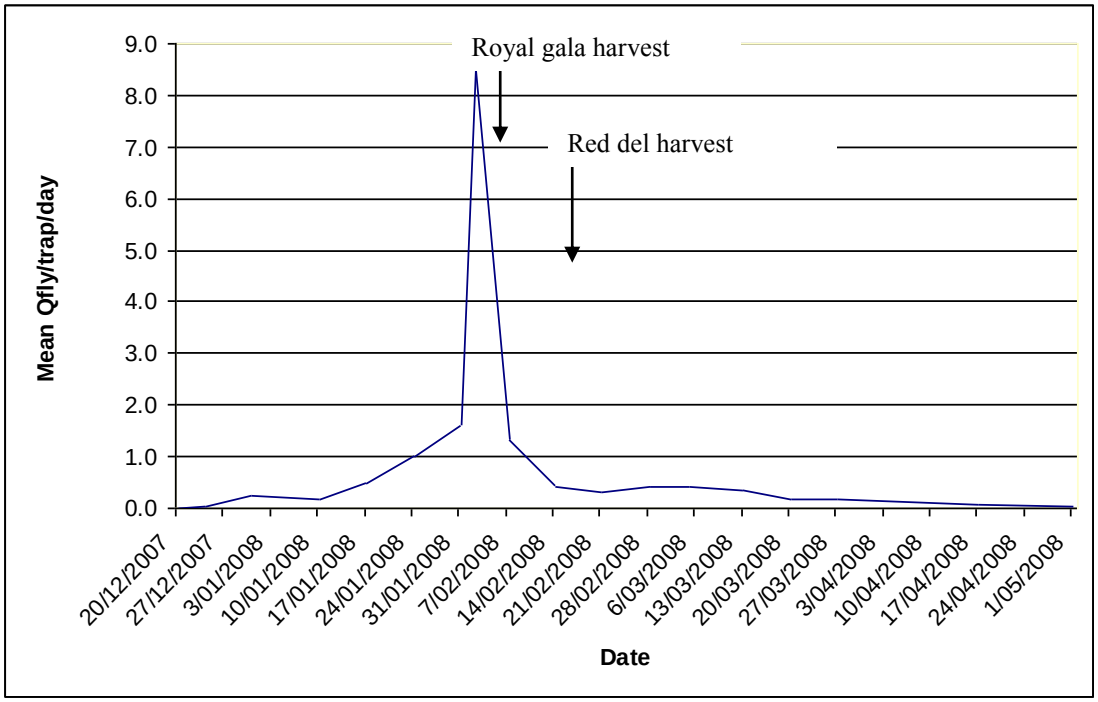

Figure 4 Mean number of *B. tryoni* per trap per day at Mattiazzi's

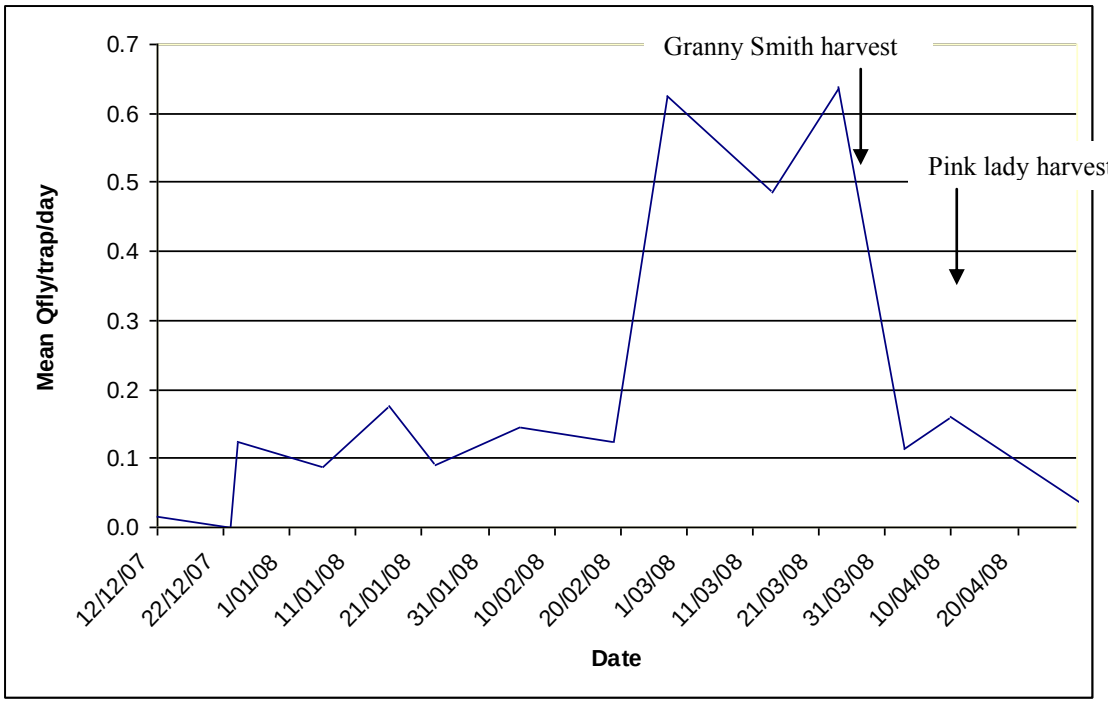

Figure 5 Mean number of *B. tryoni* per trap per day at Carniel's

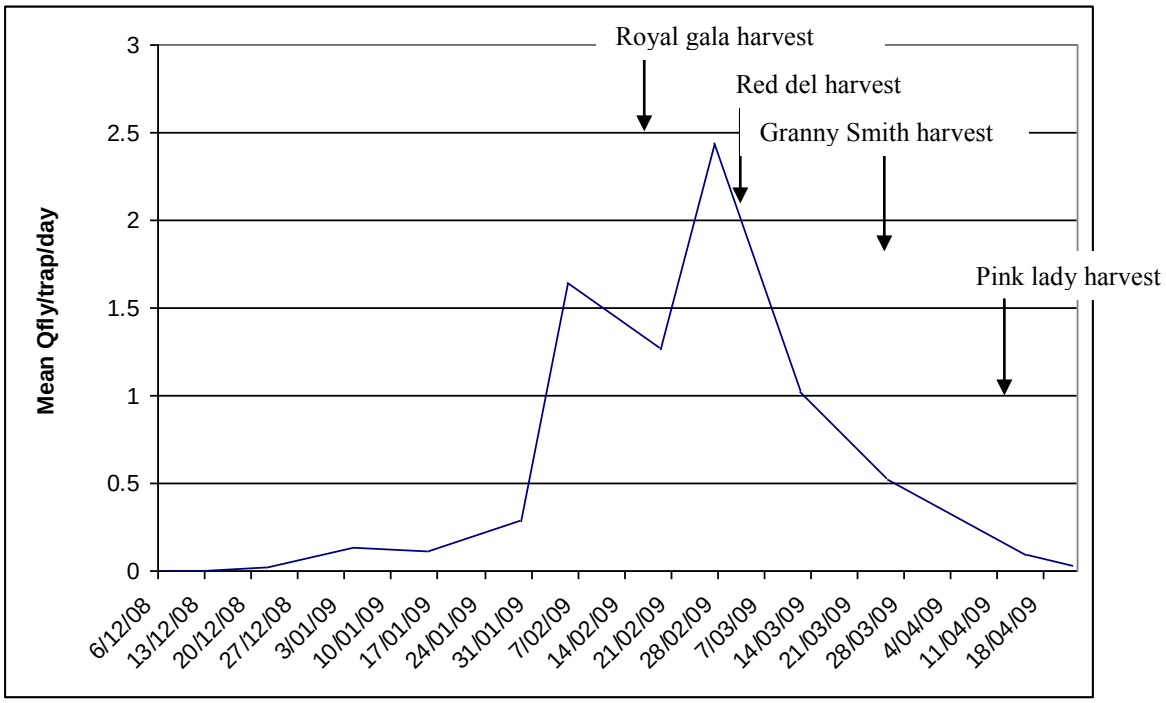

Figure 6 Mean number of *B. tryoni* per trap per day at Rizzato's

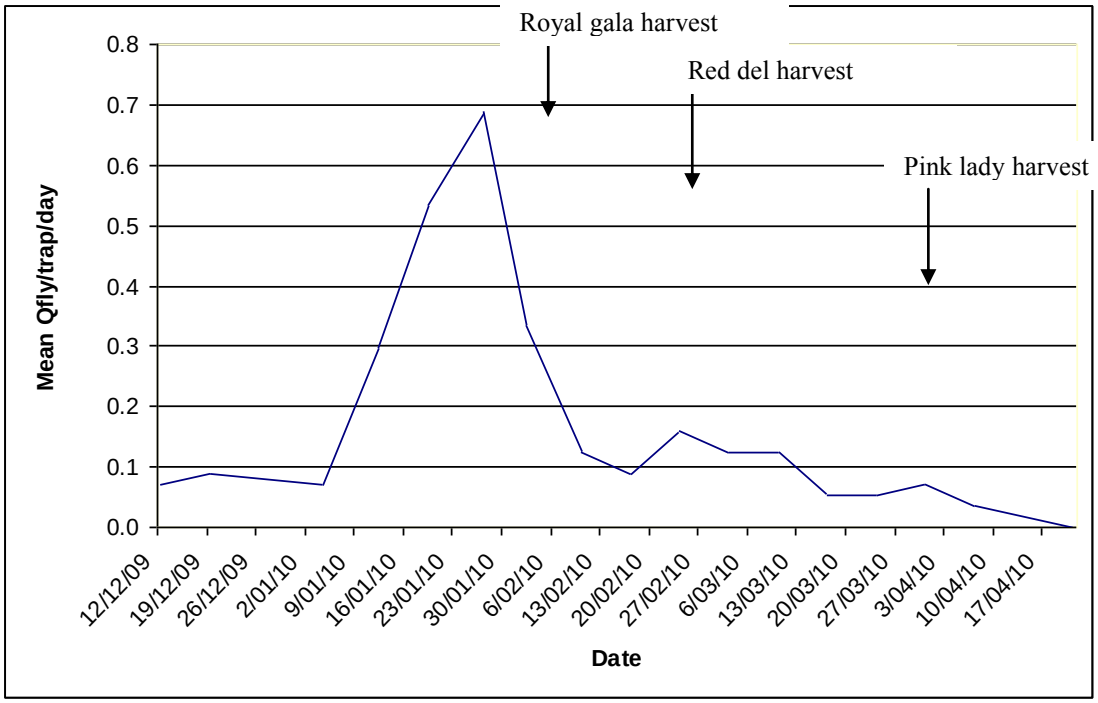

Figure 7 Mean number of *B. tryoni* per trap per day at Mattiazzi's

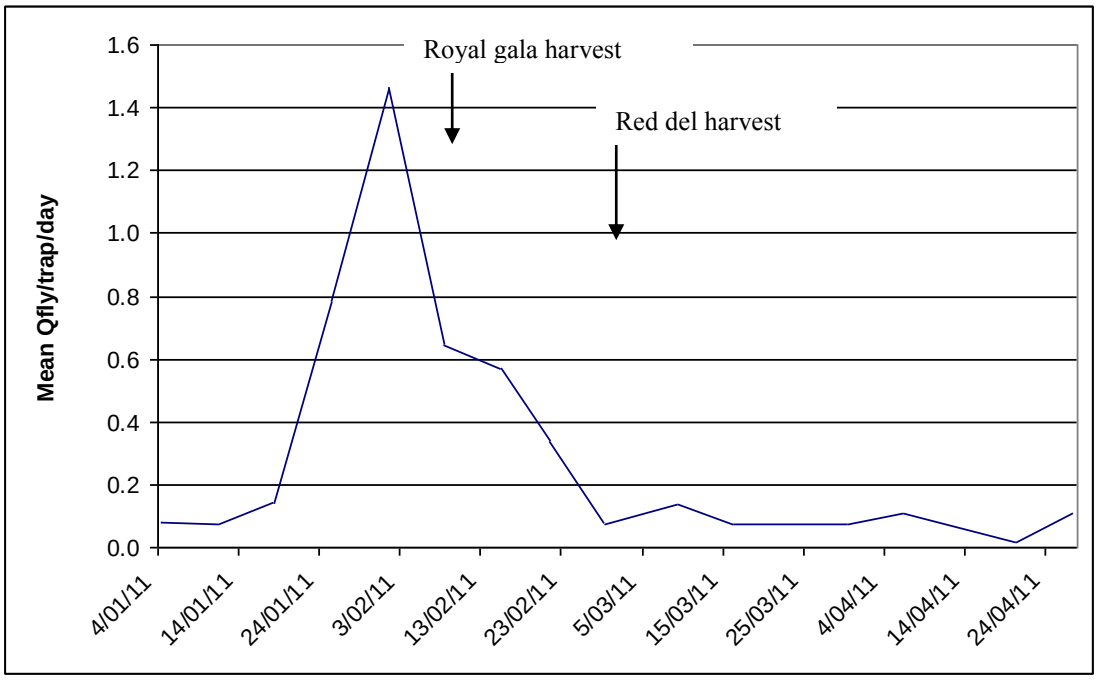

Figure 8 Mean number of *B. tryoni* per trap per day at ARS

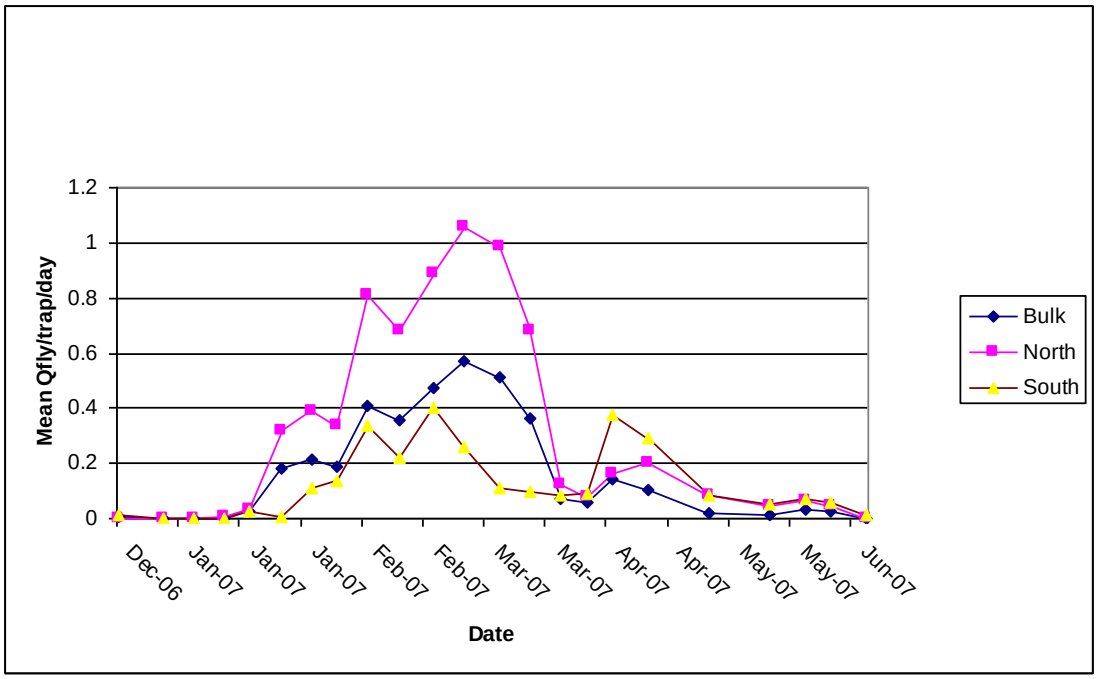

Figure 9 District (non orchard, non urban) trap catches 2007

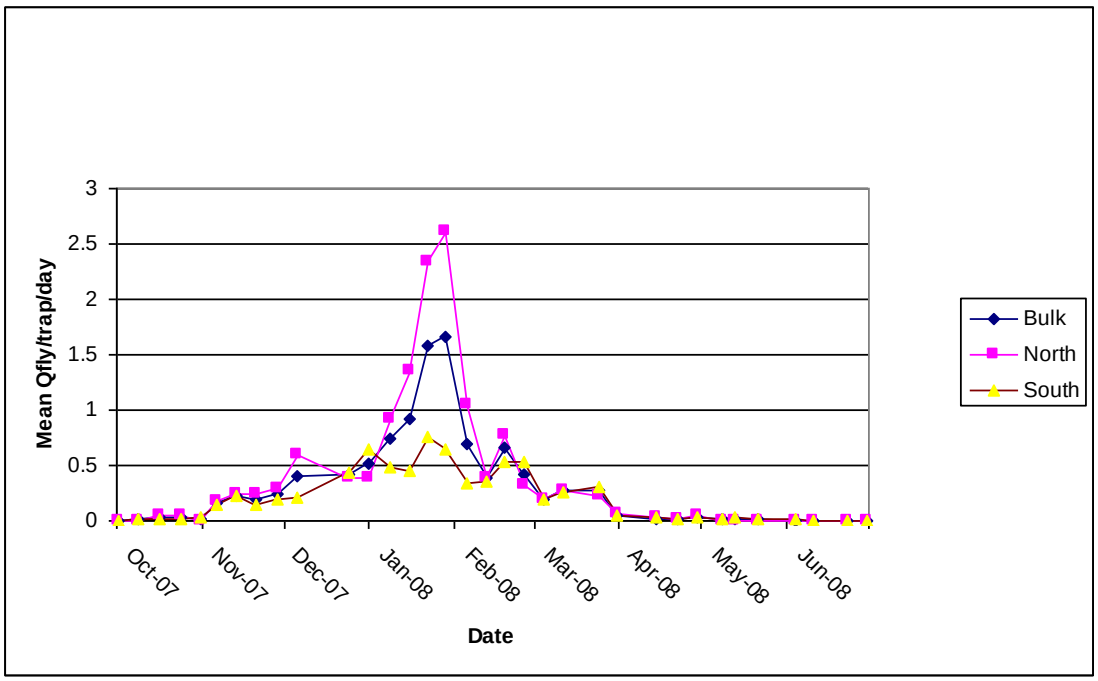

Figure 10 District (non orchard, non urban) trap catches 2008

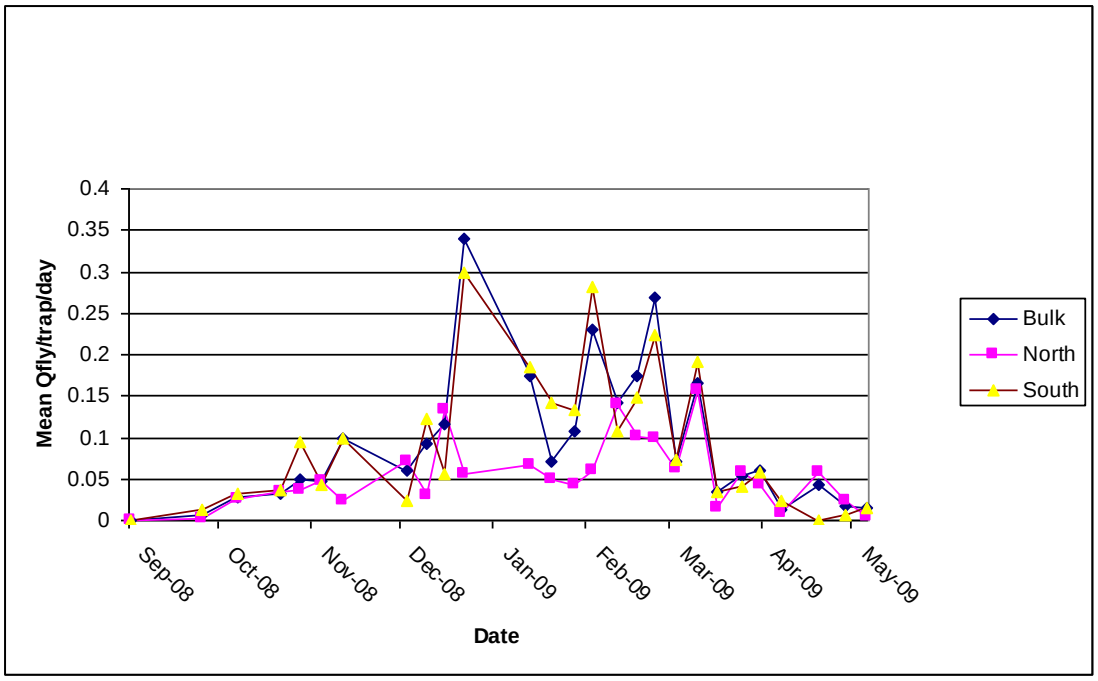

Figure 11 District (non orchard, non urban) trap catches 2009

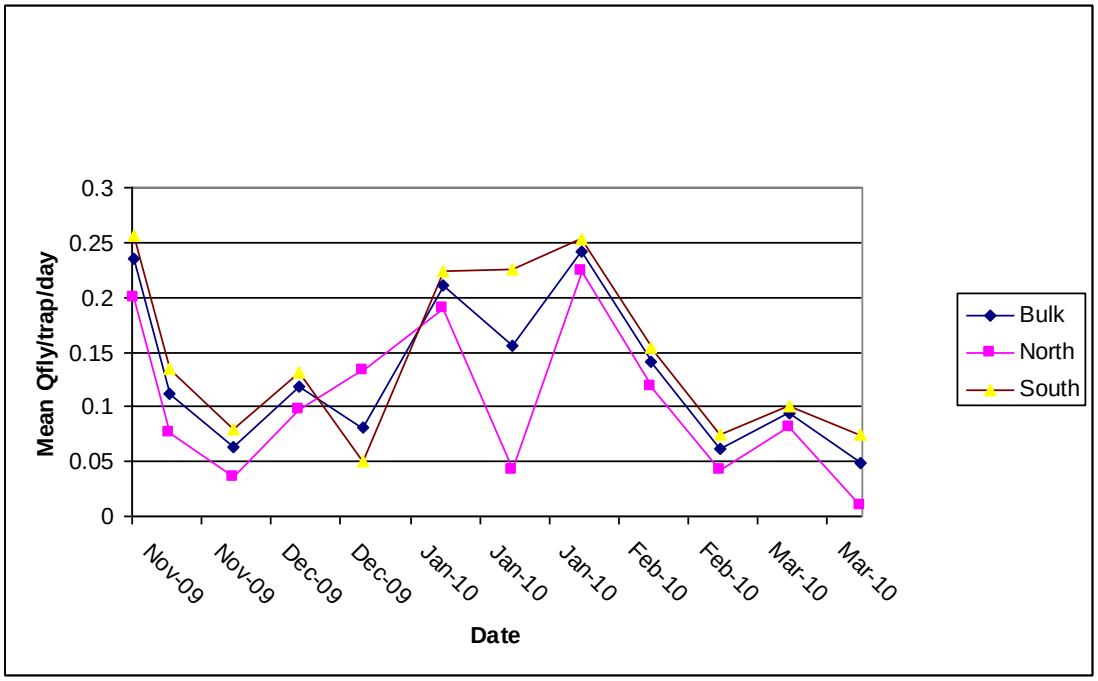

Figure 12 District (non orchard, non urban) trap catches 2010

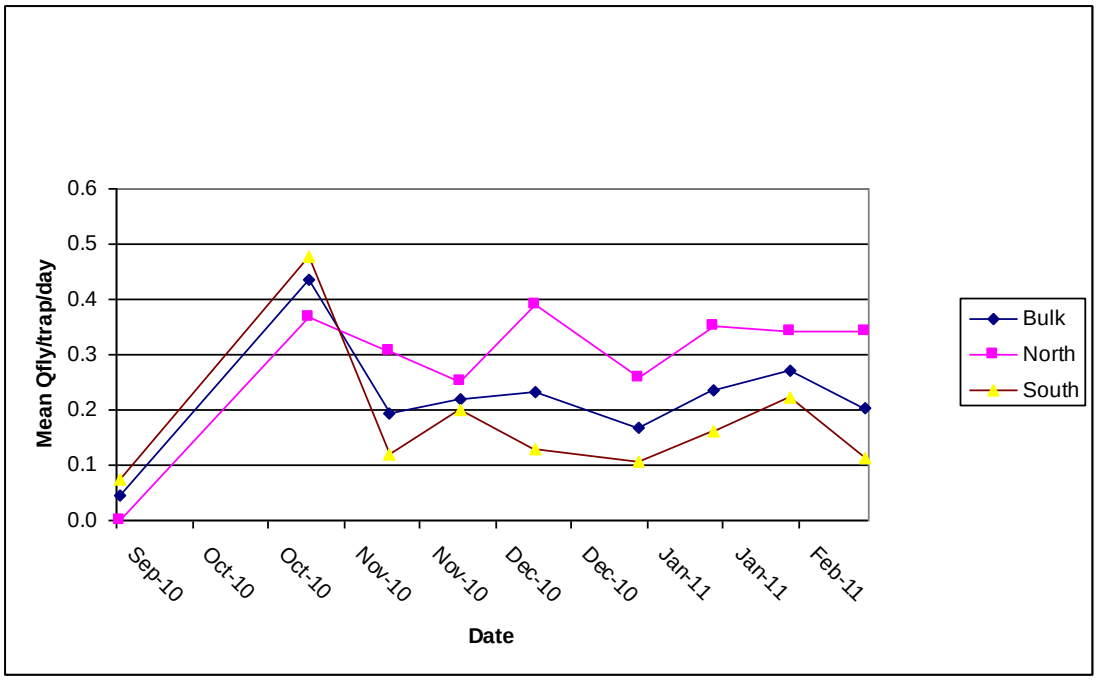

Figure 13 District (non orchard, non urban) trap catches 2011

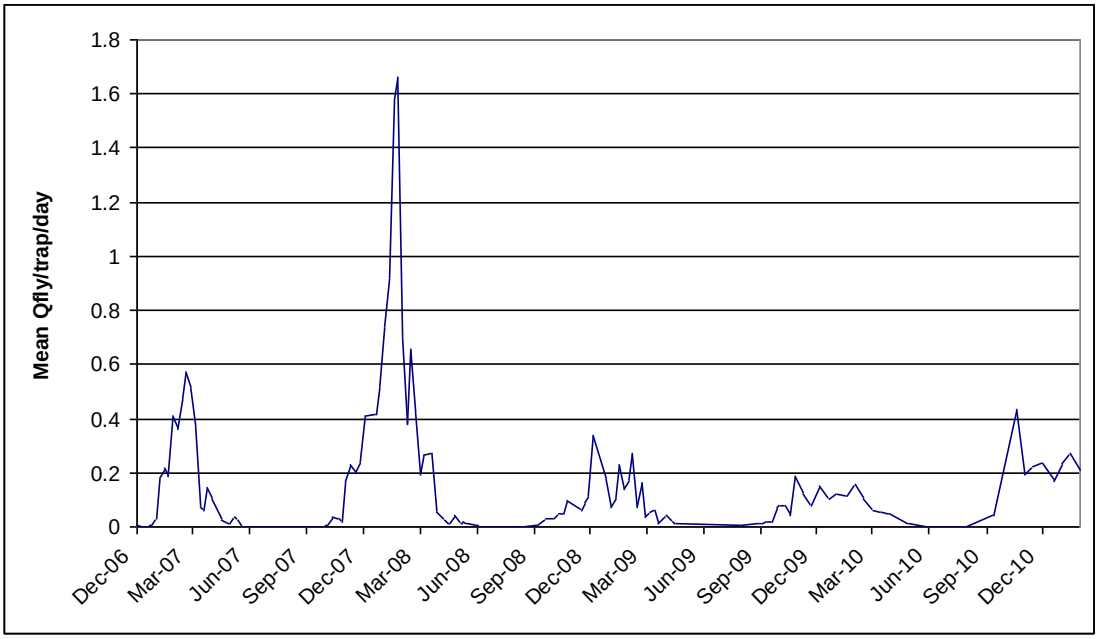

Figure 14 District (non orchard, non urban) trap catches 2006 – 2011

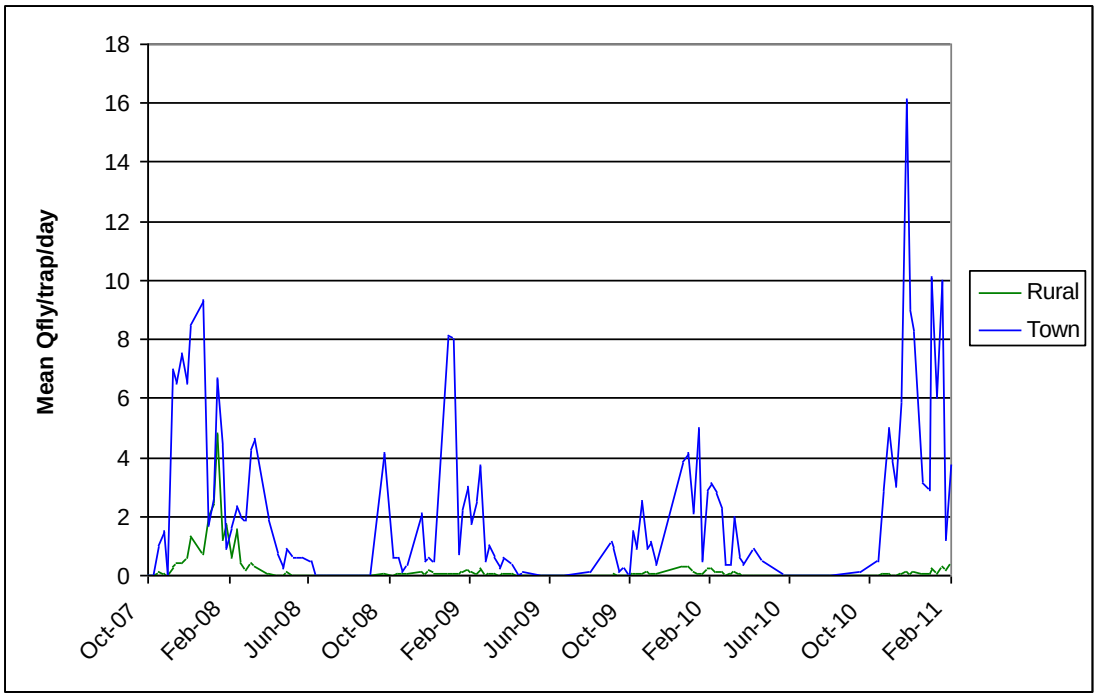

Figure 15 Mean number of *B. tryoni* per trap per day - rural versus town traps

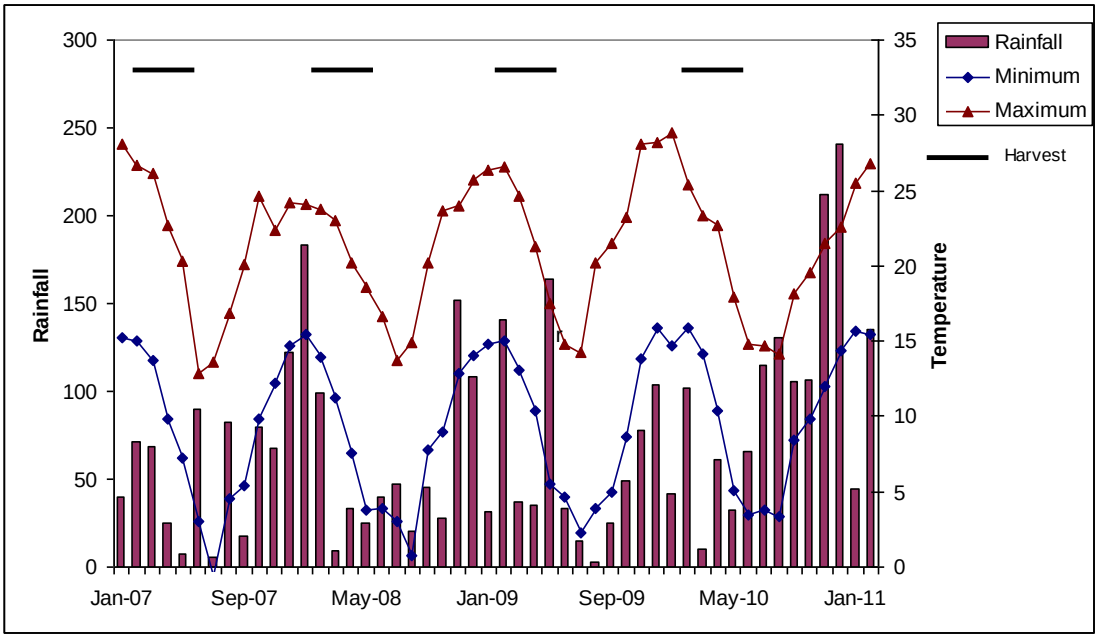

Figure 16 Max-Min average air temperatures and rainfall records Applethorpe Research Station

Discussion

For the 2007 harvest of Granny Smiths and Royal Gala, we were to realise that unlike citrus or table grapes, apples are generally subjected to a time of cold, bulk storage before passage across the packing line. Our fruit had periods of continuous cold of 5°C (4.5-5.5°C) – 43 days; 2°C (1.5- 3.5°C) - 21 days; interspersed with more continuously varied temperatures (9 - 21°C) This cold storage, though not as precise as the requirements for ICA 07, would still be inimical for fruit fly development. The effect that we wished to examine, i.e. the inspection process would have been masked by the period in cold storage.

In consequence, as we could not access commercial packing lines without cold storage, we could not include this process in our trial work. Notwithstanding inspection, we discarded any misshapen, miscoloured or dimpled fruits that looked like fruit fly oviposition prior to packing our holding boxes before direct incubation in the constant temperature room. The numbers of reject fruit are shown in Table 2

For the 2008 harvest, all cultivars gave upper % infestation (95% confidence) values of less then 0.4. However for the 2009 harvest, only the Granny Smiths were below the 0.4 threshold. The Red Delicious and Royal Gala were so infested that the biometrics programme could not calculate values.

These high values greatly puzzled us. It was our opinion that if growers were experiencing similar infestation levels even in fruits sent to the local markets, there would be obvious concern. Neither our extension staff nor ourselves had heard such disquiet. The only thing that growers were doing different to what we were doing was utilising cold storage in their agronomy.

To show this probable involvement, we divided the 2010 harvest into two. One part of the harvest we boxed but placed in cold storage (2 ± 0.5°C for 12 days following the recommendations of Peter Leach) in an old cold-room on the research station. The boxes were subsequently removed from the cold–room and directly incubated.

The other part of the harvest was directly incubated without any cold involvement.

Plate 5 Exterior of cold room used

Plate 6 Interior of cold room used

From the table, a degree of difference with the cold treatments can be detected although the overall infestation is light, with all treatments below the 0.4 threshold.

For the 2011 harvest, we attempted to strengthen the protection system by additionally using azinphos-methyl (Gusathion 200®) as a later component of the codling moth spray schedule, in addition to the bait spraying. [Thiacloprid (Calypso®) was used in the earlier codling moth programme sequence to alternate the chemical groups as a resistance prevention mechanism]. Azinphos-methyl has a listed side benefit of helping to control fruit flies, (Anon 2011).

The Red Delicious were picked on two dates (4 March and 7 April 2011), incubated & analysed separately However as the fruit on both dates were harvested from the same plots, the samples were assumed to belong to the same fruit population and be subjected to the same conditions of fruit fly presence. So a bulked total was also included in the table.

Table 3 has taken the data from all direct incubations for all years and bulked it for analysis. We followed the advice of our biometrician, Dr. Rosemary Kopittke, who advised that as long as the post-harvest treatments were the same, bulking of harvests was legitimate.

Host susceptibility index

Details of results are shown in Table 1. Granny Smith apples were the least susceptible and Royal Gala apples were the most susceptible variety with a Host Susceptibility Index of 0.003 ± 0.001 and 0.197 ± 0.040 respectively.

The mean number of days to first pupal recovery was 24 days for the Granny Smith variety and 13-17 days for all other varieties. For all four varieties the mean number of days to last pupal recovery was 30-35 days. The results indicate that for Qfly, the four tested varieties have a low to medium suitability as a host, similar to citrus (Table 2). The relatively longer time for pupal development in apples compared to other crops suggests that other physiological factors may impede fruit fly development in apples.

District trapping
(Orchard traps)

The results of fruit fly trappings for each harvest site are shown in Figures 3-8. Comparison of these figures with fruit infestation levels in Table 1 would suggest that

cue lure trapping of male flies is not a reliable estimation of fruit infestation levels in the apple orchards that were studied.

From the 2007 harvest, the fruit infestation was light and traps recorded a peak of 1.2 flies/trap/day. However in the same orchard for the 2008 harvest a peak of 8.4 flies/trap/day was reached yet infestation for the harvest was light. The harvest in 2009 was heavily infested but this was not reflected in the traps which only reached 2.4 flies/trap/day at Pozieres.

The orchard traps at Cottonvale in 2010 were low with a peak of 0.68 flies/trap/day and infested fruits were also slight. At Applethorpe in 2011 a low peak of1.5 flies/trap/day did not reflect the much higher infestation levels for the period.

(Non orchard traps)

The yield of the non-orchard traps are shown in Figure 14 for the entire trial period and in more detail for individual years in Figures 9-13. As a generalisation, the non-orchard traps mirror the yields of the orchard traps. Both show the higher fly populations of 2008; which by comparison with Figure 16 shows good summer rainfall for the period.

While yields from the northern traps were better in 2007, 2008, 2011; the dominance is reversed in 2009 & 2010.

The importance of the urban trapping is shown in the comparison of yields of urban and non-orchard traps in Figure 15. Not only did the town traps collect more flies, the traps continued to catch further into the autumn and spring. Although both traps were barren in winter, the results would hint at a possible overwintering focus in the towns.

The Queensland fruit fly populations in the district essentially started in September and were gone by June. Peak numbers occurred around February when the early apple cultivars were at their most susceptible.

Technology Transfer

Updates of the project were prepared for inclusion in the HAL Apple & Pear Industry report for 2007/08, 2008/09 & 2009/10.

Recommendations

The trial work showed that effective control of Queensland fruit fly can be achieved in apple orchards with the protein bait spray technique. However the degree of control will vary with both years and cultivars. For the uniform level of control required for quarantine our late maturing cultivars Pink Lady & Granny Smith gave the more consistent results although even they did not reach the required 99.99% level that will be required for the data to be considered by the Domestic Quarantine Working Group for a potential ICA.

Logistically we could not utilise the degree of culling by inspection on the commercial packing line that other colleagues have utilised successfully for other crops, because harvested fruit were almost invariably placed in cold storage immediately after harvest. Our work has hinted at the utility of using periods of cold storage to further strengthen the degree of control found in bait spraying.

Under the provisions of ICA-07 (Cold Treatment) coldrooms for this operational procedure have to be purpose built. The degree of temperature sensing & recording needed for compliance makes that coldroom virtually a dedicated facility. However most growers already have coldrooms for storage & "putting the apples to sleep". These normal storage coldrooms do lack the sensory equipment required with compliance with ICA-07. Not withstanding their lack of temperature regulation, it is felt that they gain unwitting protection by infested fruits not developing further. Work with a robust system of accumulation of cold units that could be adapted to growers' on-farm storage rather than a dedicated disinfestation facility may be a direction worth further investigation.

Although the insecticide spinetoram was not used as part of the production schedule on any of the farms in our work, it is registered for use in apples & pears for codling & light brown apple moths (Delegate®.) It is understood that laboratory trials are underway to look at its control of fruit fly [Gu, H. (2011) personal communication]. If spinetoram has an action against fruit fly; it would be a potential inclusion to strengthen a systems approach utilising protein baiting. In this way it may well come within striking range of an ICA.

Acknowledgements

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Appendix

HAL Apple & Pear Industry Annual Report 2007/2008

Project No: AP06006 Project Title: Alternative fruit fly management for market access for apples

What was the reason & methodology of the project?

The project started because there are strong indications that the use of the chemicals fenthion & dimethoate were to be restricted. Moreover project work in the Central Burnett had shown that the use of protein autolysate bait sprays in conjunction with both inspection on the packing line combined with the normal spraying or agronomy for other pests & diseases; can be accepted by interstate destinations (ICA28). This work was conducted on citrus by Dr. Annice Lloyd.

Our project was to repeat this procedure for apples, with the aim of gathering enough data to satisfy the requirements of importing states. With Dr.Lloyd as a collaborator it was anticipated that her expertise would guide us

.

What's been achieved this year?

Project activity for the previous season had focussed on getting information on infestation levels in two late maturing cultivars. We had found that no Qld. fruit flies had infested any of the 10,327 fruits we harvested, incubated & dissected for the Granny Smiths. Of the 10,412 fruits of Pink Lady, similarly treated, 12 fruits were infested but no live fruit fly larvae were obtained.

This absence of live larvae in the Pink Lady exposed a shortcoming with our experimental protocol. We had agreed to a field collection as well as a collection from our treated areas after passage along the packing line. The procedure followed that used for citrus to obtain ICA28. We were to find that apples, in contrast to citrus, are cold stored-either at normal or controlled atmospheres-before passage over the packing line.

So while there is little doubt about the success of the Granny Smith control, mortality of the larvae in the 12 fruits of the Pink Lady could be from either the normal orchard husbandry or from cold storage.

Discussions with both our biometrician (Dr.Rosemary Kopittke) and senior disinfestation scientist (Dr.Annice Lloyd), suggested that the protocol be amended to include no cold storage component. So in addition to last seasons work, we repeated the treatments on both Granny Smith & Pink Lady as well as the proposed earlier cultivars Royal Gala and Red Delicious, during this season.

No infested fruit has been found for the Royal Gala & Red Delicious, after incubating & dissection. However infested fruit, with live larvae, have been found in the Granny Smiths. This is puzzling, particularly in view of the lack of any infestation last season. Population studies from our fruit fly traps would suggest that this season was slightly worse for fruit fly than the last.

One difference that is becoming more apparent & may help to explain the anomaly is the incidental effect of cover sprays applied for other pests. It is strongly suspected that one particular codling moth spray may have an (otherwise unreported) effect on populations of Qld. fruit fly.

Identifying alternative fruit fly management for local market access 08/09

The role of cold storage in fruit fly management to facilitate local market access has been recognised by a current project (AP6006).

The impetus for the project was the high risk of industry losing access to some chemical disinfestation treatments in the near future. This risk particularly applies to full cover spray treatments of dimethoate or fenthion, or postharvest dips with dimethoate for apples going to specific destinations interstate.

The use of a regimen of protein autolysate baiting pre-harvest as well as inspection on the packing line, had gained access for Queensland citrus to the Victorian market (Interstate Certification Agreement 28). It was hoped that a similar systems approach might be successfully adapted to interstate export of Queensland apples.

Work in previous seasons had shown that, while data for the apple cultivars 'Royal Gala', 'Red Delicious' and 'Granny Smith' looked promising; Pink Lady® was more damaged by fruit fly.

This season the project concentrated on getting more data to strengthen the case for the four cultivars. Upwards of 10,000 fruits of each cultivar were taken from baited plantings, inspected and boxed and stored in constant temperature rooms to promote any fruit fly development.

However infestation levels were higher than previous seasons and threw doubt on the possible utility of using the protein baiting and inspection as a viable option for apples.

What is becoming more apparent is that the use of cold temperatures normally used in either cold storage or controlled atmosphere conditions has a marked effect on fly mortality. Apple storage in bulk bins in cold store straight after harvest is a ubiquitous farm practice locally (in Queensland).

Growers reducing fruit fly field infestation by chemical or bait spraying, cold or controlled atmosphere storage, and inspection during packing, are using the one element that this project lacked; this element is critical.

Project AP6006

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Alternative fruit fly management for market access for apples

Based on project work and accepted protocols for citrus, alternative fruit fly treatment protocols for apples to meet ICA28 market access requirements were investigated (Project AP06006).

The project was initiated in response to the possibility that the use of fenthion and dimethoate might be restricted following an APVMA review.

Project work in Queensland's Central Burnett had shown that the use of protein autolysate bait sprays, in conjunction with both inspection on the packing line and the normal spraying or agronomy for other pests and diseases, can be accepted by interstate destinations (ICA28). This project repeated this procedure for apples with the aim of gathering enough data to satisfy the requirements of importing states.

Project activity for the previous season had focussed on getting information on infestation levels in two late maturing cultivars. No Queensland fruit flies (Q-fly) were found to infest any of the 10,327 Granny Smith fruits harvested, incubated and dissected. Of the 10,412 Pink Lady™ fruits similarly treated, 12 fruits were infested but no live fruit fly larvae were obtained.

The absence of live larvae in the Pink Lady exposed a shortcoming with the experimental protocol. Collection methods had followed a procedure used for citrus to obtain ICA28. However, unlike citrus, apples are cold- or CA-stored before passage over the packing line. Therefore mortality of the larvae found in the Pink Lady could have resulted from either normal orchard husbandry or from cold storage. The protocol was amended to exclude a cold storage component. Treatments were repeated this season on both Granny Smith and Pink Lady, as well as Royal Gala and Red Delicious.

No infested fruit was found among the Royal Gala and Red Delicious. However infested fruit - with live larvae – were found in the Granny Smith. This is puzzling in view of the previous lack of infestation.

Population studies suggested that this season was slightly worse for Q-fly than the last. The anomaly might also be explained by the incidental effect of cover sprays applied for other pests including one particular codling moth spray that may have an (otherwise unreported) effect on populations of Q-fly.

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Apple & Pear Industry Annual Report summary request

Project: APO6006 Alternative fruit fly management for market access for apples.

With changes in the human toxicology indices for dimethoate & fenthion; the usage of these products is currently under review. Most at risk are post harvest treatments, especially for crops with edible peel, e.g. apples.

In citrus, a systems approach, incorporating pack line inspection & protein autolysate baiting has been most successful in the south Burnett, resulting in ICA28 as well as area freedom. This project sought to apply the techniques used in citrus to apple orchards.

The initial trial work was promising; with very low infestation (a level of probit 8.7 is required for quarantine). But we had hoped to increase the numbers of fruits examined – and the viability of sampling- by using subsequent larger & possibly bulked samples. However the consequent fruit fly infestation was much heavier and would be unacceptable to interstate quarantine.

Accordingly to strengthen the procedure this season, we applied azinphos –methyl each fortnight as the codling moth spray. The spray has an additional action against fruit flies overseas as well as anecdotal evidence in the Granite Belt. With the rains, this season was expected to be one of high fruit fly pressure. Of the harvests taken off to date, 8000 Galas showed 2% damage while 16000 Red Delicious around 1.2%. Although low, the infestation is still too high for quarantine.

Our most successful approach has been to use a period of cold storage (2°C for 12 days) as well as the protein baiting with 10,700 fruit showing no infestation.