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Yeast autolysate bait sprays for control of Queensland fruit fly on passionfruit in Queensland

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Abstract

Trials were conducted with yeast autolysate incorporating a range of chemicals to evaluate their efficacies against Queensland fruit fly, *Dacus tryoni* Froggatt (Diptera : Tephritidae), on passionfruit, *Passiflora edulis* Sims, their phytotoxicities and their effects on selected beneficial fauna.

The yeast autolysate showed no phytotoxicity when applied to passionfruit foliage at Nambour, Queensland. In laboratory studies, chlorpyrifos was the most effective insecticide in combination with the bait to control *D. tryoni*. Trichlorfon and maldison also gave good control. In an eight hectare orchard, baiting at seven day intervals with 10g a.i./L yeast autolysate mixed with 2 g a.i./L chlorpyrifos or 5 g a.i./L maldison gave very good control for the eight months' trial period. During this time, *D. tryoni* caused up to 75% fruit damage in an adjacent orchard where there was some use of dimethoate.

Laboratory tests on the insecticide component showed maldison to have high toxicity, and chlorpyrifos and trichlorfon low toxicity to a key predator, *Cryptolaemus montrouzieri* Mulsant (Coleoptera:Coccinellidae). Yeast autolysate was not attractive to *C. montrouzieri* or to the hymenopterous parasites *Aphytis lingnanensis* Compere (Aphelinidae), *Leptomastix dactylopii* Howard (Encyrtidae) or *Encarsia* sp. (Encyrtidae).

INTRODUCTION

Queensland fruit fly, *Dacus tryoni* (Froggatt) (Diptera : Tephritidae), is the most important pest of passionfruit, *Passiflora edulis* Sims in south-east Queensland, stinging up to 100% of the fruit. Passionvine mealybug, *Planococcus pacificus* Cox (Hemiptera : Pseudococcidae), and red scale, *Aonidiella aurantii* (Maskell) (Hemiptera : Diaspididae), are also common pests (Murray 1976 and Hargreaves *et al.* 1986). In the past, cover sprays of dimethoate were used to control *D. tryoni*. These gave only partial control of *P. pacificus* and *A. aurantii* and by destroying natural enemies (Murray 1978), eventually increased the incidence of these pests. The use of spot sprays of maldison combined with hydrolysed protein bait to attract and kill *D. tryoni* as an alternative to cover sprays was reported by Hargreaves *et al.* 1986. Bait sprays were used first in Hawaii by Steiner (1955, 1957) and in Australia by Jones and Skepper (1965) and Bateman *et al.* (1966).

D. A. H. Murray and J. R. Hargreaves (pers. comm. 1974 and 1978) found that the then most common commercially available bait (a 223 g/L formulation manufactured by Lanes Limited) was strongly phytotoxic to passionfruit foliage. This formulation was an acid hydrolysed protein and contained 17% salt. Consequently, Hargreaves *et al.* (1986) applied bait to strips of marine plyboard attached to the trellis posts supporting the vines. Results were poor but it was concluded that better control may have resulted from foliar applications. Keiser and Wakabayashi (1981) and Drew and Fay (1988) supported this conjecture by showing that bacterial activity in the bait produces volatile chemicals and that it is these that makes them attractive to the flies. Moisture and bacteria are more likely to persist on foliage than on marine plywood strips.

One bait not tested by Hargreaves *et al.* 1986 was an autolysed protein (yeast autolysate) made by Mauri Foods of Toowoomba, Queensland, and commercially available since 1975. This was a 500 g/L preparation consisting of yeast cells (killed by being subjected to low heat) and having a very low salt content.

It was decided to determine the phytotoxicity of the Mauri yeast autolysate and, if no damage occurred, to test it against *D. tryoni* on passionfruit by foliar application. It was also important to determine if the bait was attractive to or disruptive of natural enemies of the passion vine mealybug and red scale.

This paper presents data on phytotoxicities of bait sprays to passionfruit, efficacies of baiting against *D. tryoni* both in the laboratory and in the field, and the effects of baits on some natural enemies, particularly *Cryptolaemus montrouzieri* Mulsant, (Coleoptera : Coccinellidae) the main predator of *P. pacificus.*

MATERIALS AND METHODS

Chemical treatments used in this study are detailed in Tables 1, 2 and 3. Formulations of insecticides and protein baits used were:

Insecticides

chlorpyrifos	500 g/L	emulsifiable concentrate
	250 g/kg	wettable powder
DDT	500 g/kg	dispersible powder
dimethoate	300 g/L	emulsifiable concentrate
endosulfan	350 g/L	emulsifiable concentrate
fenthion	550 g/L	emulsifiable concentrate
maldison	250 g/kg	wettable powder
	500 g/L	emulsifiable concentrate
	1000 g/L	emulsifiable concentrate
trichlorfon	625 g/L	emulsifiable concentrate

Protein baits

protein hydrolysate	223 g/L solids	an acid hydrolysed protein containing 17% salts (Amalgamated Chemicals Ltd., Sydney, New SouthWales)
yeast autolysate	500 g/L solids	an autolysed protein containing 1.2% potassium sorbate. (Mauri Foods, Toowoomba, Queensland)

Phytotoxicity tests

A series of tests was conducted at Maroochy Horticultural Research Station from October 1966 to February 1988 on the passionfruit variety E23. Treatments included maldison (250g/kg, 500 and 1000 g/L) at 5 and 10 g a.i./L applied alone and in combination with the low salt yeast autoylsate and the high salt protein hydrolysate using either one or two applications. Yeast autolysate was used at 10 g a.i./L and protein hydrolysate at 4.5 g a.i./L (both at 20 mL of commercial product perL). Chlorpyrifos (both emulsifiable concentrate and wettable powder) and trichlorfon (625 g a.i./L) were also tested at 5 and 10 g a.i./L in combination with the yeast autolysate at 10 g a.i./L. Treatments were applied with a hand held atomiser to tagged shoots (20 leaves or more including young mature leaves) in a completely randomised layout. Each treatment was replicated three times.

Phytotoxicity was rated two days after treatment as follows: 0 – no injury; 1 – a trace of burning or leaf curl on 1 or 2 leaves; 2 – burning or leaf curl evident on several leaves; 3 – burning or leaf curl on most leaves; 4 – heavy burning destroying most of the leaves.

Efficacy of baits against *D. tryoni*

Laboratory tests

Tests were conducted using *D. tryoni* adults reared on a carrot medium (Heather and Corcoran 1985). The unit test-plot consisted of two young grafted custard apples (*Annona spp. hybrid*) each 0.9 m high in an aluminium framed gauze cage (0.9 × 0.9 × 0.6 m in dimension). Treatments (Table 1) were applied with a hand held atomiser to three leaves on one of the trees. Yeast autolysate at 10 g a.i./L was sprayed on to three leaves of the other tree as a non-toxic food source for flies in the event that the insecticide being tested was repellant. There were two types of control treatments. In one, three leaves on one of the trees were sprayed with 10 g a.i./L yeast autoylsate and in the other, three leaves on one of the trees were smeared with 4 mL of a thick paste of one part of honey and one part of yeast autoylsate. The leaf area on each tree was about 0.2 m^2 and the area treated about 0.02 m^2 or 10% of the total. Treatments were replicated three times. Approximately 50 fruit flies were released into each cage 15 minutes after the initial treatments. Mortality was measured after 24 hours. Fresh flies were introduced 2, 7 and 10 days after the initial treatments and mortality in each case again measured after 24 hours. Water was provided in each cage. The caged trees were held at 25°C during the tests. On days 3 to 7 and 9 and 10 while the fruit flies were not being exposed the plants were held outside exposed to the sun and temperatures from 16.4°C to 31.0°C and to light rain (total of 5 mm).

Field tests

Trials were conducted using an eight hectare passionfruit orchard (8 blocks of 1 to 3 years old Purple Gold variety) at Nambour from 9 September 1986 to 8 June 1987. Baits were applied at approximately weekly intervals (not on wet days) using yeast autolysate at 10 g a.i./L mixed with 5 g a.i./L maldison (wettable powder formulation) until 24 February and then with 2 g a.i./L chlorpyrifos until 14 April. The mixture was applied from a four wheel 'fat track' motorbike fitted with a 70 L fibreglass tank at 35 L/ha. The spray was delivered at 350 kPa through paired coarse nozzles on adjustable swinging arms on each side. Nozzles were adjusted (depending on the age of the vines) to spray as low as possible and to cover only 10 to 20% of the vine. The vines were sprayed only from one side and a spray was not repeated if it rained before the next spray was due.

Another orchard 200 m from the trial orchard was sprayed by an orchardist at 3 to 4 weekly intervals with 0.3 g a.i./L dimethoate commencing in early September. An air-blast sprayer applying 1700 L/ha was used. The recommended interval between dimethoate sprays for *D. tryoni* control is a fortnight. In this instance, a monthly schedule was used and so a high level of control was not expected.

Efficacies of treatments in the trial orchard were assessed by randomly monitoring 800 fruit (100 fruit per block) at 7 to 14 day intervals commencing on 2 September and continuing until 8 June. In the second orchard 200 fruit were randomly assessed at about monthly intervals. Mature fruit (colouring if possible) were assessed *in situ* for presence or absence of stings. The majority of such fruit would have been stung about 8 to 10 weeks earlier when the fruit were up to 3 weeks old (J. R. Hargreaves pers. comm. 1987). Two Steiner traps (Drew 1978) charged with Cue-lure^R and dichlorvos were hung in the trial orchard and another 200 m away in low scrub. These were emptied at 7 to 14 day intervals. A fourth trap was placed in the dimethoate sprayed orchard but not until early April 1987.

Effect on beneficial fauna

Laboratory testing of insecticide on *C. montrouzieri*

Field collected adults and larvae of the predator *C. montrouzieri* were subjected to a range of insecticides that could be used in passionfruit particularly against *D. tryoni* (Table 2).

The first test measured survival of adults feeding on citrus mealybug, *Planococcus citri* (Risso) (Hemiptera:Pseudococcidae), reared on small butternut grammas. (*Cucurbita moshchata* Duchesne). The grammas were held at 25°C in 2 L clear plastic containers with a mesh-covered hole (100 mm diameter) in the lid. Air was drawn through the containers via a vacuum pump to promote ventilation. *C. montrouzieri* adults were collected from *P. pacificus* on passionfruit in the field by sweeping and shaking vines. Approximately 25 adults were used per container and treatments were replicated either three or six times. For testing, gramma, mealybugs and *C. montrouzieri* were sprayed with a hand held atomiser. Assessment of survival was made after 48 hours exposure and was based on the ability of adults to climb the sides of the container.

The second test measured survival of larvae (mostly 3rd and 4th instar) using a similar procedure as that for the adults but approximately 50 individuals per container were used. The assessment of survival was done after 24 hours exposure.

The third test followed a similar procedure to the second but on this occasion the number of larvae surviving to adulthood was assessed. Containers with most of the lid cut away and replaced with mesh were used to minimize build up of humidity. Clumps of fresh citrus mealybug eggs and crawlers were provided as food daily.

Attractancy of hydrolysed protein

A series of four tests was designed to determine if the yeast autolysate applied to attract *D. tryoni* also attracted important natural enemies (Table 3). Those tested were *Aphytis lingnanensis* Compere (Hymenoptera:Aphelinidae), a parasite of red scale, *Leptomastix dactylopii* Howard (Hymenoptera:Encyrtidae), a parasite of citrus mealybug, *Encarsia* sp. (Hymenoptera:Encyrtidae), a parasite of red scale and *C. montrouzieri*. *A. lingnanensis* was reared in the laboratory on oleander scale, *Aspidiotus hederae* Vallot (Hemiptera:Diaspididae), *L. dactylopii* on citrus mealybug and *Encarsia* sp. on oleander scale. All of the hosts were reared on butternut grammas. *C. montrouzieri* was field collected from passionvines.

In tests 1 and 2, sixteen 50 × 100 mm pieces of waxed paper were attached in pairs randomly to one of eight faces of a clear perspex cross consisting of two bisecting sheets each 300 × 200 mm. Before attachment, six pieces of waxed paper were randomly treated with fine droplets of undiluted yeast autolysate, six similarly with honey and four were left untreated. The cross was then placed inside a 350 mm clear perspex cube with a fine mesh top and surrounded with eight 40 watt fluorescent tubes.

In test 1, approximately 1000 *A. lingnanensis*, 100 *L. dactylopii* and 200 *Encarsia* sp. were introduced. The numbers moving across, resting or feeding on each of the wax papers were recorded (without disturbing the cross) every two hours on 10 occasions over three days. After each count, the cross was rotated 90°. Four small butternut grammas covered with six-week-old oleander scale were placed in the cage to provide scales for any host feeding by *A. lingnanensis*. In test 2, three potted citrus plants (0.6 m high) were placed in an aluminium-framed mesh cage (0.9 × 0.9 × 0.6 m) to provide a more natural medium for the parasites to move on. Three perspex crosses were placed in the cage at heights of 0.2 m and sheets of waxed paper were again treated and attached as in test 1. There were five papers treated with yeast autolysate, five with honey and five untreated per cross.

The cage was illuminated again from all sides and above with a total of twelve 40 watt fluorescent tubes. Approximately 1000 *A. lingnanensis* were introduced to the cage and every two hours on 10 occasions over three days the numbers on the papers were recorded. One large pumpkin covered with oleander scale was provided for host feeding.

In test 3, the treatments were applied directly to the foliage of nine potted trees, the yeast autolysate sprayed with an atomiser and the honey dabbed on with a piece of waxed paper. After 24 hours, treatments were reapplied before the trees were placed randomly in a similar cage as in test 2. The 24 hour interval was to allow bacterial development. Approximately 1000 *A. lingnanensis* were released and the number of parasites on the treated leaves recorded at two hour intervals on seven occasions over two days.

Test 4 used the same perspex cube and design as that in test 1. Approximately 200 *C. montrouzieri* adults were introduced and the numbers on the papers recorded at two hour intervals on seven occasions over two days.

RESULTS

Phytotoxicity

None of the treatments showed phytotoxicity to passionfruit.

Efficacy of baits against *D. tryoni*

Laboratory tests

The data from the 13 treatments applied at four different exposure times was analysed as a factorial.

Chlorpyrifos at 1, 2 and 5 g a.i./L, trichlorfon at 2 and 5 g a.i./L and maldison at 2 and 5 g a.i./L gave significantly higher mortality than maldison 1 g a.i./L, trichlorfon 1 g a.i./L, endosulfan 5 g a.i./L and DDT 5 g a.i./L when flies were exposed 15 minutes after initial treatment (Table 1). Most flies exposed to chlorpyrifos died within the first few hours in contrast to endosulfan and DDT which were much slower acting. The same pattern was shown in succeeding tests at 2, 7 and 10 days but with a progressive decrease in efficacy as the interval from initial treatment increased (and the concentration of insecticide decreased). After seven days, 5 g a.i./L chlorpyrifos killed 93.8% of flies, 5 g a.i./L trichlorfon 87.2%, 2g a.i./L chlorpyrifos 77.6% and 5 g a.i./L maldison 65.0% of flies. After 10 days, 5 g a.i./L chlorpyrifos, trichlorfon and maldison still gave significantly higher mortality than the controls with 83.3%, 72.5% and 64.2% of flies respectively being killed.

As could be expected, exposure of the flies to treatments after 15 minutes and two days resulted in a significantly higher mortality than exposure after seven and 10 days (Table 1).

Field tests

Field sprays of yeast autolysate mixed either with 5 g a.i./L maldison or 2 g a.i./L chlorpyrifos gave very effective control of *D. tyroni* reducing the incidence of stung fruit for both the early and late summer crops to near zero (Figure 1). The 30% stinging peak in November at the first farm represented fruit stung the fortnight before spraying commenced on 9 September. As expected on the second farm, the cover spraying with dimethoate was too irregular to give satisfactory control and heavy periods of stinging occurred during November (shown in stung fruit counts peaking at 75% during January–February) and during March (shown in stung fruit counts peaking at 50% during May). The high percentage of stinging in November contrasts with the pattern observed by Hargreaves (1979) at Redland Bay where a maximum 26% of fruit were stung in early summer.

Table 1. Percentage mortality of adult *D. tryoni* exposed 15 minutes, 2, 7 and 10 days after application of yeast autolysate—insecticide bait sprays to young custard apple trees

Insecticide and concentration (g a.i./L) days	Percentage dead adults (24 hours exposure) Time from spraying to beginning of exposure			
	15 minutes	2 days	7 days	10
Maldison 5 g a.i./L	93.167	89.467	65.033	64.233
Maldison 2 g a.i./L	98.600	87.867	52.533	20.0
Maldison 1 g a.i./L	57.767	52.167	31.300	10.0
Trichlorfon 5 g a.i./L	94.467	92.367	87.233	72.500
Trichlorfon 2 g a.i./L	98.667	77.767	59.667	33.333
Trichlorfon 1 g a.i./L	65.733	64.533	28.800	12.667
Chlorpyrifos 5 g a.i./L	100.0	100.0	93.800	83.333
Chlorpyrifos 2 g a.i./L	100.0	100.0	77.633	35.0
Chlorpyrifos 1 g a.i./L	100.0	90.767	33.367	15.0
Endosulfan 5 g a.i./L	45.467	55.567	44.167	29.500
DDT 5 g a.i./L	11.867	34.033	33.067	28.067
Untreated honey + yeast autolysate	0.500	5.933	1.667	0.0
Untreated yeast autolysate	7.733	9.783	9.733	17.283
LSD (treatment means)	$P = 0.05$	19.898		
Exposure time means	67.226	66.172	47.538	32.377
LSD (exposure time means)	$P = 0.05$	5.519		

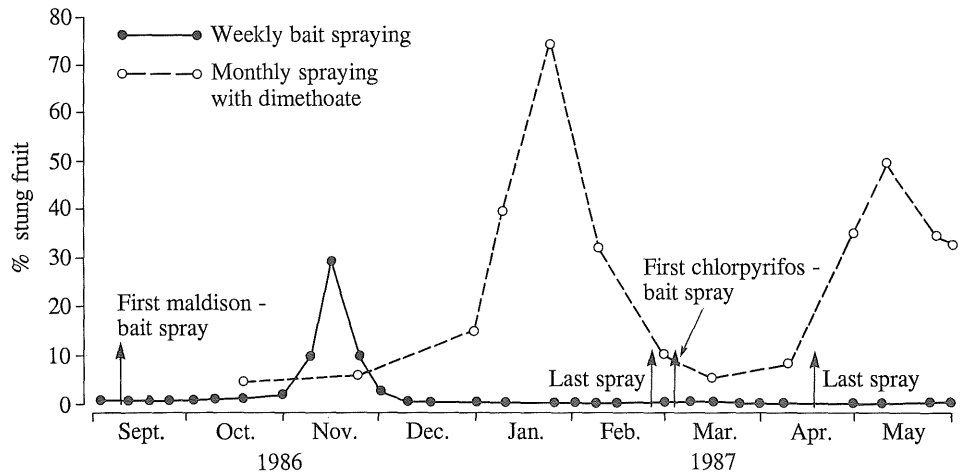

Figure 1. Control of *D. tryoni* in two passionfruit orchards at Nambour 1986–87, one sprayed weekly with yeast autolysate bait sprays and the other monthly with dimethoate cover sprays.

The number of male flies per Steiner trap per day on the trial farm averaged 0.6 (range 0.1 to 2.1) from 9 September to 18 April. In the first, second and third weeks before baiting started on 9 September the average daily catches were respectively 9.3, 0.4 and 0.5. In the trap located 200 m outside the farm, numbers of males averaged 11.2 per day (range 3 to 19) from 9 September to 18 April. During April 1987 the trap in the dimethoate sprayed orchard averaged daily catches of two.

Rainfall during the period of the trial was about average being 1235 mm (average 1389) and there were 100 wet days (average 113).

No phytotoxicity was observed on the Purple Gold variety during these extensive field trials.

Effect on beneficial fauna

Laboratory testing of insecticides on *C. montrouzieri*

Maldison 0.5g a.i./L, dimethoate 0.5g a.i./L, fenthion 0.5 g a.i./L and endosulfan 0.5g a.i./L were all highly toxic to adult *C. montrouzieri* (Table 2). Endosulfan was less toxic against larvae and in test 3, 54% survived to adulthood. Chlorpyrifos at 0.5 to 2 g a.i./L and trichlorfon 0.5 to 5 g a.i./L had low toxicity to both adults and larvae. Chlorpyrifos at 5 g a.i./L caused approximately 50% mortality in both adults and larvae. The results with maldison, dimethoate and endosulfan are similar to those obtained on adults by Bartlett (1963) who applied test materials with an atomiser to heavy wax paper. Morse and Bellows (1986) who applied test materials to lemon leaves found chlorpyrifos to have low toxicity to adult *C. montrouzieri* and (in contrast to these results) also dimethoate.

Table 2. Pesticide toxicity to adult and larval *Cryptolaemus montrouzieriu* in laboratory tests

Insecticide and concentration (g a.i./L)	Percentage live adults (48 hr exposure)	Percentage live larvae (24 hr exposure)	Percentage larvae reaching adulthood
Dimethoate 0.5 g a.i./L	0.0	9.0	1.7
Chlorpyrifos 0.5 g a.i./L	86.6	94.8	90.6
Chlorpyrifos 1 g a.i./L	95.3		
Chlorpyrifos 2 g a.i./L	84.7	78.1	
Chlorpyrifos 5 g a.i./L	49.4	53.4	
Endosulfan 0.5 g a.i./L	8.6	77.6	54.1
Maldison 0.5 g a.i./L	0.0	72.5	5.0
Trichlorfon 0.5 g a.i./L	92.6	95.3	87.2
Trichlorfon 1 g a.i./L	92.7		
Trichlorfon 2 g a.i./L	90.5	94.3	
Trichlorfon 5 g a.i./L	91.7	93.9	
Fenthion 0.5 g a.i./L	8.6		
untreated	100.0	98.9	80.8
LSD $P = 0.05$	10.5	14.8	15.9

Table 3. Mean number of *Aphytis lingnanensis, Leptomastix dactylopii, Encarsia* sp. and *Cryptolaemus montrouzieri* attracted to honey or yeast autolysate in laboratory tests

Treatment	1. On wax paper (perspex cage)		2. On wax paper (large gauze cage)	3. On citrus foliage (large gauze cage)		4. On wax paper (perspex cage)
	A.Lingnanensis	*L.dactylopii*	*Encarsia*	*A.lingnanensis*	*A.liagnanensis*	*C.montrouzieri*
Honey	119.2	11.2	13.7	118.7	148.0	17.1
Yeast autolysate	53.2	12.6	8.0	25.1	11.3	1.4
Untreated	69.5	11.8	6.3	27.0	11.3	1.4
LSD $P = 0.05$	20.6	7.2	5.7	35.4	35.7	3.6

Attractancy of yeast autolysate

Parasite counts at each two hour assessment for each of the three treatments were summed. Each assessment was regarded as a replicate for purposes of analysis (Table 3). *L. dactylopii* and *Encarsia* sp. in test 1 showed no significant preferences for either yeast autolysate or

honey. *A. lingnanensis*, however, showed a highly significant preference for honey in tests 1–3 as also did *C. montrouzieri* in test 4. Yeast autolysate was not significantly attractive compared with untreated paper in any of the tests.

DISCUSSION

Both the yeast autolysate and the protein hydrolysate showed no phytotoxicity to the E23 variety of passionfruit and the yeast autolysate was used for eight months over eight hectares without causing any damage to the Purple Gold variety. The high salt content of the hydrolysed proteins used by Murray and Hargreaves in the 1970s was most likely a major contributing factor to the phytotoxicity they observed, but the hydrolysed protein used in this study also had a high salt content. Until the reason for the change is clear, the low salt yeast autolysate is preferred for usage on passionfruit. Drew (pers. comm. 1986) also considers that a high salt content in the bait is less conducive to bacterial growth and thus less attractive to *D. tryoni*. Maldison, chlorpyrifos and trichlorfon were not phytotoxic to passionfruit. These chemicals and both baits were also observed on a range of other subtropical tree crops affected by *D. tryoni*: grapefruit, low chill peach, kiwi fruit, custard apple, avocado and persimmon. Some phytotoxicity occurred with emulsifiable concentrates of maldison and chlorpyrifos on the last three of these.

Chlorpyrifos was the most effective insecticide against *D. tryoni* in the laboratory and because of its greater persistency was preferred to trichlorfon for field testing. Baiting with 10 g a.i./L yeast autolysate mixed with 5 g a.i./L maldison or 2 g a.i./L chlorpyrifos at seven day intervals was very successful in the field in spite of heavy local populations of *D. tryoni* as evidenced on the adjacent farm. The bike sprayer designed by the grower allowed him to spray eight hectares in about two hours. This was a great saving compared with 8 hours every 14 days previously spent cover spraying dimethoate with a tractor powered air blaster. Low pressure bait application resulted in much less spray drift than with an air blast and less exposure of the operator to pesticide.

Bait spraying did not threaten natural enemies by attracting them to feed on the yeast autolysate. There was, however, some indication that the 5 g a.i./L maldison even when applied to only 10 to 20% of the area of the vines was reducing numbers of adult *C. montrouzieri*. Both chlorpyrifos and trichlorfon showed much less toxicity to *C. montrouzieri* than maldison in the laboratory tests. Because this predator plays such an important role in controlling *P. pacificus* in passionfruit, maldison was replaced with chlorpyrifos. Trichlorfon has a low mammalian toxicity and would be a suitable alternative to maldison in the home garden.

P. pacificus was a very serious problem on the study site in the previous season continuing on into the early summer crop. Replacement of dimethoate cover sprays with bait spraying for *D. tryoni* permitted a build up of *C. montrouzieri* which controlled the mealybug within four months. Studies on natural control of *P. pacificus* and *A. aurantii* are continuing.

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References

Bartlett, B. R. (1963), The contact toxicity of some pesticide residues to Hymenopterous parasites and Coccinellid predators, *Journal of Economic Entomologyt* **56**, 694–98.

Bateman, M. A., Friend, A. H. and Hampshire, F. (1966), Population suppression in the Queensland fruit fly *Dacus (Strumeta) tryoni*, II. Experiments on isolated populations in western New South Wales, *Australian Journal of Agricultural Research* **17**, 699–718.

Drew, R. A. I. (1978), Fruit fly collecting, in R. A. I. Drew, G. H. S. Hooper and M. A. Bateman (eds.) *Economic Fruit Flies of the South Pacific Region*, Queensland Department of Primary Industries, Brisbane.

Drew, R. A. I. and Fay, H. A. C. (1988), Comparison of the roles of ammonia and bacteria in the attraction of *Dacus tryoni* (Froggatt) (Queensland fruit fly) to proteinaceous suspensions, *Journal of Plant Protection in the Tropics* **5**, 1–4.

Hargreaves, J. R. (1979), Damage to passionfruit by the Queensland fruit fly, *Dacus tryoni* (Froggatt). *Queensland Journal of Agricultural and Animal Sciences* **36**, 147–50.

Hargreaves, J. R., Murray, D. A. H. and Cooper, L. P. (1986), Studies on the stinging of passionfruit by Queensland fruit fly, *Dacus tryoni* and its control by bait and cover sprays. *Queensland Journal of Agricultural and Animal Sciences* **43**, 33–40.

Heather, N. W. and Corcoran, R. J. (1985), *Dacus tryoni*, in Pritam Singh and R. F. Moore (eds.). *Handbook of Insect Rearing* Elsevier

Jones, E. L. and Skepper, A. H. (1965), Suppression of Queensland fruit fly *Dacus (Strumeta) tryoni* (Froggatt) (Tephritidae (Dipt.)) in Narrandera, New South Wales. *Agricultural Gazette of New South Wales* **76**, 501–503.

Keiser, I. and Wakabayashi, N. (1981), Fermentation *per se* as a biological mechanism for releasing co-factors of fruit fly attractants, i D. H. Lewis (ed.). *Controlled Release of Pesticides and Pharmaceuticals*, Plenum Press, NY.

Morse, J. G. and Bellows, T. S. (1986), Toxicity of major citrus pesticides to *Aphytis melinus* (Hymenoptera:Aphelinidae) and *Cryptolaemus montrouzieri* (Coleoptera:Coccinellidae). *Journal of Economic Entomology* **79**, 311–14.

Murray, D. A. H. (1976), Insect pests of passionfruit. *Queensland Agricultural Journal* **102**, 145–51.

Murray, D. A. H. (1978), Effect of fruit fly sprays on the abundance of the citrus mealybug, *Planococcus citri* (Risso), and its predator, *Cryptolaemus montrouzieri* Mulsant, on passionfruit in south-eastern Queensland. *Queensland Journal of Agricultural and Animal Sciences* **35**, 143–47.

Steiner, L. F. (1955), Fruit fly control with bait sprays in relation to passionfruit production. *Proceedings of the Hawaiian Entomological Society* **15**, 601–7.

Steiner, L. F. (1957), Field evaluation of Oriental fruit fly insecticides in Hawaii. *Journal of Economic Entomology* **50**, 16–24.

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