THE USE OF THE SELECTIVE INSECTICIDE PIRIMICARB FOR INTEGRATED PEST MANAGEMENT OF PLUM APHIDS IN UK ORCHARDS

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ABSTRACT

Current control measures for plum aphids involve tar oil winter washes and broad-spectrum insecticide sprays, both of which are damaging to natural enemy populations. In the absence of natural enemies, populations of pesticide-resistant damson-hop aphid (*Phorodon humuli*) increase unchecked. The effects of pirimicarb, a selective insecticide, on aphids and their natural enemies were assessed in plum orchard trials. The results confirmed the effectiveness of pirimicarb against spring populations of leaf-curling plum aphid (*Brachycaudus helichrysi*) and showed no damaging effects on polyphagous predators. With these predator populations intact, the mid- to late-season populations of *P. humuli* were heavily predated and remained below economic thresholds. The selectivity of pirimicarb has made it a valuable component of an integrated pest management programme for plum aphids.

INTRODUCTION

Aphids are frequently the most important pests of plum (*Prunus domestica*)(Ward, 1969; Gratwick, 1992). In the UK, three potentially damaging species overwinter on a range of both wild and cultivated *Prunus* species; the leaf-curling plum aphid (*Brachycaudus helichrysi*), the mealy plum aphid (*Hyalopterus pruni*), and the damson-hop aphid (*Phorodon humuli*). In addition to causing direct feeding damage and contaminating fruit as a result of sooty mould (*Cladosporium* spp.) development on honeydew, all three aphid species are vectors of plum pox virus ('Sharka')(Conti, 1986). Of the three species, *B. helichrysi* is probably the most common, and certainly causes the most severe damage (Alford, 1984).

Current chemical control of plum aphids is problematic. *Phorodon humuli* is resistant to all the pesticide groups currently registered for use against plum aphids (Muir, 1979; see also numerous papers in Campbell & Hrdý, 1988). The obvious concern over *P. humuli* resistance has prompted a move back towards the traditional use of dormant sprays which act against the overwintering egg stage and any eggs that have hatched. While tar oil winter washes are accredited with toxicity against resistant aphids (Gratwick, 1992), recent field trials suggest that they are relatively ineffective in reducing spring populations of *B. helichrysi* (R. Umpelby, ADAS Worcester, pers. comm.). In addition, tar oil winter washes are highly toxic to all natural enemies overwintering within plum orchards. In spring, adequate control of *B. helichrysi* and *H. pruni* can still be achieved through the use of available pesticides. However, the prophylactic use of these non-selective pesticides can destroy natural enemies, allowing populations of the pesticide-resistant *P. humuli* to increase uninhibited. The absence of an effective pesticide for *P. humuli* makes it the greatest concern for growers.

In order to relieve the selection pressure for resistance, and minimise detrimental side-effects of pesticides on natural enemies, an integrated approach to aphid management in plum orchards must be developed. Indigenous natural enemies are probably the major form of biological control available for IPM in orchards (Luck *et al.*, 1988). In unsprayed orchards, aphids are often of no economic importance because they are limited by predators (Niemczyk, 1966). In experimental orchards where broad-spectrum pesticides are not used, most foliage-feeding pests are controlled by naturally-occurring enemies (Lawson *et al.*, 1994). In order for the full potential of natural enemies to be exploited, orchard management practices, primarily concerning pesticide use, must be modified to encourage biological control.

This paper describes the development of a pest management strategy for plum aphids which integrates the conservation of indigenous natural enemy populations with the rationalised use of the selective insecticide, pirimicarb.

MATERIALS AND METHODS

Pesticide application

Field experiments were carried out during 1995 in a plum orchard (cv. 'Victoria') at East Malling. No tar oil washes had been applied in the previous winter. The orchard was divided into 12 equally-sized plots, each containing 16 trees. An additional row of guard trees separated each individual plot from all adjacent plots. On six randomly selected plots a single application of pirimicarb (Aphox 50% wt/wt, water soluble granules, Zeneca) at 0.14 g a.i./litre (equivalent to 280 g a.i./ha) was applied (to run off) on 31 March using a hand-lance attached to a Berthoud 600 sprayer. The remaining six plots were left as untreated controls.

Monitoring plum aphids

Weekly leaf samples were examined to monitor the aphid population development within the plum orchard from late April to early November. Separate samples of 100 leaves were selected without bias from both the untreated and pirimicarb-sprayed orchard plots. The species and numbers of all aphids present were recorded.

Predator exclusion experiments

The impact of predators on spring populations of *P. humuli* was determined using exclusion cage techniques.The cages were white polyester net bags (60 cm wide by 100 cm long, with mesh holes *c.* 0.1 mm^2), slipped over a branch and supported internally by two wire hoops (diameter *c.* 50 cm) which had been cross-braced onto the branch *c.* 50 cm apart. The experimental design consisted of six blocks (where a single tree constitutes a "block"), each containing the following three treatments: (1) uncaged, predators allowed access, (2) closed-caged, net bag tied close and predators removed, and (3) open-caged, net bag pegged open, predators allowed access. The open-caged treatment was used to address microclimate modification, a recognized disadvantage of net exclusion cages (Luck *et al.*, 1988). The experimental trees were located within the six pirimicarb-sprayed orchard plots. The three treatments were allocated at random to three similar-size branches, each bearing *c.* 100

dormant buds within the treatment area. Each treatment branch was inoculated with five fourth-instar *P. humuli* nymphs, reared from field-collected fundatrices, and left for 14 days to allow the introduced aphids to disperse and settle. After 14 days, and at weekly intervals thereafter, *P. humuli* numbers were monitored non-destructively; 10 leaves were selected without bias from within each treatment, and the numbers of aphids on these leaves were counted.

Monitoring aphid predators

A beating tray covered with white muslin cloth (*c.* 110 cm x 86 cm) was used to sample the aphid natural enemies within the plum orchard. The tray was held beneath a branch, and the branch was sharply struck four times with a 0.5 m long club, padded on its striking end to avoid injury to the tree. Branches below 2 m, and of roughly equal size, were sampled. Each set of four strikes constituted one "beat", 25 random beat samples being taken at weekly intervals from both the untreated and pirimicarb-sprayed orchard plots. Beneficial insect species that fell on the tray were identified, sexed where possible, and recorded.

Statistical treatment of data

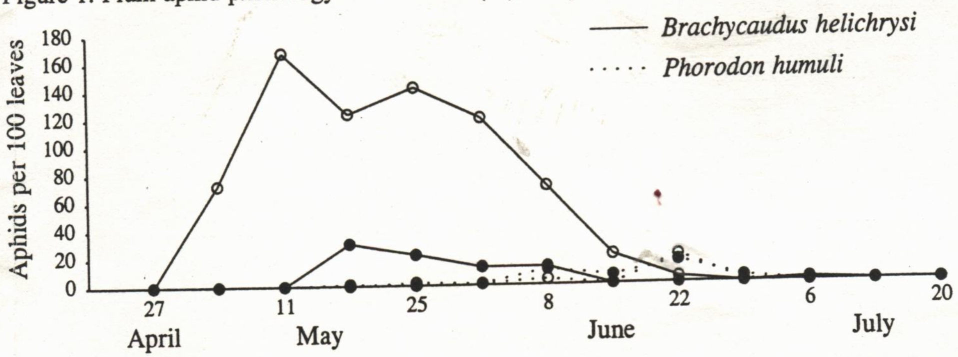
Data were transformed [$y = \text{Log}_{10}(x+1)$, where x= untransformed counts] to stabilize variances, and analyzed using an analysis of variance (ANOVA). The LSD test was used for means separation at $p<0.05$, when the F-statistic for the treatment effect was significant at $p<0.05$.

RESULTS

Aphid phenology

No plum aphids were observed in the initial leaf sample on 27 April. In the following two weeks *B. helichrysi* populations on untreated plots built-up rapidly, peaked over the period 11-25 May, and steadily declined over the following seven weeks (Figure 1). The number of *B. helichrysi* found on the untreated plots was significantly greater than that found on the pirimicarb-sprayed plots ($p<0.001$).

Figure 1. Plum aphid phenology in untreated (O) and pirimicarb-sprayed (●) orchard plots.



The delayed build-up and early decline of *B. helichrysi* populations within pirimicarb-sprayed plots reduced the period of infestation to 5 weeks, compared to that of 11 weeks in untreated plots (Figure 1).

Populations densities of *P. humuli* did not differ significantly between untreated and pirimicarb-sprayed plots. In all plots, populations built-up slowly from mid-May and peaked on 22 June (Figure 1). In the plum orchard the period of *P. humuli* infestation was six weeks in both the pirimicarb-sprayed plots and the untreated plots. The peak populations of *P. humuli* in all plots were smaller than the peak populations of *B. helichrysi* in pirimicarb-sprayed plots (Figure 1). No spring populations of *H. pruni* were found in leaf-samples during 1995.

Aphid predators

The impact of natural enemies on *P. humuli* populations is shown in Figure 2. From late May onwards aphid numbers were significantly higher for the closed-caged treatment than for any other ($p<0.05$)(Figure 2). Aphid numbers for the open-caged treatment were not significantly different from aphid numbers on the uncaged control branches (Table 1), showing that any

Figure 2. Average number of *P. humuli* in closed-caged, open-caged and uncaged populations.

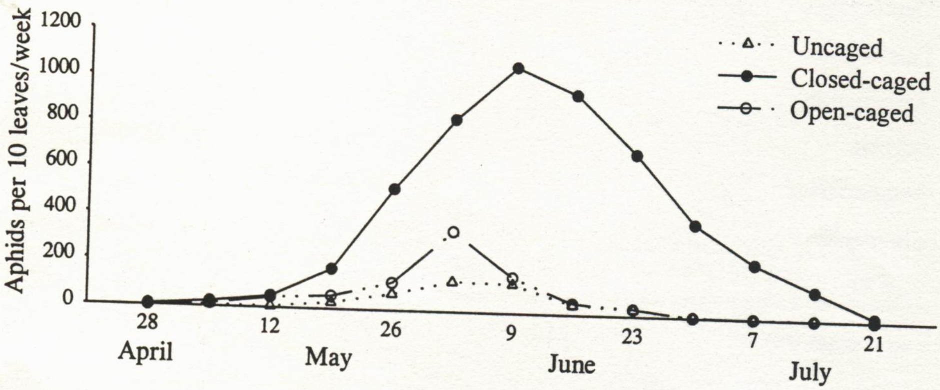


Table 1. Effect of various levels of predator exclusion on the number of *P. humuli* on plum[1].

Treatment	Log (n+1) mean *P. humuli* counts[2]
Uncaged	2.01[b]
Closed-caged	4.95[a]
Open-caged	2.26[b]
SED (0.05, 30 d.f.)	0.162

[1] Summary of 13 weekly records.

[2] Means subtended by the same letter are not significantly different ($p<0.05$), by an LSD test.

alterations to microclimate caused by the net bags were not sufficient to affect *P. humuli* development.

Aphid predators from eight arthropod families were identified from beating-tray samples (Table 2). The only predators that were abundant during the period of *P. humuli* infestation were polyphagous Araneae and *Forficula auricularia* (Dermaptera). The numbers of these polyphagous predators sampled within the untreated plots and the pirimicarb-sprayed plots were not significantly different. Differences in abundance of predator groups between the untreated and pirimicarb-sprayed plots were evident for aphid-specific species, most notably the Coccinellidae. The catches of Coccinellidae were dominated by larvae (64%) which were

Table 2. Total predatory arthropods caught during the period of *P. humuli* infestation (11 May - 13 July), using beating-tray sampling within untreated and pirimicarb-sprayed plum orchard plots .

Arthropod taxa	Untreated plots	Pirimicarb- sprayed plots
Araneae	359	245
Forficula auricularia	333	255
Coccinellidae	97	6
Cantharidae	4	4
Anthocoridae	50	13
Miridae	64	55
Hemerobiidae[1]	4	0
Chrysopidae[1]	16	0
TOTAL	927	528

[1] Larval stages only.

found exclusively within the untreated plots. Predatory ladybirds usually require abundant supplies of prey as ovipositional stimuli. Hence, the total absence of coccinellid larvae from pirimicarb-sprayed plots reflects the low numbers of aphid prey available, i.e. the absence of any ovipositional stimuli for adults. In contrast, the flourishing populations of *B. helichrysi* within untreated plots provided abundant prey and oviposition stimuli for early-season aphidophages. Once adult, these predators become more mobile, and consequently were equally abundant in both untreated and sprayed orchard plots.

DISCUSSION

These studies have shown the value of the selective aphicide, pirimicarb, for the integrated control of plum aphids. Control of severely damaging *B. helichrysi* populations can be achieved with a single, accurately-timed application of pirimicarb. The rationalised use of this selective aphicide has no detectable effects on the most abundant indigenous natural enemies present in the orchard. These predator populations remain intact to prevent the build-up of pesticide-resistant *P. humuli* populations later in the season.

Pirimicarb is currently used for the IPM of plum aphids elsewhere in Europe, and for the control of aphid pests on other *Prunus* species in the UK, such as cherries. In addition to reducing the environmental impact, the use of pirimicarb within such IPM strategies can reduce the number of treatments and overall pesticide costs by 40%, compared to orchards where conventional pest management is practised (Malavolta *et al.*, 1995). Future availability of pirimicarb, possibly through a specific off-label approval, would considerably enhance the prospects for integrated control of plum aphids.

ACKNOWLEDGEMENTS

This work was funded by the Horticultural Development Council. Thanks are due to Martin Ridout for his assistance with the statistical analysis.

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A NEW BIOLOGICAL PRODUCT FOR CONTROL OF MAJOR GREENHOUSE PESTS

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ABSTRACT

The patented *Beauveria bassiana* JW-1 strain of fungus is active as a mechanical (non-chemical) mode of action against major greenhouse pests including whiteflies, thrips and mites. Studies indicate that beneficials such as *Encarsia* spp., *Eretmocerus* sp., *Chrysoperla* spp., and others are not impacted by the *B. bassiana* JW-1 strain. The target pests must come into contact with the fungal spores after direct application, movement on treated surfaces, or bodily contact with other target pests already exposed (horizontal transfer). Application of the flowable formulation can be by electrostatic, air-assist, pulse foggers, injection/water systems, ultra-low volume (ulv) or universal hand equipment. The *B. bassiana* JW-1 strain can be tank mixed with most pesticides and fertilizers but not with most fungicides. Some identified fungicides are compatible; however, a time interval of 48 h before or after application of fungicides is suggested. Extensive evaluation has yielded no observed phytotoxicity. Toxicological studies indicate that the *B. bassiana* JW-1 strain does not have an adverse impact on humans, livestock, birds, fish, beneficial insects, crops, waterways, or groundwater resources.

INTRODUCTION

Biological or natural alternatives for pest control have been sought for many years with few successes. The development of fungi as an alternative has been considered for many years, mainly by academics. Problems with activity, stability, formulations, production, economics, limited markets, registrations, commercial protection, etc., were associated with the lack of commercialization of fungi in the pest control arena. Considerable effort by Troy Biosciences Inc in collaboration with the United States Department of Agriculture (USDA) initiated a successful fungal research program which eventually established that the JW-1 strain of *B. bassiana* was commercially viable.

NATURALIS® is a commercial formulation containing *B. bassiana* JW-1 that has demonstrated excellent efficacy against major pests of cotton, vegetables, ornamentals, and turf. In this paper we will present experiments designed to control the major greenhouse pests, aphids, whiteflies, thrips and mites with examples from the United States, Spain, New Zealand and Egypt.