COMBINING CHLORPYRIFOS AND DIFLUBENZURON FOR EFFECTIVE MANAGEMENT OF CLOVER FLEA (*SMINTHURUS VIRIDIS*)

B.E. WILLOUGHBY¹, B. COOPER², K. PANCKHURST² and D.J. WILSON¹

¹AgResearch, Private Bag 3123, Hamilton, New Zealand

²AgResearch, PO Box 23, Kerikeri, New Zealand

Corresponding author: bruce.willoughby@agresearch.co.nz

ABSTRACT

Clover flea (syn. Lucerne flea) (*Sminthurus viridis*) populations were controlled in pasture in Northland over spring with a single application of insecticide. A mixture of organophosphate insecticide (chlorpyrifos) at a range of rates (12.5 to 100 g/ha) combined with an insect growth regulator (diflubenzuron) at 12.5 g/ha was applied to small plots in two locations in spring 2000. Field scale demonstration plots were treated with chlorpyrifos at 12.5 g/ha combined with diflubenzuron at 12.5 g/ha at nine sites in spring 2001. In small plots (2000), chlorpyrifos alone and with diflubenzuron reduced the clover flea populations by 98% within 24 – 48 h regardless of rate. Plots treated with diflubenzuron alone had 67% fewer fleas than untreated ones at this time. No differences existed between insecticide treatments 3 – 12 weeks after spraying. In the demonstration plots (2001), clover flea numbers were maintained at low levels for at least 33 days over the spring season. Cost, health and environmental advantages may accrue from the reduced use of organophosphate insecticide.

Keywords: clover flea, *Sminthurus viridis*, chemical control, diflubenzuron, chlorpyrifos.

INTRODUCTION

Clover flea (*Sminthurus viridis* L. (Collembola: Sminthuridae)) is present throughout New Zealand (Dumbleton 1938) and has been recognised as a pasture pest since the 1970s (Townsend et al. 1979). Severe damage to white clover (*Trifolium repens*), the preferred host, has been recorded in pastures in parts of Northland, South Auckland, Waikato and the Bay of Plenty (Wrenn et al. 1983; Willoughby et al. 2000). Pasture damage levels peak in spring and autumn. Clover flea activity declines over winter and the insect may aestivate in the egg stage in hot dry summer conditions (Wallace 1968). Organophosphates (OPs) (Wrenn et al. 1983) and the insect growth regulator (IGR), diflubenzuron (Addison et al. 1992), can provide effective control of clover flea. However, often farmers report poor efficacy, with 2 – 3 insecticide applications necessary in a season. Insecticide resistant clover flea populations were implicated but no evidence of resistance was found (B.E. Willoughby, unpubl. data). Trials were conducted to identify a more reliable pesticide treatment that would provide an immediate cessation of pasture damage and also offered long term control. Environmental and health advantages were also envisaged in reducing the rate of OP used.

This paper reports on a series of field trials designed to assess the efficacy of combining the organophosphate chlorpyrifos (Lorsban® 40% EC) with the insect growth regulator diflubenzuron (Dimilin® 25% WP) against clover flea populations.

MATERIALS AND METHODS

Small plot trials

On 19 October 2000 two small plot trials were established on separate properties 1 km apart in Northland. The trial design was a randomised block with four replicates. Plot size was 10 m x 10 m. Treatments included chlorpyrifos applied at 50, 25 and 12.5 g/ha in

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combination with diflubenzuron at 12.5 g/ha, with chlorpyrifos and diflubenzuron applied alone at 100 g/ha and 12.5 g/ha respectively. The treatments were applied using a CO₂ powered precision back pack sprayer operating at 220 kPa through XR TEEJET 800 4WK flat fan nozzles delivering 200 litres/ha at 1 m/s. The control plots were sprayed with water only. Conditions at spraying were overcast with a very light (<5 knots) intermittent breeze and air temperature around 16°C. Pasture height at each site ranged from 30 – 70 mm of predominantly ryegrass (*Lolium perenne*) and white clover.

Clover flea numbers were sampled using a 30 cm diameter sweep net dragged over two 6 m transects diagonally across the plot. Samples were taken immediately prior to treatment, then 24–48 h and 3, 6 and 12 weeks post-treatment. A further sample was taken in April 2001

Demonstration plots

On 25 October 2001 nine paired demonstration plots were established on a mixture of dairy, beef and mixed dry stock farms in an area between Kaikohe and Kerikeri in Northland. The trial design was a treated block (50 m x 50 m) with an adjacent untreated control of similar size. Chlorpyrifos was applied at 12.5 g/ha (1/8 the recommended label rate) in combination with the diflubenzuron at the label rate of 12.5 g/ha. The chemicals were applied using a vehicle mounted 6 m boom sprayer operating at 220 kPa through XR TEEJET® 800 4WK flat fan nozzles delivering 150 litres/ha at 10 km/h. Spraying conditions were overcast with a light (<5 knots) intermittent breeze and air temperature around 18°C. Pasture grasses were kikuyu (*Pennisetum clandestinum*), perennial ryegrass (*Lolium perenne*) and tall fescue (*Festuca arundinacea*) with white clover and some red clover (*Trifolium pratense*). Pasture height ranged from 30 – 70 mm in height.

Clover flea numbers were sampled pre-treatment and 11, 19, 33 and 57 days after treatment (DAT). Four sampling transects, using a 30 cm diameter sweep net dragged for 6 m over the pasture surface, were made in each plot. The sampling intervals were determined by suitable conditions comprising dry pasture and light winds.

For the purpose of data analysis the trial was treated as two treatments with nine replicates. Data was analysed using ANOVA in Minitab version 13.31.

RESULTS AND DISCUSSION

Small plots

Clover flea counts as mean values from both small plot trials are presented in Figure 1. The results of the two trials did not differ and have been pooled. The large increase in clover flea numbers across the untreated plots 24 – 48 h after treatment application may be the result of a large hatch of eggs. Migration of clover flea from treated to untreated plots was unlikely as neither chemical is known to have strong insect repellency. Plot size was adequate as Wrenn et al. (1983) monitored clover flea populations for up to 9 weeks in 4.8 x 10 m plots with no evidence of migration. Differences in ambient conditions between the pre- and post-treatment sampling days may have an impact on sweep net catches but

FIGURE 1: Clover flea numbers at five sampling times after various rates of the organophosphate (OP) chlorpyrifos in combination with the insect growth regulator (IGR) diflubenzuron were applied in small plot trials. Data are the mean values from two trials.

care was taken to ensure that sampling conditions were as favourable as possible and since relative comparisons were being made this simplified the task. All treatments containing chlorpyrifos had equal efficacy, irrespective of rate used (Fig. 1). The addition of diflubenzuron did not improve duration of control. As diflubenzuron does not affect adults, alone it showed a third less the reduction in clover flea numbers than chlorpyrifos in 24–48 h. However, by week 3, it was providing the same level of clover flea control. By 12 weeks, there was no difference between treated and non-treated plots, indicating the disappearance of residual activity.

These results show rates as low as $\frac{1}{8}$ the recommended rate of chlorpyrifos in combination with diflubenzuron, can provide the best attributes of both chemicals, namely the fast reduction in population numbers, followed by at least 6 weeks of control. The result is no better than 100 g/ha chlorpyrifos alone but has the advantage of less organophosphate in the environment. A further sampling of the plots in April 2001, after the summer diapause of clover flea, indicated that there was no effect of the insecticides on the populations of the subsequent autumn clover flea generations.

Demonstration plots

The results from the nine paired demonstration plots are presented in Table 2 and represent the total clover flea count for 4 sweeps. Pre-treatment populations were variable; however at all sites the farmer considered there were increasing clover flea populations that they would contemplate spraying. The untreated population 11 DAT at Site 6 vividly illustrates the capacity of this pest to increase its numbers. Unsuitable weather rendered it impractical to sample sites 1, 2, 3, and 7 at 11 DAT. This omission is not significant as 98% control of clover flea populations over all sites was maintained at 19 DAT. Acceptable levels of control at 91% were maintained to 33 DAT. At this time some populations (sites 5, 8 and 9) were beginning to show a natural decline, probably as summer conditions initiated aestivation (Wallace 1968). At 57 DAT (21 December 2001) the clover flea populations at all but one site (site 7) had declined to very low levels. The level of clover flea control at site 7 was still 88% at this time.

Poor insecticide efficacy previously reported by farmers may be attributed to a number of factors. Applying insecticide to hard grazed pasture may reduce efficacy. New foliar growth will dilute insecticide if pasture growth conditions are good. Fresh growth may

TABLE 2: Clover flea numbers from 4 sweep net counts per plot in the demonstration plots. Data are shown for untreated plots (untrtd) and plots treated with 12.5 g/ha chlorpyrifos and 12.5 g/ha diflubenzuron (trtd) taken 11, 19, 33 and 57 days after treatment (DAT).

Site	Pre Treat	11 DAT		19 DAT		33 DAT		57 DAT	
		untrtd	trtd	untrtd	trtd	untrtd	trtd	untrtd	trtd
1	221			317	5	76	6	2	0
2	116			403	28	93	7	2	1
3	106			132	9	89	7	1	1
4	180	106	1	112	0	122	8	0	1
5	66	158	1	93	0	6	5	0	1
6	49	464	2	131	1	27	1	0	0
7	85			91	0	127	15	34	4
8	64	157	13	190	2	0	0	0	0
9	65	167	1	233	0	3	1	0	0
Mean		210.4	3.6	189.1	5.0	60.3	5.6	4.3	0.9
SED			1.5		1.0		8.0		
% control			98		98		91		(88) ¹

¹Site 7 only.

also provide untreated foliage for the insect to feed on. As diflubenzuron must be ingested by the insect to be effective, new pasture growth could be rapidly infested by clover flea juveniles emerging in treated pastures. While both chlorpyrifos and diflubenzuron have a withholding period of 7 days the residual action of the latter may extend to 14 days (Addison et al. 1992). Grazing a pasture too soon after the insecticides have been applied may reduce efficacy through stock ingestion of treated foliage.

The range of pre-treatment clover flea populations (Table 2) illustrates the difficulty farmers face when judging when to apply an insecticide. Farmers respond when they first perceive pasture damage. With the capacity of clover flea to rapidly grow both physically and in numbers, pasture damage from this point can quickly reach economic levels. Delayed identification of the presence of the pest also means that there is a range of life stages present, from egg to adult. While chlorpyrifos is fast acting and effective against both the adult and nymph stage it does not kill the egg stage. Chlorpyrifos has an LD50 residual life of 4.2 days at 100 g/ha (Wrenn et al. 1983). Clover flea eggs hatch in 8 days at 22°C (Dumbleton 1938), 12 days at 18.3°C and up to 35 days at 10°C (Anon. 1971). If eggs hatch after the residual activity of the chemical has fallen to ineffective levels, population resurgence can be expected. Diflubenzuron is only effective against the developing or nymphal stage of clover flea. Consequently IGRs are seen by farmers as unreliable because pasture damage is only marginally checked and the clover flea population may resurge from eggs that continue to be laid by the adult clover flea.

The combination of chemicals overcomes some of the problems associated with the use of each alone. The use of a low rate of chlorpyrifos achieves a rapid knock down of the nymph and adult stages feeding in a pasture. The longer residual activity of diflubenzuron applied in conjunction with chlorpyrifos is effective against the clover flea nymphs emerging from eggs resident in the pasture. The IGR has a better chance of being effective as diflubenzuron is more active against early instar clover flea nymphs (Wrenn et al. 1983). Chlorpyrifos, by removing all the feeding stages of the clover flea, effectively 'resets the clock' for the development of the next generation, allowing diflubenzuron to be used with greater confidence. While trials testing this combination spray have only been made against spring populations of clover flea, there is no reason to believe it will not be equally effective against autumn clover flea populations.

This series of trials has shown that combining low application rates of chlorpyrifos with label rates of diflubenzuron achieves good control of clover flea populations. The practice should find acceptance from an environmental point of view with the reduction of OP applied and the effective use of an IGR. Cost effectiveness arises from a reliable response to a single application of chemicals when 2 – 3 applications in the past have been necessary.

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REFERENCES

- Anon. 1971: Lucerne flea. (An information sheet reprinted from) *Tasmanian J. Agric.*: 273 – 274.
- Addison, P.J.; Firth, A.C.; Cliffe, A. 1992: The effects of diflubenzuron on lucerne flea. *Proc. N.Z. Plant Prot. Conf.*: 197-200.
- Dumbleton, L.J. 1938: The lucerne flea (*Sminthurus viridis*) in New Zealand. *N.Z. J. Sci. Technol.* 20: 197-211.
- Townsend, R.J.; Pottinger, R.P.; Rowe, S. J. 1979: Evaluation of alternative insecticides for lucerne flea on pasture. *Proc. 32nd Weed and Pest Control Conf.*: 68 – 71.
- Wallace, M.M.H. 1968: The ecology of *Sminthurus viridis* (Collembola) 11. Diapause in the aestivating egg. *Aust. J. Zool.* 16: 871 – 883.

- Willoughby, B.; Cooper, B.; Blackwell M. 2000: Clover flea, national distribution and impact on dairy farming. Report prepared for the Northland Clover Pest Interest Group. 7 p.
- Wrenn, N.R.; Pottinger, R.P.; Dentener, P.R.; McGhie, R.A. 1983: Evaluation of insecticides for lucerne flea control in pastures. *Proc. 36th Weed and Pest Control Conf.*: 185-189.
- Wrenn N.R.; McGhie R.A. 1986: An evaluation of the insect growth regulators diflubenzuron and teflubenzuron for control of lucerne flea (*Sminthurus viridis*). *Proc. 39th Weed and Pest Control Conf.*: 27-32.